

ably mucks, should be fumigated at lower moisture levels than sandy soils.

Soil Type — Diffusion of fumigants through more porous sandy soils is easier than through less porous clay soils. Also sorbtion of these gases, principally by the colloidal soil particles, is greatest in clay, second in muck and least in sandy soils. Although gas sorbtion is not as great in muck as in clay, it is apparently more prolonged. In general, clay and muck soils should be fumigated with higher dosages, shallower applications, in looser condition,

at lower soil moisture contents and at higher temperatures than sandy soils and a longer period should be allowed for aeration.

Rates of Application—The usual rates of application are about 500 lbs. of chlorpicrin, 200 lbs. of methyl bromide, 200 lbs. of D-D and 50 lbs. of Ethylene dibromide per acre. Dosages are increased somewhat when soil conditions are adverse for retention or diffusion of gas. Also heavier dosages are applied in muck and clay soils than in sandy soils.

WIREWORM CONTROL STUDIES ON THE LOWER SOUTHEASTERN FLORIDA COAST, 1946-47

D. O. WOLFENBARGER

*Florida Agricultural Experiment Stations
Sub-Tropical Experiment Station
Homestead*

There is no question but that serious losses from wireworms have been sustained by potato growers in South Florida. The important question is how can the losses be stopped. This report records results of rather extensive experiments conducted in the 1946-47 season on the use of insecticides for wireworm control. An enumeration of three characteristics of the wireworm problem in South Florida is as follows: (1) one of the corn wireworms, *Melanotus communis* Gyll, is the insect involved, (2) most of the insects complete their life cycle in one year, as shown by Wilson¹, and (3) most of the insects are in the larval stage during the entire potato growing season. Adaptation of control measures found effective elsewhere may not be effective in South Florida, nor do the

differences necessarily preclude an easier solution to the problem.

Some of the newer insecticides were tested to determine their effectiveness in wireworm control. They included DDT, benzene hexachloride, termed HCH (for 1, 2, 3, 4, 5, 6-hexachlorocyclohexane) in this report, and the fumigants dichloropropane - dichloropropylene under the proprietary names of *D-D*, and *Dowfume N*, and ethylene dibromide, or *Dowfume W-10*.

All experiments were conducted on the calcareous or marl soil in commercial fields of potatoes of South Dade County. This soil is alkaline and was found to range in pH between 7.5 and 8.7. It might be questioned, owing to the alkalinity, how DDT and benzene hexachloride could be effective in wireworm control, since both insecticides are understood to decompose in alkaline media. Some wireworm control, however, was obtained.

FIELD EXPERIMENTS

In cooperation with the Farsouth Growers Cooperative Association an experiment was conducted in which different concentrations

¹ WILSON, J. W. Present status of the wireworm in South Florida. *Proc. Fla. State Hort. Soc.* for 1946: 103-106.

TABLE I—WIREWORMS PER SQUARE FOOT ON SAMPLING DATES, PERCENTAGE OF TUBERS INJURED, PERCENTAGE OF CONTROL, AND YIELDS OBTAINED

| Treatment | Wireworms per sq. ft on | | | % tubers injured | % control | Yield bu./A. |
|--------------------------------------|-------------------------|------|-------|------------------|-----------|--------------|
| | 6/28 | 7/21 | 10/31 | | | |
| DDT—50% W.@16.2 lbs./A. | 0.05 | 1.13 | 0.57 | 10.7 | --3 | 251 |
| DDT—50% W.@32.4 lbs./A. | 0.09 | 0.85 | 0.95 | 9.8 | 6 | 246 |
| DDT—50% W.@64.8 lbs./A | 0.05 | 1.04 | 0.57 | 5.2 | 50 | 251 |
| Check | 0.42 | 1.18 | 1.98 | 10.4 | — | 263 |
| Sq. ft of soil sampled per treatment | 21.2 | 21.2 | 10.1 | | | |

Planted December 2, 1946, and harvested February 20, 1947.

of DDT were sprayed on the ground and then disked in. Three concentrations were applied in 25-foot strips across an 80-acre field, on May 13, 1946. This was subsequent to the potato growing season, preceding the rainy season, and during the egg deposition period of the wireworm adult. The soil was disked after treatment in order to place the DDT below the surface.

