EVALUATION OF DIP TREATMENTS TO DESTROY *DIAPREPES ABBREVIATUS* ON CITRUS NURSERY TREES[1]

WILLIAM A. SIMANTON AND ROBERT C. BULLOCK

Agricultural Research and Education Center,
Lake Alfred, Fla. 33850, and Agricultural Research Center,
Ft. Pierce, Fla. 33450, respectively

ABSTRACT

Of 67 treatments evaluated as root-dip larvacides for citrus nursery trees only 25 produced more than 50% mortality of larvae of *Diaprepes abbreviatus* L. None were considered sufficiently effective and safe for practical use.

Of 21 treatments tested as foliage-dip ovicides on potted citrus trees, 11 demonstrated slight ovicidal action but none were promising for practical use. Because eradication efforts restricted the supply of satisfactory test insects, only limited tests were possible. Vigorous washing and careful inspection of nursery stock have helped contain the infestation which continues to be a threat to Florida citrus in 1973.

In September 1968, several citrus groves and nurseries in the Apopka, Florida area were found to be infested with a large curculionid, *Diaprepes abbreviatus* L. The weevil apparently had been introduced accidentally several years earlier from the West Indies where it is a pest of sugarcane, citrus, and other plants.

Because of the potential of the weevil as an important pest of citrus, a program was started to prevent its spread from the several hundred infested acres, and hopefully to eradicate it. This program is a joint effort of the Florida Department of Agriculture and the U. S. Department of Agriculture. University of Florida entomologists have assisted in research to develop control methods appropriate to the Florida situation.

At the start of the eradication effort late in 1968, nothing was known of the life history of the species under Florida conditions, and only limited control data obtained by Wolcott (1954) in Puerto Rico was available. Bullock (1971) investigated foliar sprays for control of adults on Florida citrus. Information on the life history, description, and importance of *D. abbreviatus*, largely from West Indian sources, has been summarized by Woodruff (1964, 1968).

The infested area has many nurseries growing citrus trees for shipment out of the area. Hence, one need of the program was a method of treating nursery trees to assure that they would not harbor viable weevils, eggs, or larvae when shipped. This paper reports a search for satisfactory treatments.

The authors wish to emphasize that the tests reported here were conducted of necessity under very restrictive conditions: 1) All tests were to be performed within the quarantine area. Only an open shed and a trailer were available as laboratories. 2) The only available test insects were field-collected adults and larvae obtained from areas where soils had probably been previously exposed to contamination by one or more persistent pesticides. No method of rearing

[1]Florida Agricultural Experiment Stations Journal Series No. 4847.

this species is known. 3) The tests and methods would have to be compatible with the current policies regarding safety to humans and animals, and as far as possible, without undue burden to the agricultural economy of the area.

Except for the egg stage, the ages of the test insects were not known. To avoid the effects of field contamination on collected larvae as much as possible, the larvae were held for several days prior to use in uncontaminated soil and with uncontaminated citrus seedlings as food. Only larvae that appeared healthy were selected for testing. Although extreme care was taken to avoid contamination of check insects, mortalities as high as 40% were obtained in the check lots for some series of trials. The scarcity of test insects prevented planned replications. However, any treatment that appeared promising in 1 trial was included in a later series where possible.

Despite the shortcomings of the procedures, no better information on nursery stock treatment has been obtained in the ensuing 4 years. Researchers associated with the problem have recommended that results reported here, although largely negative, be recorded in the literature as background for further investigations.

Methods

The selection of methods for evaluation of treatments was determined by the habits and life history of the insect as well as by practical aspects of nursery operation.

Two methods were devised: the first an immersion of roots and larvae to evaluate treatments for destroying any living forms on the roots; and the second an immersion treatment of foliage to evaluate pesticides for destroying any eggs on leaves of potted ornamental citrus plants such as those commonly grown for sale to tourists throughout Florida.

Dipping the tree roots in a tank of pesticidal liquid for washing away the soil and destroying the larvae was quickly abandoned when early trials disclosed that one of the best soil insecticides, aldrin, at high concentration (2 lb active per 100 gal = 2400 ppm) did not kill larvae that had been immersed for 72 hr and then held for 4 days. Subsequently, the following root-dip treatment was used:

1. Materials known or suspected of having larvicidal properties were tested at 2 and 4 times the recommended concentration. In some trials an inert water thickener, Hercules Natrosol (N), was added at 0.062% to increase the quantity of liquid retained by the larvae or roots after dipping.

2. Ten apparently healthy half-grown larvae were placed in a 1-in. (26 mm) square wire mesh cage and immersed with gentle agitation for 30 sec in a pint of the pesticide mixture. On removal, the cage was opened and the larvae emptied into a pint jar containing 1 in. of moist, sterilized soil and a citrus seedling. The jar was then filled with soil, covering the grubs and the root system.

