TABLE 2.—Weight in grams of clean wheat seed from one-yard square samples per replicate harvested on September 4, 1962, Kersley, B.C.

| Treatment | Replicate | | | | Total | Average per yd.² | % Increase over check |
|---|---|---|---|---|---|---|---|
| DDT | | | | | | | |
| Sample 1 | 54 | 54 | 62 | 87 | | | |
| " 2 | 20 | 72 | 64 | 80 | 493 | 61.6 | 78.6 |
| Check | | | | | | | |
| Sample 1 | 28 | 20 | 50 | 31 | | | |
| " 2 | 44 | 27 | 42 | 34 | 276 | 34.6 | |

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# INHERENT TOLERANCE IN LARVAE OF THE ROOT WEEVILS *Sciopithes obscurus* HORN AND *Nemocestes incomptus* (HORN) TO COMMON SOIL INSECTICIDES[1]

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The strawberry root weevil, *Brachyrhinus ovatus* (L.) and the black vine weevil, *B. sulcatus* (F.), are controlled in strawberry plantings by the soil insecticides heptachlor, aldrin, dieldrin, or chlordane (Eide, 1955; Cram and Andison, 1958). But the indigenous root weevils *Sciopithes obscurus* Horn and three species of the genus *Nemocestes,* which were previously not of economic importance, seriously damaged commercial strawberry plantings in 1954 in soil treated with heptachlor or aldrin at 5 lb, dieldrin at 3 lb, or chlordane at 10 lb of toxicant per 6-inch acre. *S. obscurus* adults were abundant in plantings in soil treated with heptachlor at 5 lb, and *N. incomptus* (Horn) in soil treated with aldrin at 5 lb. In a field treated with heptachlor, larvae of *S. obscurus* caused such extensive damage before the first picking season that the planting was ploughed under. Attacks by *N. incomptus, N.* prob. *montanus* Van Dyke and an unnamed species of *Nemocestes* were not so rapid, and severe damage did not usually occur until the second or third season.

This is a report of experiments in the greenhouse and field with soil insecticides for control of larvae of *S. obscurus,* and in the greenhouse alone for larvae of *N. incomptus.*

## Methods

*Greenhouse Tests*—Coarse, sandy loam (pH 6.0, 10.1% organic matter) was passed through a 4-mesh screen, measured into a box of 0.5 cu ft, then spread 0.5 inch deep on paper. Each insecticide was applied evenly on the soil at a rate equivalent to broadcasting and mixing dust in the top 6 inches of soil in the field. The treated soil was mixed uniformly, then used to pot 9 runner strawberry plants, each in a 6-inch clay pot. When two insecticides were combined one was mixed with the soil first before the other was applied. The materials are detailed in Table 1.

Larvae were obtained from eggs laid by adults collected at night by

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TABLE 1—Larvae of **S. obscurus** and **N. incomptus** recovered 3 to 4 months after first instar larvae were placed on the soil of pots containing strawberry plants in soil treated with insecticide dusts.

| Dusts | Toxicant per 6-inch acre, lb. | Larvae per plant[1] S. obscurus | N. incomptus |
|---|---|---|---|
| **1956—25 larvae per pot** | | | |
| Aldrin 2½% | 5 | 19.3 ab | 17.0 a |
| " | 10 | 17.3 ab | 15.0 a |
| Dieldrin 2% | 5 | 21.7 a | 17.0 a |
| " | 10 | 17.0 abc | 18.7 a |
| Heptachlor 2½% | 5 | 12.7 cd | 14.7 a |
| " | 10 | 11.7 cd | 17.0 a |
| DDT 5% | 5 | 18.3 ab | 18.3 a |
| " | 10 | 8.7 d | 16.0 a |
| Untreated | — | 19.0 ab | 16.3 a |
| **1957—50 larvae per pot** | | | |
| Diazinon 5% | 5 | 20.3 a | not tested |
| Malathion 4% | 5 | 16.7 ab | not tested |
| Toxaphene 5% | 10 | 18.7 ab | 26.7 a |
| Endrin 1% | 1 | 16.7 ab | 17.0 a |
| " | 2 | 18.0 ab | 29.0 a |
| Lindane 0.5% | 0.5 | 14.3 ab | 23.0 a |
| " | 1 | 6.7 b | 19.0 a |
| Untreated | — | 12.3 ab | 17.7 a |
| **1957—50 larvae per pot** | | | |
| Lindane 0.5% | 1 | 18.7 ab | |
| " | 1 | 12.0 b | |
| +heptachlor 2½% | 5 | | |
| Lindane 0.5% | 1 | 12.7 b | |
| +aldrin 2½% | 5 | | |
| Untreated | — | 36.7 a | |

