POTENTIAL FOR CONTROLLING CITRUS ROOT WEEVIL LARVAE AND ADULTS WITH CHEMICALS

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ABSTRACT

Larvae of 5 weevil species attack the roots of citrus trees in Florida. Since 1932, insecticides have been evaluated and recommended for control of the soil-inhabiting larvae as well as foliage-feeding adults of this weevil complex whose members include *Diaprepes abbreviatus* L., *Pachnaeus litus* (Germar), *P. opalus* (Olivier), *Pantomorus cervinus* (Boheman), and *Artipus floridanus* Horn. At the present time, no chemical compound is available that has sufficient persistence as a foliar spray or soil treatment to provide a Florida citrus grower with season-long control.

RESUMEN

Larvas de 5 especies de gorgojos atacan las raíces de árboles cítricos en la Florida. Desde 1932 se han evaluado y recomendado insecticidas para controlar larvas que habitan en la tierra, lo mismo que adultos que se alimentan del follaje, el grupo de gorgojos cuyos miembros incluyen a *Diaprepes abbreviatus* L., *Pachneous litus* (Germar), *P. opalus* (Olivier), *Pantomorus cervinus* (Boehman), *Artipus floridanus* Horn. Actualmente no hay ningún compuesto químico que sea suficientemente persistente como rociador de follaje o para tratar los suelos, y proveer control durante toda la temporada al agricultor.

Watson and Berger (1932) published the first recommendation for control of a citrus root weevil in Florida. They suggested poisoning adult *Pachnaeus litus* (Germar) by spraying trees with a fluosilicate. Cryolite and parathion were evaluated by Wolfenbarger (1952).

Foliar sprays have continued to be part of the control program for these insects as well as the Fuller rose beetle (FRB) *Pantomorus cervinus* (Boheman) (Bullock 1965, Dickson 1950, Elmer 1960, King 1958) that King (1958) reported as a pest of Florida citrus and *Diaprepes abbreviatus* L. (Bullock 1971, Herbaugh 1978, Schroeder & Lyons 1976, Wong et al. 1975a), detected in 1964 at Apopka, Florida.

Some of the early problems in pesticide screening arose from the investigators' attempts to evaluate adult populations quantitatively in field tests by shaking limbs or dislodging the adults onto ground cloths (Elmer 1960, King 1958, Wolfenbarger 1952) or by searching trees for specified lengths of time (Elmer 1960). It was difficult for these researchers to determine whether live weevils had survived exposure to spray residues or had just arrived in the tree. Measurements of efficacy became more exact when adults were caged on treated foliage (Bullock 1971, Elmer 1960).

During the past 25 years, the insecticides and acaricides appearing in the "Spray & Dust Schedule" and "Citrus Spray Guide" have been screened against one or more of the members of the weevil complex. Other compounds, registered for use on citrus but not necessarily recommended in these publications, were also tested as well as promising compounds as yet unregistered (Bullock 1965, 1971a, 1971b, Collins et al. 1976, Harbaugh 1978, Lovestrand & Beavers 1980, Schroeder et al. 1976, Schroeder & Lyons 1976, Wong et al. 1975a). This screening program revealed that compounds tested as dilute foliar sprays differed in efficacy against FRB and *Diaprepes*. Duration of effectiveness seldom exceeded 7 days for any compound tested at manufacturer's rates. Increasing the dosage or application in concentrate sprays extended the period of effectiveness to at least 4 weeks (Schroeder et al. 1976, Wong et al. 1975b).

No material had sufficient persistence to permit a Florida grower, wishing to employ foliar spraying as his sole method of adult weevil control, to realize success with a single application. Protection of attractive, young, expanding flush was not feasible since continued leaf expansion, as well as emergence of subsequent flushes, generated new leaf area lacking toxic residues. To control adults, multiple applications were deemed necessary. This procedure failed to provide adequate control of *Diaprepes* in one Apopka grove and resulted in destruction of many beneficial insects that had flourished in the infested grove prior to the eradication attempt (Collins et al. 1976).

Treatment of soil for control with insecticides effective against larval stages offers a different approach that spares certain beneficials and eliminates the spectre of environmental contamination from spray drift. Control of soil-inhabiting grubs was initiated by Barrow in 1921 vs. *Diaprepes* sp. with paradichlorobenzene and was continued against that genus by Wolcott (1951) in Puerto Rico and by King (1958) in Florida vs. FRB with chlorinated hydrocarbons. Even though dieldrin and aldrin were the recommended insecticides used in the Florida program from 1958 until 1975, 59 candidate insecticides have been screened in field tests since 1963 to find suitable substitutes for use in a soil treatment program (Table 1). No material will provide control with a single application. None are sufficiently persistant to last a growing season or even the 3-month span of the weevil with the shortest life cycle: the little leaf notcher (LLN), *A. floridanus*.