Samplings of the soil were made at three different times after the treatment to determine the wireworms populations. The results of the samplings and of the percentage of the tubers injured and of the yields at harvest time are presented in Table 1.

More wireworms were taken in the check samples than in the samples from treated soil, on each sample date. As many wireworms were taken from the 16.2-pound concentration of 50% wettable DDT per acre as from the 64.8-concentration on each sampling date, except July 21 and it was nearly so. It is of interest to note however, that the percentage of injured tubers showed an order of decrease with DDT concentration increase. Possibly the slowness of action of DDT may in part explain these observations. Although the average yield figure is slightly more for the check than for the plots treated with DDT the differ-

TABLE 2 — MATERIALS AND AMOUNT OF SOIL FUMIGANTS USED. AVERAGE PERCENTAGE OF WIREWORM INJURED TUBERS, PERCENTAGE CONTROL, AND AVERAGE YIELD

| Material and amount applied/acre | Avg. % injured tubers | Percentage control | Avg. yield bu. per A. |
|----------------------------------|-----------------------|--------------------|-----------------------|
| D-D —22 gals. (220 lbs.) | 8.5 | 21 | 235 |
| W-10—22 gals. (161 lbs.) | 4.5 | 58 | 235 |
| N —26 gals. (260 lbs.) | 7.5 | 31 | 234 |
| Check | 10.8 | — | 256 |

Planted December 2, 1946, and harvested February 20, 1947.

ences are within the limits of chance occurrence and are considered insignificant.

The soil fumigants were arranged in treated strips 12-feet wide across a field about 1250 feet long, also in cooperation with the Farsouth Growers Cooperative Association and with the companies marketing these proprietary fumigant mixtures. Dispersion of the fumigants was by a fumigant applicator, one with injector tubes spaced 12 inches apart, injecting the fumigant at from 6 to 9 inches in depth and at intervals of 15 inches in each row. The fumigants were applied on November 7 and the field was planted December 2. At harvest time, in February, samples of tubers were dug,

More control of the wireworm is shown by the *W-10*, ethylene dibromide material than by the other or of the check. The four bushels difference in yield is regarded as insignificant.

In cooperation with Mr. August Burrichter an experiment was conducted in which 11 treatments, including a check, were used. The 44 treatment plots were each four rows wide by about 300 feet long, comprising a tract of approximately 4 1/2 acres. The insecticides DDT and HCH were applied by different methods. Each was used as follows: (1) as wettable powder broadcast and then disked in the soil, (2) as a dust, presumably without a wetting

TABLE 3—WIREWORM INJURED TUBERS, PERCENTAGE CONTROL, AND YIELD FROM TWO SOIL FUMIGANTS

| Material and amount applied/acre | Avg. % injured tubers | Percentage control | Avg. yield, bu. per A. |
|----------------------------------|-----------------------|--------------------|------------------------|
| W-10—22 gals. (161 lbs.) | 7.2 | 59 | 238 |
| N —26 gals. (260 lbs.) | 11.2 | 36 | 241 |
| Check | 17.4 | — | 242 |

Planted December 2, 1946, and harvested February 20, 1947

weighed for yield, and determined as to wireworm injured tubers. The results are summarized in Table 2.

The ethylene dibromide *W-10*, gave the best control, 58 percent. The other mixtures were less efficient. The check samples yielded more than the treatments, but the differences are attributed to chance occurrence.

Another comparison involving the *Dow-fumes W-10* and *N* fumigants with untreated (check) soil were also obtained from other treatment strips in the same field. The applications were made by the same method, on the same day as above stated. A summarization of the results is presented in Table 3.

agent, broadcast and then disked in, (3) mixed with fertilizer and applied in bands at the side of the rows at planting time, and (4) the wettable material of each insecticide was dusted on the cut potatoes before they were planted. The soil fumigants *D-D* and *W-10* were also included in the experiment for further comparisons. The results are presented in Table 4.