[1] Means of 3 replicates. Values followed by the same letter are not significantly different at p=.05 (Duncan, 1955).

sweeping the tops of strawberry plants with a net. *S. obscurus* were collected in late June and July, and *N. incomptus* in October, March and April. Wide mouthed jars with screen lids, each containing 200 adults were kept in a rearing cabinet at 70° F and 75 to 85% relative humidity. The adults were fed fresh strawberry foliage twice weekly. Both species deposited their eggs in rows at the edges of the leaves, then folded the edges over and cemented them down. Eggs were laid in the same manner on tissue paper. They were trimmed from the foliage and paper twice weekly and kept in open jars in the cabinet where they hatched in 13 days. Newly emerged larvae cannot climb glass, so that fresh larvae could be obtained daily by merely covering the jars with 14x18-mesh screen, inverting the jars, and shaking them over paper. The unhatched eggs remained in the trimmings. Larvae were used in batches of 25 in 1956, and 50 in 1957. Unlike those of *B. sulcatus*, these larvae do not harm each other when confined in large numbers. The larvae were placed on the previously loosened soil in each of three pots per treatment.

In 1956, *S. obscurus* larvae were introduced 22 days and *N. incomptus* 49 days after the soil was treated. In 1957, *S. obscurus* larvae were introduced 64 days and *N. incomptus* 348 days after the soil was treated. In 1957 with insecticides in combination using *S. obscurus*, the larvae were introduced 15 days after the soil was treated. After 3 to 4 months, when the larvae were large enough to be found easily in the soil, the pots were emptied and the surviving larvae counted.

*Field Test*—In a planting of var. British Sovereign strawberry plants on the same soil used for the green-

house pot tests, the soil was treated to test methods of applying insecticides for control of *Brachyrhinus* spp. The single-row plots, each 48 feet long, were 3 feet apart and replicated in 4 blocks. Before planting in April, 1956, dusts, sprays, or granules were applied to the soil, either alone in 10-inch bands, or combined with an application to the roots. These treatments are detailed in Table 2. The soil insecticides were mixed in the top 6 inches of soil with a 15-inch rotovator. From September 10 to 12, 1956, 50 newly-emerged *S. obscurus* larvae were placed on the soil around the crown of the first plant of each plot, and from September 26 to October 24, around the second plant of each plot. The larvae moved into the soil immediately. From May to July of the following year the plants were dug, and the soil was sifted in a 12-inch circle around the plant to a depth of 6 inches using a mechanical sifter (Cram, 1964). The larvae were counted. Earlier tests had shown that at this time of year nearly all the larvae are found in a sample of this size.

The insecticides were obtained as follows: aldrin, dieldrin, and endrin from Shell Chemical Co., Vancouver, B.C.; heptachlor from Velsicol Corp., Chicago, Ill.; toxaphene from Stauffer Chemical Co., Portland, Ore.; DDT from Buckerfield's Ltd., Vancouver, B.C.; lindane from Commercial Chemicals, Vancouver, B.C.; malathion from American Cyanamid, New York, N.Y.; and diazinon from Geigy Agricultural Chemicals, New York, N.Y.

## Results and Discussion

*Greenhouse Tests* — None of the insecticides tested in 1956 gave adequate control (Table 1). The fewest larvae of *S. obscurus* were recovered from soil treated with DDT or heptachlor at 10 lb per acre, but the reduction was not adequate since 37 and 47%, respectively, survived. The toxicity to *B. sulcatus* of these materials was verified when larvae failed to survive in any of the treated soils, but in the untreated soil 29% survived. This is a high average survival rate for the species. An exception was DDT, which does not affect larvae of *B. sulcatus* even at 10 lb per 6-inch acre (unpublished data).

In 1957, none of the insecticides adequately reduced the survival of larvae below that of the untreated soil for either species (Table 1). With *S. obscurus,* lindane at 1 lb per acre was significantly better than diazinon at 5 pounds, but the reduction was inadequate. Larvae of *N. incomptus* were not affected by any of the treatments (Table 1), and with a single exception the lowest survival of larvae was in the untreated soil. Some biological control factor may have been more active here in untreated than in treated soil.

