LOW PRESSURE SOIL APPLICATION OF CARBARYL FOR CONTROL OF THE PECAN WEEVIL, CURCULIO CARYAE1,2

J. A. Payne,3 J. D. Dutcher,4 and H C Ellis5

Abstract: In 4 yr (1978-1981), pecan, Carya illinoensis (Wangenheim) K. Koch plots treated with five foliar application of carbaryl at 2.7 kg AI/ha on a 7- to 10-d application schedule had significantly less pecan weevil, Curculio caryae (Horn), damage (infested pecans) than plots treated with 8 - 9 soil applications of carbaryl. In 1979, when the pecan weevil infestation in untreated plots was relatively high (60.7%), there was only 7.4% reduction in pecan weevil infested nuts in the plots receiving soil applied carbaryl. However, with moderate weevil pressure (23.3%), as in 1978, there was a 74.7% reduction in infested nuts in plots receiving soil applied carbaryl.

Key Words: Curculio caryae, carbamate, pest suppression, insecticide, pecan pest management, nut pest, Carya illinoensis.

The pecan weevil, Curculio caryae (Horn), spends 2 or sometimes 3 yr in the soil in larval, pupal, and adult stages. There are three times in the life cycle during which it is potentially vulnerable to chemical control: as a free-living adult in the foliage and during its burrowing into (larva) and out of (adult) the soil. These facts suggest treatment of the soil with insecticides as a means of control.

In previous reports of field tests, several materials applied to the soil were not effective (Hinrichs 1951; Nickels 1952; Tedders and Osburn 1971; Neel et al. 1976 and 1979; Payne et al. 1974 and 1975; Polles et al. 1972 and 1973). Of the various materials evaluated, only carbofuran, EDB, and DBCP seemed worthy of further consideration; however, even these compounds have shown limited efficacy (Polles et al. 1973; Payne et al. 1975). Pollet and Aitken (1978) reported that ground application of carbaryl compared favorably with foliar application of carbaryl, the standard treatment, in providing pecan weevil control. Although our earlier attempts with soil applied carbaryl were not as promising (Payne et al. 1974), we decided to further pursue this avenue for control, especially since repeated foliar applications of carbaryl have caused aphid and mite resurgences in managed pecan orchards in Georgia (Dutcher and Payne 1983).

MATERIALS AND METHODS

This study was conducted 4 yr (1978 - 1981) in a 8.9 ha (264 tree) non-irrigated, pecan Carya illinoensis (Wangenheim) K. Koch, orchard with a known infestation of pecan weevil located at the Southeastern Fruit and Tree Nut Research Laboratory. The orchard was located in the Coastal Plain of Georgia, where pecan weevil is a serious pest. The pecan weevil, Curculio caryae (Horn), spends 2 or sometimes 3 yr in the soil in larval, pupal, and adult stages. There are three times in the life cycle during which it is potentially vulnerable to chemical control: as a free-living adult in the foliage and during its burrowing into (larva) and out of (adult) the soil. These facts suggest treatment of the soil with insecticides as a means of control.

In previous reports of field tests, several materials applied to the soil were not effective (Hinrichs 1951; Nickels 1952; Tedders and Osburn 1971; Neel et al. 1976 and 1979; Payne et al. 1974 and 1975; Polles et al. 1972 and 1973). Of the various materials evaluated, only carbofuran, EDB, and DBCP seemed worthy of further consideration; however, even these compounds have shown limited efficacy (Polles et al. 1973; Payne et al. 1975). Pollet and Aitken (1978) reported that ground application of carbaryl compared favorably with foliar application of carbaryl, the standard treatment, in providing pecan weevil control. Although our earlier attempts with soil applied carbaryl were not as promising (Payne et al. 1974), we decided to further pursue this avenue for control, especially since repeated foliar applications of carbaryl have caused aphid and mite resurgences in managed pecan orchards in Georgia (Dutcher and Payne 1983).

MATERIALS AND METHODS

This study was conducted 4 yr (1978 - 1981) in a 8.9 ha (264 tree) non-irrigated, pecan Carya illinoensis (Wangenheim) K. Koch, orchard with a known infestation of pecan weevil located at the Southeastern Fruit and Tree Nut Research Laboratory. The orchard was located in the Coastal Plain of Georgia, where pecan weevil is a serious pest. The pecan weevil, Curculio caryae (Horn), spends 2 or sometimes 3 yr in the soil in larval, pupal, and adult stages. There are three times in the life cycle during which it is potentially vulnerable to chemical control: as a free-living adult in the foliage and during its burrowing into (larva) and out of (adult) the soil. These facts suggest treatment of the soil with insecticides as a means of control.