In addition, the bare root system of a citrus seedling was immersed in the test solution for 30 sec and was separately potted with moist, sterilized soil to evaluate possible phytotoxicity.

Check lots of 10 larvae each were immersed for 30 sec in water or in water plus Natrosol. One check was scheduled at the start of a series of treatments, a second check was scheduled at mid-series, and a third check was included at the end of the series.

All tests were conducted in an open shed during mild weather. Treated materials were held in the open shed during the observation period.

3. At the end of 3 and 7 days, contents of the jars were emptied, and larval mortality and root feeding were recorded. Surviving larvae and the seedling were then repotted for a final reading at 14 days. The treated but uninfested seedlings were observed for 14 days or longer for possible phytotoxicity. Kill data were adjusted by Abbott's formula (1925).

The dip tests for foliage were conducted in the following manner:

1. Citrus seedlings were caged with adults for 1 or 2 days until females had deposited about 12 egg masses totalling about 300 eggs on the foliage of each plant.

2. The infested seedlings, growing in cans, were inverted and the foliage dipped in the pesticide mixture for 5 sec, then held 3 days in an air-conditioned laboratory (24° C) until eggs were 5 days old. On the fifth day, the leaves with egg masses were cut off with scissors, placed in covered petri dishes, and held in the laboratory. On the 10th day, when all viable eggs had hatched, a count was made of hatched eggs and living larvae. Infested plants dipped in water at the beginning and end of each series served as checks. Materials that exhibited some ovicidal activity were included in a subsequent series of tests. Lack of healthy adults to provide eggs terminated the foliage-dip trials.

All 21 foliage-dip treatments were mixed at the rate of 4 lb active ingredient per 100 gal water (4800 ppm) except the FC 435 oil which contained 5% oil by volume in the emulsified mixture.

Candidate materials lacking approved common names were:

Akton™ 0-(2-chloro-1-(2,5-dichlorophenyl)vinyl) 0,0-diethyl phosphorothioate

Bayer 37289 0-ethyl 0-2,4,5-trichlorophenyl ethylphosphonothioate

Biotrol™ *Bacillus thuringiensis* Berliner

Dasanit™ 0,0-diethyl 0-p-((methylsulfinyl)phenyl) phosphorothioate

DD 136 Nematodes *Neoaplectana dutkyi* (Jackson). Concentrate contained 51,000 per ml; 33% active

Gardona™ 2-chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate

Landrin 3,4,5-trimethylphenylmethylcarbamate, 75%; 2,3,5-trimethylphenylmethylcarbamate, 18%

Mocap™ 0-ethyl S,S-dipropyl phosphorodithioate

Monitor™ 0,S-dimethyl phosphoramidothioate

Nemacur™ ethyl 4-(methylthio)-m-tolyl isopropylphosphoroamidate

Nemagon™ 1,2-dibromo-3-chloropropane

Pyrenone™ preparation of pyrethrins and piperonyl butoxide

Supracide™ S-((2-methoxy-5-oxo-Δ^2-1,3,4-thiadiazolin-4-yl)methyl) 0,0-dimethylphosphorodithioate

TH 427 S-(((1-cyano-1-methyl-ethyl)carbamoyl)methyl) 0,0-diethyl phosphorothioate

Nemacide™ 0-2,4-dichlorophenyl 0,0-diethyl phosphorothioate

Zinophos™ 0,0-diethyl 0-2-pyrazinyl phosphorothioate

Results and Discussion

The root-dip treatments that produced more than 50% kill of larvae within 7 days in at least 1 trial are listed in Table 1. Of 25 treatments involving 17 pesticides, only hot water, which caused tree injury, and Dasanit at the 4 lb rate achieved 100% kill. There were very few high larval mortalities in this

TABLE 1.—ROOT-DIP TREATMENTS CAUSING 50% OR MORE ADJUSTED KILL OF *D. Abbreviatus* LARVAE IN 7 DAYS.

Material	Active/100 Gal	% Kill	
		3 Days	7 Days
Hot water 120°F for 10 min		87	100
Hot water 120°F for 5 min		22	100
Dasanit 6	4 lb	54	100
Dasanit 6	2 lb+N	42	72
Dasanit 6	2 lb	9	67
Mocap 4	2 lb+N	77	86
Mocap 4	2 lb	48	83
Supracide 3.55	4 lb	77	86
naled	2 lb+N	31	86
naled	4 lb	42	72
ethylene dibromide	6 lb+N	54	86
ethylene dibromide	13 lb	31	72
azinphosmethyl	2 lb	0	67
Pyrenone 606	2.3 lb	28	61
coumaphos	4 lb	54	58
carbofuran	4 lb	54	58
carbofuran	2 lb+N	42	58
parathion	4 lb	42	58
T-H 427-I 2E	4 lb	42	58
phoxim	4 lb	20	58
methomyl	2 lb+N	54	44
methomyl	4 lb	52	48
Zinophos	2 lb	35	50
fenthion	4 lb	22	50
propoxur	4 lb	9	50

group and 2 treatments, naled and coumophos, permitted root feeding. Larval mortality at 14 days was not considered to be meaningful because of high mortality in the check insects.