The fewest wireworm injuries were found on tubers grown in soil that had been treated with HCH broadcast, applied at three pounds of the gamma-isomer per acre, but the yield was also reduced. The fumigants each gave 63 percent control, without significant yield differences as compared with the check. The seed piece treatment

TABLE 4—EXPERIMENTS AT BURRICHTER'S LISTING TREATMENT, MATERIALS, AMOUNTS USED PER ACRE, AVERAGE PERCENTAGE OF TUBERS INJURED BY WIREWORMS, PERCENTAGE OF CONTROL, AND YIELD IN BUSHELS PER ACRE

| Treatment material | Amt. used Lbs./Acre | Avg. % | | Yield bu. per acre |
|--|------------------------|------------------------------------|-----------------------|-----------------------|
| | | wireworm Injured tubers | Percentage control | |
| DDT—Wettable, 50%, b'cast, disked in ¹ | 50 | 10.8 | 15 | 213 |
| DDT—Dust, 50%, b'cast, disked in ² | 50 | 10.9 | 13 | 208 |
| DDT—Wettable, 50%, with fertilizer ¹ | 138 | 7.8 | 37 | 201 |
| DDT—Wettable, 50%, seed piece treatment ¹ | 30 | 5.9 | 44 | 138 |
| HCH—Wettable, 6% gamma-isomer, b'cast, disked in ¹ | 30 (1.8)* | 6.0 | 51 | 222 |
| HCH—Dust, 1% gamma-isomer, b'cast, disked in ³ | 300 (3.0)* | 3.0 | 76 | 124 |
| HCH—Wettable, 6% gamma-isomer, with fertilizer ¹ | 139 (8.3)* | 6.6 | 46 | 212 |
| HCH—Wettable, 6% gamma-isomer, seed piece treatment ¹ | 29 (1.7)* | Nearly all tubers failed to sprout | | |
| W-10 ⁴ | 32 gals. | 4.6 | 63 | 234 |
| D-D ⁵ | 25 gals. (254 lbs.) | 4.6 | 63 | 253 |
| Check | — | 12.3 | — | 253 |

(* Lbs. gamma-isomer per acre.)

Wireworm population sampled (25 cores, each 0.53 sq. ft. area) October 28, 1946, was 1.02 wireworms per sq. ft. Treatments made October 8, 1946, and tubers planted November 19, 1946.

¹ Obtained from California Spray Chemical Company

² Obtained from Pennsylvania Salt Company

³ Obtained from Commercial Solvents Corporation

⁴ Obtained from Dow Chemical Company

⁵ Obtained from Shell Agricultural Chemicals.

with HCH was fatal to nearly every seed piece treated.

Results of an experiment involving about 10 acres, in cooperation with Farsouth Growers Cooperative Association, are presented next. Different amounts of DDT and HCH were added to the fertilizer. The insecticide-fertilizer combinations were applied at planting time, in bands 2 inches wide, 2 inches at each side and 1 inch below the seed pieces. The planting was made December 2 and 3, 1946, with the Sabago variety. A summary of the data is given in Table 5.

now be recommended. If improved manufacturing processes can eliminate the taste contaminant, it may be found suitable for wireworm control.

Real reductions of wireworm injuries resulted from the use of the fumigants but more nearly perfect control had been expected from these materials. It is likely that improvements in the preparation of the soil or in the application methods may be found more effective in the marl soils. Some consideration from different viewpoints may provide more understanding and improvement of the methods of application.

TABLE 5—FERTILIZER-INSECTICIDES COMBINATION, WIREWORM CONTROL AND YIELDS

| Material and amount applied/acre | % injured tubers | Percentage control | Yield bu. per acre |
|----------------------------------|------------------|--------------------|--------------------|
| DDT - 50% W. @ 17.6 lbs. | 43 | -- 2 | 134 |
| DDT - 50% W. @ 35.2 lbs. | 49 | -- 17 | 129 |
| DDT - 50% W. @ 70.4 lbs. | 37 | 12 | 128 |
| HCH - 50% W. @ 17.6 lbs. (0.88)* | 24 | 43 | 135 |
| HCH - 50% W. @ 35.2 lbs. (1.76)* | 20 | 52 | 131 |
| HCH - 50% W. @ 70.4 lbs. (3.52)* | 21 | 50 | 127 |
| Check, fertilizer only | 42 | — | 132 |

* Pounds of gamma-isomer per acre.