In previous reports of field tests, several materials applied to the soil were not effective (Hinrichs 1951; Nickels 1952; Tedders and Osburn 1971; Neel et al. 1976 and 1979; Payne et al. 1974 and 1975; Polles et al. 1972 and 1973). Of the various materials evaluated, only carbofuran, EDB, and DBCP seemed worthy of further consideration; however, even these compounds have shown limited efficacy (Polles et al. 1973; Payne et al. 1975). Pollet and Aitken (1978) reported that ground application of carbaryl compared favorably with foliar application of carbaryl, the standard treatment, in providing pecan weevil control. Although our earlier attempts with soil applied carbaryl were not as promising (Payne et al. 1974), we decided to further pursue this avenue for control, especially since repeated foliar applications of carbaryl have caused aphid and mite resurgences in managed pecan orchards in Georgia (Dutcher and Payne 1983).

MATERIALS AND METHODS

This study was conducted 4 yr (1978 - 1981) in a 8.9 ha (264 tree) non-irrigated, pecan Carya illinoensis (Wangenheim) K. Koch, orchard with a known infestation of pecan weevil located at the Southeastern Fruit and Tree Nut Research Laboratory. The orchard was located in the Coastal Plain of Georgia, where pecan weevil is a serious pest. The pecan weevil, Curculio caryae (Horn), spends 2 or sometimes 3 yr in the soil in larval, pupal, and adult stages. There are three times in the life cycle during which it is potentially vulnerable to chemical control: as a free-living adult in the foliage and during its burrowing into (larva) and out of (adult) the soil. These facts suggest treatment of the soil with insecticides as a means of control.

In previous reports of field tests, several materials applied to the soil were not effective (Hinrichs 1951; Nickels 1952; Tedders and Osburn 1971; Neel et al. 1976 and 1979; Payne et al. 1974 and 1975; Polles et al. 1972 and 1973). Of the various materials evaluated, only carbofuran, EDB, and DBCP seemed worthy of further consideration; however, even these compounds have shown limited efficacy (Polles et al. 1973; Payne et al. 1975). Pollet and Aitken (1978) reported that ground application of carbaryl compared favorably with foliar application of carbaryl, the standard treatment, in providing pecan weevil control. Although our earlier attempts with soil applied carbaryl were not as promising (Payne et al. 1974), we decided to further pursue this avenue for control, especially since repeated foliar applications of carbaryl have caused aphid and mite resurgences in managed pecan orchards in Georgia (Dutcher and Payne 1983).
Laboratory, Byron, GA. The pecan weevil infestation was assumed to be uniform throughout the plot since insect control was not exercised for 5 yr prior to the experiment. The planting consisted predominately of 'Stuart' and 'Schley' trees which were approximately 50 yr old. Tree spacing was 18.3 x 18.3 m. The soil type was a Faceville sandy loam. Georgia Cooperative Extension Service recommendations (Livingston and Bruce 1979) were followed for fertilization, weed control, and other cultural practices within the orchard.

The 8.9 ha orchard was divided into three plots: soil carbaryl, foliar carbaryl, and untreated. The carbaryl soil treatment plot was 12 tree rows wide and contained 144 trees (4.9 ha). The large size of the plot was needed to eliminate or reduce inter-tree movement of pecan weevils from the adjacent foliar treated and untreated plots. The untreated (control) plot (1.6 ha, 48 trees) was adjacent to, but not randomized, within the soil carbaryl plot. The foliar carbaryl plot (2.4 ha, 72 trees) was also adjacent to, but not randomized, within the soil treatment plot. Each year the large treatment plots were relocated in the 8.9 ha orchard.

Carbaryl (Seven 80S) was applied at the Georgia recommended rate of 2.7 kg AI/ha in 1172 liters of water (Ellis and Arnett 1978) as both a foliar and soil application for pecan weevil control. Soil application was accomplished by a John Bean® low-pressure (3.5 kg/cm²) horizontal boom applicator delivering 45.4 liters of finished spray per tree and uniformly covering the entire area beneath the tree canopy and 3 m beyond the dripline. Foliar treatments were applied with a John Bean airblast sprayer equipped with a pecan volute delivering 45.4 liters of finished spray per tree. Application dates were determined by pecan weevil emergence monitored with cone emergence traps (Polles and Payne 1972); each cone cage covered 0.66 m² of soil surface. Weevil emergence was monitored in an untreated pecan orchard outside and 600 m from the experimental plot since the treatments may have altered adult emergence. Soil surface application was initiated when weevils were first detected and repeated at 7-d intervals until weevils were no longer present (Fig. 1). Application dates were 3 August-21 September in 1978, 31 July-18 September in 1979, 19 August-15 October in 1980, and 4 August-22 September in 1981. Foliar application was initiated at the pecan shell hardening stage (about 10-15 August) and repeated at 7- to 10-d intervals until adult weevils were not longer present. Application dates were 14 August-19 September in 1978, 17 August-25 September in 1979, 26 August-3 October in 1980, and 11 August-18 September in 1981.