In the following list are 25 root-dip treatments that resulted in adjusted mortality of less than 50% at the concentration (lb active per 100 gal) shown.

phoxim	2.0 lb	disulfoton	4.0 lb
parathion	2.0 lb	chlorpyrifos	4.0 lb
propoxur	2.0 lb	Akton	4.0 lb
naled	2.0 lb	Nemacur	4.0 lb
malathion	2.5 lb	oxydemetonmethyl	4.0 lb
chlordane	2.0 lb	DD 136 Nematodes conc.	Drench
diazinon	4.0 lb	DD 136 Nematodes dilute	Drench
Clorox	4.2 lb	Biotrol 25 WP	Drench
trichlorfon	4.0 lb	Biotrol 25 WP	4.0 lb
aldrin	2.0 lb	dieldrin	4.0 lb
toxaphene	4.0 lb	nicotine sulfate	4.0 lb
carbaryl	4.0 lb	ethylene dibromide	6.5 lb
Bayer 37289	2.0 lb		

The following 17 root-dip treatments not only resulted in mortality under 50% but permitted root feeding in the 14 day post-treatment period. Formaldehyde was the only treatment that injured the test trees and it killed the tree within 14 days. Active ingredient per 100 gal is shown.

rotenone	.2 lb	Pyrenone 606	2.3 lb
lindane	.5 lb	plus Malathion 5E	2.5 lb
methomyl	2.0 lb	dicrotophos	4.0 lb
fenthion	2.0 lb	formetanate	4.0 lb
T-H 427-I 2E	2.0 lb	Nemagon	4.0 lb
coumaphos	2.0 lb	Monitor	4.0 lb
Nemacide	4.0 lb	Landrin	4.0 lb
Pyrenone 606	2.3 lb	dichlorvos	4.0 lb
Pyrenone 606	2.3 lb	formaldehyde	30.0 lb
plus lindane	.5 lb		

Since none of the root-dip treatments appeared promising for practical use from the standpoint of both effectiveness and/or safety, it was recommended that newly dug nursery stock be subjected to high pressure water spray to dislodge the soil and larvae, and that this be followed by supervised visual inspection and handling. Further investigation of root treatments was discontinued because treatments with foliar sprays and soil insecticides applied in the containment program eliminated the possibility of obtaining suitable test insects.

The following 11 materials used in foliage-dip treatments resulted in less than 30% hatch:

FC 435 Oil 99% E	carbofuran	ethylene dibromide
propoxur	Dasanit	lindane
dimethoate	carbaryl	formetanate
diazinon	Nemagon	

The oil emulsion permitted only 7% of the eggs to hatch and was the best treatment. Next best was propoxur which permitted a 9% hatch. While none of the above treatments was adequate, it is possible that combinations with oil might have merit.

The following materials permitted more than 30% of eggs to hatch. The check treatments showed 78 to 92% hatch.

naled	Gardona	Pyrenone 606
trichlorfon	TDE	toxaphene
dichlorvos	malathion	chlordane
		Nemacide

Several workers in Florida and in West Indies locations have continued research on control methods including soil insecticides, sprays for aerial application, and biological control organisms. To date no method has been highly effective in Florida. Application of carbaryl as a foliage spray and of chlordane as a soil treatment combined with careful supervision and much inspection has greatly reduced the initial weevil population and helped to restrict its spread. However, *D. abbreviatus* remains a serious threat to the

Florida citrus industry in 1973. The search for effective larvicides and ovicides reported here illustrates the difficulties in finding means of eradicating, or even of containing, this species.

Literature Cited

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Ent. 18:265-267.

Bullock, R. C. 1971. Effectiveness of foliar sprays for control of *Diaprepes abbreviatus* L. on Florida citrus. Trop. Agr. (Trinidad) 48:2:127-131.

Wolcott, G. N. 1954. Residual effectiveness of insecticides against soil-inhabiting insects. J. Agr. Univ. Puerto Rico 38:2:108-114.

Woodruff, R. E. 1964. A Puerto Rican weevil new to the United States (Coleoptera, Curculionidae). Ent. Circ. 30 Fla. Dep. Agr., Div. Plant Indus.

Woodruff, R. E. 1968. The present status of a West Indian weevil (*Diaprepes abbreviata* (L)) in Florida (Coleoptera: Curculionidae). Ent. Circ. 77 Fla. Dep. Agr., Div. Plant Indus.

The Florida Entomologist 56(4) 1973