Earlier field observations indicated that strawberries on soil treated with lindane at 1 lb of toxicant per 6-inch acre were not attacked by *N. incomptus.* Since introduced larvae in pot tests were not affected it may be that the flightless adults are repelled from, or inhibited from ovipositing on, strawberries in soil treated with lindane. Aldrin or heptachlor at 5 lb combined with lindane at 1 lb per acre significantly reduced the numbers of *S. obscurus* larvae (Table 1), but still 34% survived.

*Field Tests* — Significantly fewer larvae of *S. obscurus* were recovered from the first plant of untreated rows than from many of the treated rows (Table 2). *S. obscurus* appeared to survive better in treated soil (33% average survival) than in untreated soil (13%). There were no significant differences between treatments of the second plant in each row, which was infested later. In 1957 a natural population of *B. sulcatus* infested the untreated but not the treated rows.

TABLE 2—Larvae of **S. obscurus** recovered in 1957, 8 months after 50 first instar larvae per plant were placed on the soil around strawberry plants in field plots treated with soil insecticides.

| Soil[1] and/or root[2] treatments | Number of larvae[3] First plant | Second plant |
|---|---|---|
| Heptachlor EC+root | 25.0 a | 15.8 a |
| " 2½% gran | 22.5 ab | 13.8 a |
| Dieldrin EC | 20.8 abc | 14.2 a |
| " EC+root[4] | 20.2 abcd | 17.0 a |
| Heptachlor EC | 19.8 abcd | 14.2 a |
| Aldrin 2½% D+root | 18.8 abcd | 11.2 a |
| " 2½% D | 16.8 abcd | 22.5 a |
| Heptachlor 2½% G+root | 16.5 abcd | 8.5 a |
| Dieldrin 2% G | 16.0 abcd | 14.8 a |
| " 2% G+root | 14.5 bcde | 19.2 a |
| Heptachlor root only | 14.5 bcde | 11.5 a |
| " 2½% D | 12.8 bcde | 18.8 a |
| Aldrin root only | 11.0 cde | 10.2 a |
| Heptachlor 2½% D+root | 10.8 de | 16.0 a |
| Untreated | 5.0 e | 8.0 a |

1 Dusts, sprays, and granules were applied to the soil in a 10-inch band to rows 3 ft. apart at 1.4 lb toxicant per acre for all treatments except heptachlor granules at 2.1 lb and rotovated to a depth of 6 inches.

2 Roots treated with 5 lb or appropriate dust per 10,000 plants.

3 Means of 4 replicates. Means followed by the same letter are not significantly different at p=.05 (Duncan, 1955).

4 Dieldrin 2% dust.

There were no apparent phytotoxic symptoms from the insecticides tested in the greenhouse or field. The plants infested with larvae of either *S. obscurus* or *N. incomptus* were severely damaged.

## Summary

The root weevils *Sciopithes obscurus* Horn and *Nemocestes incomptus* (Horn) are indigenous to the Pacific Northwest. Both are serious pests of strawberries but cannot be controlled with organochlorine soil insecticides at ordinary dosages on southern Vancouver Island or in the lower Fraser Valley. In commercial fields, populations were not reduced by treatment with aldrin or heptachlor at 5 lb, dieldrin at 3 lb, or chlordane at 10 lb of toxicant per 6-inch acre. In potted soil treated with insecticide dusts and artificially infested, first instar larvae survived treatment with heptachlor, aldrin, dieldrin, or DDT each at 5 or 10 lb toxicant per 6-inch acre, toxaphene at 10 lb, endrin at 1 or 2 lb, or lindane at 0.5 or 1 lb. *S. obscurus* survived in soil treated with the organophosphates diazinon or malathion at 5 lb, but a combination of 1 lb of lindane with aldrin or heptachlor at 5 lb reduced the numbers of larvae by 66%.

When introduced into field plots, from 2 to 5 times more larvae of *S. obscurus* were recovered in the treated than in the control plots where the treatments were: 1.4 lb toxicant per 6-inch acre of aldrin or heptachlor dust, dieldrin or heptachlor spray, or dieldrin granules. These were applied either alone in a 10-inch band to rows 3 ft apart, or combined with 5 lb of appropriate dust per 10,000 plants. Heptachlor granules at 2.1 lb were ineffective.

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