Two of the pesticides listed in the "Florida Citrus Spray Guide 1984" will provide complete kill: the soil fumigants Soilbrom (EDB) and Telon II (1, 3-dichloropropene). Both are effective eradicants that have been used in land preparation and nematode barriers. Both materials, when chiselled-in commercially or injected experimentally were lethal to buried FRB and LLN larvae.

Using Wylie's (1956) *Drosophila* technique, bioassay of dieldrin- and aldrin-treated grove soils during the 1960's at Ft. Pierce revealed that those compounds were acting as weevil adulticides. Being nearly insoluble in water, they remained where they were placed, i.e., within the top inch when broadcast applied or at whatever depth a disk or mechanical hoe was set when 'incorporating' the material. The efficacy of both compounds, measured by failure of weevil emergence, was mistakenly attributed to larval mortality although, under Indian River area conditions, it was actually death of adults when they commenced passage through the toxic

TABLE 1. LIST OF CHEMICALS TESTED AS SOIL INSECTICIDES.

	Year(s) Tested		Year(s) Tested
Abate 2 SG	1976	*HLR-RO-13-42175G	1979
Agnape GF-35	1966		
Akton 10G	1965, 71	ICI-PP211 10G	1972
Altosid SR-10	1984	Kepone 5G	1966
Amaze 15G	1979-81	Landrin 15G	1980-4
Baygon 5G	1967-8	Lorsban 15G	1979-83
Bay 25141 (see		(see Dursban)	
Dasanit)		*MAAG RO-15-	1984
Bay 37289 10G	1965	6510 500EC	
Bay 77488 5G	1967	MAT-4016 10G	1979
Bay 78182 1G, 5G	1967-8	Methyl-ethyl	
Bay 88941 10G	1970	Guthion 10G	1963
Bux 10G	1966, 70-1	NAK-1420 1G	1979, 80
Carbaryl 20G	1970	Nemacur 15G	1975-6
CGA 12223 10G	1976-7, 79,	Nemagon 8.6EC	1968
	82-3	NIA-10242 (see	
Chevron 5305 10G	1968, 70	Furadan)	
Chlordane 10G	1970-1	Morton EP-316 2G	1967
Counter 15G	1976	Oncol 5G, 20E	1983
Dasanit 5G	1964-5	Ortho-5353 (see	
Diazinon 5G	1963-4	Bux)	
*Dimefex 10%G	1980	Ortho-11775 10G	1970
DS-15647 10G	1975	Padan 10G	1971
duPont 1179 5G,	1966, 68	Phosvel 5G	1976
95WS		Shell SD-9098	
Dursban 10G	1971	(see Akton)	
*Dyfonate 10G	1979	SD-41706 10G	1976
EDB (Soilbrom)	1982	Sta-thion 10G	1967
FBC-34570	1984	Stauffer N-2790 5G	1966
Ficam 10G, 76W	1982-4	Supracide 2E	1972
FMC-35110 15G	1979-80	TDE 5G	1966
Furadan 10G	1966, 70-1	Thiodan 5G	1958
GC-4072 10G	1964-5	Temik 15G	1976
Geigy GS-13005 5G	1971	UC-54229 100S	1980
Guthion 10G	1963-4	UC-57193 4E	1980
HCS-3260 10G	1971-2, 75-6	UC-67546 75W	1980
Heptachlor	1957	Vydate 10G, 2L	1972, 77-8,
			80-3

*Evaluated only at CREC.

barrier at the soil surface during exodus. Nigg et al. (1979) reported a similar placement for chlordane applied to an Indian River area soil.

We realize now that aldrin, chlordane, and many other soil-applied insecticides are toxic to neonate larvae dropping to the soil to enter the ground. The survival of neonate larvae in treated soils was first investigated in Florida by Norman et al. (1974) at the USDA laboratory in Orlando. With a different technique, Jones and Schroeder (1984) and Schroeder and Sutton (1978) revealed that the maximum period of acceptable control (80% mortality) does not exceed 8 weeks in the sandy soils used in their assay vs. *D. abbreviatus.* Assays of 4 weeks duration conducted by Brooks at CREC Lake Alfred with soils prepared in the laboratory confirmed the activity of the same insecticides against *P. opalus*, *P. litus*, and *P. cervinus*. Bioassay of field soils one year after treatment revealed that effectiveness was reduced by over one half.