Pecan samples of 100 nuts were collected from each tree at shuck dehiscence or harvest (12 November-17 November) in the 8.9 ha orchard in 1978, 1980, and 1981 to evaluate control. In 1979, the yield was too low for individual tree samples, and 293 to 989 nuts were harvested from each row of trees. All pecans were cracked and examined by hand for pecan weevil infestation or injury. The proportion, X, of infested and injured pecans was calculated and transformed to arcsine (√X) before analysis so that the data would better approximate a normal distribution (Zar 1974). Since plot sizes were variable between treatments and years, all data were analyzed by the general linear models procedure of the statistical analysis system (Helwig and Council 1979). The experimental unit for 1979 was the row of trees with row size varying from six to twelve trees. In the other 3 yr each tree was an experimental unit. The differences between treatment means over all 4 yr and between certain treatments in each yr were tested by the
Fig. 1. Emergence of adult pecan weevils from the soil at the USDA, Southeastern Fruit and Tree Nut Research Laboratory, Byron, GA, from 1978 - 1981. Total pecan weevil catch for the 1978, 1979, 1980, and 1981 seasons were 2800, 2434, 2449, and 1235 weevils, respectively, per 350 cone emergence traps.

\[ F \text{ test of the GLM procedure and by calculating the least significant differences for each mean comparison at the } P < 0.05 \text{ level.} \]

**RESULTS AND DISCUSSION**

In all 4 yr, the plots treated with 5 foliar applications of carbaryl had the least pecan weevil damage (infested pecans) (Table 1). The pecan weevil infestation in all 4 yr was highest in the untreated plots. There was only a 33% reduction over all 4 yr in percent weevil infested nuts in the plots receiving soil applied carbaryl, whereas foliar application of carbaryl caused a 98% reduction in pecan weevil infestation over all 4 yr. Even though biological constraints on the experimental design did not allow all treatment comparisons, the results clearly indicate that soil application of carbaryl has limited efficacy against the pecan weevil. Pecan weevil infestations in plots treated with soil application of carbaryl were only lower than the untreated check in 2 of 4 yr. This poor control cannot be explained unless pecan weevils moved into the canopies from untreated trees or failed to contact carbaryl when emerging through treated soil. Neel et al. (1979, 1981) also reported poor control of pecan weevil in Mississippi with ground application of carbaryl even when it is applied at 3 to 4 times the foliar rate. Gorsuch and Aitken (1980) have reported achieving control of pecan weevil with ground application of carbaryl comparable to carbaryl foliar treatments; however, weevil damage was very low in their untreated plots.

When foliar application of carbaryl for pecan weevil control is not feasible due to lack of proper equipment, poorly accessible tree location, or other factors such as small acreage production that does not justify the purchase of expensive foliar spray equipment, soil application of carbaryl may be used to provide some suppression of adult pecan weevil populations. However, soil surface application is not an alternative to foliar application under high weevil populations. With current
knowledge of pecan weevil movement, even effective soil treatments may have to be supplemented with foliar sprays to protect the nuts from weevils moving into trees from untreated orchards, especially in years of light nut crops (Boethel and Eikenbary 1979; Harris 1983).

Table 1. Effect of foliar and soil applied carbaryl (Seven 80S) on pecan weevil, Byron, GA, 1978 - 1981.

<table>
<thead>
<tr>
<th>Year</th>
<th>Soil surface application</th>
<th>Untreated check</th>
<th>Foliar application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>5.9 b‡</td>
<td>23.3 a</td>
<td>0.0 c</td>
</tr>
<tr>
<td>1979</td>
<td>56.2 a</td>
<td>60.7 a</td>
<td>1.0</td>
</tr>
<tr>
<td>1980</td>
<td>15.5 b</td>
<td>29.5 a</td>
<td>1.3 c</td>
</tr>
<tr>
<td>1981</td>
<td>6.2 a</td>
<td>11.7 a</td>
<td>0.1 b</td>
</tr>
<tr>
<td>1978 - 1981</td>
<td>21.0 b</td>
<td>31.3 a</td>
<td>0.6 c</td>
</tr>
</tbody>
</table>

* Eight applications (0.11 kg AI carbaryl/tree) in 1978, 1979, and 1981; nine applications in 1980.
‡ Five applications (0.11 kg AI carbaryl/tree).
§ Means in the same row (year) followed by the same letter are not significantly different at the P < 0.05 level (LSD test). A single row of trees was sampled in the ‘foliar application’ treatment in 1979 resulting in a single measure of response, therefore only the ‘soil surface application’ and the ‘untreated check’ treatment means were compared statistically.

ACKNOWLEDGMENT

We thank Kaine Bondari, The University of Georgia College of Agriculture, Coastal Plain Experiment Station, Computer Center, Tifton, GA, for assistance with the statistical analysis.

REFERENCES CITED