Insecticides furnished by E. I. duPont de Nemours and Company.

Planted December 2 and 3, 1946, and harvested March 8, 1947.

Benzene hexachloride gave some wireworm control at all three dosages tried; DDT may be said to have given no control. The yields differed but little among the treatments.

DISCUSSION OF RESULTS

Wireworm control was obtained from treatments of benzene hexachloride and of the three fumigants. One pound of the gamma-benzene hexachloride per acre appears to have been practically as effective as more than one pound. Unfortunately, there was a taste contamination of the tubers from the use of this material, and more definite taste where heavier dosages were applied per acre, so that it cannot

The grower considers his soil tilth and conditions for a good seedbed before the tubers are planted. Cover crops are one need of the soil and may consist of tall sesbania, heavy grass sod, rank ragweed growth, a dense covering of velvet beans, or combinations of all. Growers who wish to use the fumigants may have to change some cultural practice to obtain maximum results from the fumigants.

From the viewpoint of effective gas fumigation thorough permeation of all of the soil by the fumigant is a definite requirement. This may necessitate breaking up the sod, lumps of soil, and the plant constituents of the cover crops as if the seedbed were in preparation. It means that the seedbed so

prepared would be fumigated and left undisturbed for two weeks. After the period allowed for fumigation, the soil would need to be disked or harrowed to eliminate the weeds before the seed are planted, although the fumigant would inhibit some plant growth. Lange¹ reports that factors such as: "... soil temperature, soil type, soil texture, absorption, composition, compactness, and soil moisture, amount of fumigant used, correlation of time of treatment with the known behavior of the organism to be killed, the type of seal used following treatment and other factors" influence the effectiveness of treatments. The type, texture, composition, and compactness of the soil and the disposition of the cover crops are suspected as factors that need to be studied with regard to effective fumigation of the marl soils of South Florida.

¹ LANGE, W. HARRY. New development in soil insecticides. *Agr. Chem.* 2 (2): 20-23. 68-71. 1947.

The stronger dosage concentrations of DDT applied during the month of May provided measures of wireworm control. Those applications made just before or at the time the tubers were planted were comparatively ineffective. For marl soils, indications are that (1) heavier dosages such as 70 pounds of 50% DDT are required, and (2) it is slow acting, requiring weeks or even months to effect control.

SUMMARY

Partial control of wireworms was obtained by spraying soil with DDT about 6 months before planting potatoes, by treating soil with benzene hexachloride or by adding the chemical to the fertilizer and by fumigating with dichloropropane-dichloropropylene, or ethylene dibromide. The more promising results were obtained with the fumigants and benzene hexachloride.

THE USE OF SOME ORGANIC INSECTICIDES IN THE CONTROL OF EARWORMS ATTACKING SWEET CORN

E. G. KELSHEIMER

*Florida Agricultural Experiment Station
Vegetable Crops Laboratory
Bradenton*

Ever since the oil + pyrethrum ear treatment has been in use for the control of earworms in sweetcorn, work has been in progress to find an easier but equally effective means of control. This paper discusses some of the newer organic insecticides and their possible use as controls for the earworms.

FIRST TEST

In the fall of 1946, 2 ear treatments, a 3 percent DDT dust and an oil + 0.2 percent pyrethrum injection were compared in

a 2 acres block of Ioana sweetcorn. The dust plots received 4 applications directly to the silk, the first when the silks were well out and before pollination had taken place, and the others at 3 day intervals. The oil series received only 1 treatment when silks had wilted. There was a very heavy infestation of the fall armyworm, *Laphygma frugiperda* (A. & S.) amounting to 95 percent of the total worm population. The remaining 5 percent were the corn earworm, *Heliothis armigera* (Hbn.). This is not the usual proportion of species, but both of these worms commonly attack corn in Florida.

The entire field was dusted 1 time for budworm, using 3 percent DDT distributed with a crank duster when the corn was 12