The key factor influencing the effectiveness of an insecticide in soil is the length of time it will remain biologically active. Harris (1972) lists a number of factors that influence this biological activity: soil type, organic content, soil moisture, and temperature. The Manatee, Oldsmar, Parkwood, Pompano, and Sunniland soils of the east coast of Florida are all sandy with organic content of less than 2% and little clay. The activity of carbamates, organophosphates, and organo-chlorines are inversely proportional to the organic matter content in moist soil, so our Florida sands should provide an excellent environment in which to evaluate activity.

Perhaps the most important thing we do in our testing program is to apply our materials to moist soils. We apply at least a 1/2-acre inch of water to the plots during treatment application. This creates the best opportunity for a candidate to perform well. Moisture 'dissolves' the toxicant off the granular carrier. Volatilization requires soil moisture and if volatilization diminishes the effectiveness of a toxicant through loss of concentration in the soil, but the gas phase is toxic to the pest, then a moist soil will enhance the efficacy of the compound.

Those compounds that are water soluble and possess low partition coefficients require moist soil to move to the arena where they will be most effective. For example, if larvae are distributed to a 12-inch depth, the toxicant should be distributed evenly throughout the profile to come in contact with the larvae.

Heat is absorbed or surrendered more rapidly in wet soil. Annual fluctuations in temperature at the 6-inch depth in Parkwood soil in the Indian River area swing from 59 to 75°F and 63 to 82°F with a mean of 68.6°F in shade and 74°F in unshaded soil, respectively (DuCharme 1971). Thermolabile compounds would have to be incorporated to depths that would prevent destruction by high temperatures.

Chemical and microbial degradation and volatilization are all temperature-dependent activities contributing to dissipation of residues. Although ground cover moderates soil temperature (soil temperatures are higher in bare soils), ground cover also increases soil moisture loss through transpiration. Presence of dew on ground cover interferes with application since granules will adhere to the wet plants and fail to reach the soil. The problem with ground cover is much less important in mature groves where the tree canopy has shaded out the area from trunk to drip line.

Ground litter is a problem. In two experiments at Indian Summer Grove in St. Lucie County during 1979 and 1981 comparing the application of larvicides to clean and 'littered' soil surfaces with a tractor-mounted herbicide boom, significantly more FRB adults survived emergence through litter-covered soil treated with chlorpyrifos at 2.75 lb AI/A in 69 GPA spray and oxamyl at 10 lbs AI/A in 50 GPA than survived treatments on litter-free soil.

Soil treatment may interfere with predation of neonate larvae on the soil surface. Arboreal predators would be unaffected, but some of the predators on the grove floor identified by Buren & Whitcomb (1978), Richman et al. (1982) and Whitcomb et al. (1982) could be eliminated from the 'drop' zone. These might be temporary disruptions because recolonization by foragers could occur from neighboring untreated areas of soil as soon as toxic residues fell below lethal levels.

On two occasions, the ant-lion *Myrmeleon crudelis* Walker was successfully constructing craters in the soil of each treatment except chlorpyrifos by July, one month after treatment. In that 1979 test, at Rangeline Grove #6 in Vero Beach, active craters were never found in chlorpyrifos-treated soil but occurred in aldrin, carbosulfan, isofenphos, isozophos, NAK-1420, and MAT-4016 soils. In 1980, adult ant-lions emerged during September from all treated soils except aldrin and NAK-1420 appearing in traps over soils treated with oxamyl, chlorpyrifos, isofenphos, and trimethacarb. Ant colonies became established during June, 1979 in all treatments except isozophos and chlorpyrifos. Colonies were encountered during July in the isozophos treated soil but not until November in chlorpyrifos soil.

With a choice of compounds limited to the non-persistent pesticides now favored by government regulators, there may be little danger that non-target grove fauna will be permanently eliminated. Yet, to fully understand the influence an applied chemical has on the environment, the effect on non-target species should be investigated.

We have applied chemicals to foliage for control of weevil stages occurring in the tree canopy and treated the surface of grove soil for control of stages inhabiting that medium. Another approach is to incorporate protectants in the planting hole at the time of planting. This is being currently investigated and may be a technique to prevent destruction of young plantings being established in infested soils.

Conclusion

The potential for controlling adults and larvae of the citrus root weevil complex with the available non-persistant chemicals is not promising. The research program has identified compounds that are effective as foliar sprays against other citrus pests as well as weevils When these compounds are used for their primary purpose, they kill weevils as well and are an added benefit to the grower if applications coincide with periods of peak weevil emergence.

The research program has also identified several compounds that have shown efficacy vs. soil inhabiting stages of the weevils. Two of these, oxamyl and chlorpyrifos, have been available recently but only chlorpyrifos has been extensively used.

An annual program that combined a single foliar spray and a soil treatment timed to disrupt the adult life cycle as well as larval reentry during the species peak emergence period would contribute to population reduction and grower relief but fail to provide year-long control.

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