INSECTICIDES FOR CONTROL OF ADULT GRASS GRUB. IV. COMPARATIVE ACTIVITY OF INSECTICIDES IN CONTACT AND SOIL BIOASSAYS

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SUMMARY

Contact tests of 50 insecticides against adult grass grub (*Costelytra zealandica*) showed the knockdown activities of synthetic pyrethroids to be 3-50 times those of the most active carbamates while the organophosphates were generally inactive. In bioassays of 10 insecticides mixed with Horotiu silt loam, lindane had an LC 50 value at 1 day of 2.1 mg/kg. Isazophos, carbofuran, diazinon and phorate were less active (LC 50: 3.2 — 6.0 mg/kg) with isofenphos, bendiocarb, pirimiphos-ethyl, fenamiphos and fensulfothion being relatively inactive (LC 50: 9.8 — 30 mg/kg). There was no relation between contact and soil activities.

INTRODUCTION

Insecticidal treatment of adult grass grub as a possible alternative to larval control has been investigated by Fenemore and co-workers (1964, 1968, 1970). Screening of a range of materials did not reveal any that were particularly effective either as soil or foliar treatments. More recent work (Henzell and Lauren 1978) has demonstrated the need for high contact activity and rapid action for foliar treatments. Although synthetic pyrethroids fulfil these requirements, other materials may also be suitable. Soil bioassays have shown that isazophos and lindane have high activity against grass grub adults (du Toit *et al* 1979) and field trials demonstrated that soil treatments with lindane prior to mating flights reduced the subsequent larval population (Henzell *et al* 1981).

The work reported here was instituted to screen a range of insecticides for foliar or soil application and relate direct contact bioassay results to soil bioassays.

METHODS

Contact bioassays were conducted at 15-20°C essentially as described by du Toit (1978). Initial tests at 500 ng/beetle of each insecticide used one replicate of 14 beetles. Further tests at lower doses used 4 replicates. After 10 minutes, the treated beetles were placed on packed soil and the numbers on the surface at 1 and 24 hours after treatment recorded to assess knockdown and kill activity respectively. The KD 50 (1 hour) and LD 50 (1 day) values are estimates of the insecticidal dose (ng/beetle) required to affect 50% of treated beetles at the respective times. These were obtained by fitting linear models to the percentage affected data (after logit transformation).

The soil bioassay (du Toit *et al* 1979) was carried out at 15-20°C. The soil used was Horotiu silt loam (16.5% organic matter) at a moisture content of 40% and sieved to pass through 3 mm mesh. Stock solutions of insecticides at 0.3 mg/ml were prepared by mixing EC formulations (lindane, isazophos, pirimiphos-ethyl, diazinon), WP formulations (bendiocarb, carbofuran), or technical material in acetone (phorate, fenamiphos, fensulfothion) with water. Aliquots of the stock solution (1-10 ml) were made to 40 ml with additional water and shaken with soil (300 g) to produce homogenous mixtures at insecticide concentrations of 2.8, 5.6, 11.2 and 22.4 mg/kg (oven dry weight). Additional concentrations of intermediate activity were also prepared for lindane, isazophos and bendiocarb. The treated soils stood for 16 h in

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sealed containers at 15-20°C before use.

The soil bioassay results reported are uncorrected for control mortality which was always less than 2%. The lowest concentration of insecticide in soil to affect 50% of beetles (LC 50) was obtained by logit analysis of the mortality data.

RESULTS AND DISCUSSION

The KD 50 and LD 50 values for the most active chemicals tested in the contact bioassays are given in Table 1, in which the activities could be divided into at least four significantly different groups (P◄ 0.05). Table 2 contains bioassay results at a 1 day contact time for the chemicals that were relatively inactive compared with those in Table 1. None of these showed significant knockdown activity.

TABLE 1: Contact activity of the most active insecticides tested against grass grub beetles.

Group	Compound	Contact activity (ng/beetle)	
		Knockdown KD 50 (1 h)	Kill LD 50 (1 day)
A	decamethrin	0.5	1.2
	Dowco 417	0.7	2.7
	cypermethrin	2.7	8.1
	permethrin	5.1	6.1
	fenvalerate	10.7	nd
B	carbofuran	33	33
	bendiocarb	35	46
C	promecarb	46	72
	lindane	58	108
	methomyl	65	94
	dichlorvos	74	94
D	propoxur	217	155
	carbaryl	221	155
	dioxacarb	237	237

nd = not determined

TABLE 2: Contact activity of the less active insecticides tested against grass grub at a dose of 500 ng/beetle.

% beetles affected 1 day after treatment	Compounds
70	mecarbam, methiocarb, oxamyl, chlorpyrifos, cyanophos, diazinon, dicrotophos, EPN, etrimfos, fenitrothion, fensulfothion, methidathion, methylparathion, monocrotophos, omethoate, phorate, pirimiphos-ethyl, pirimiphos-methyl, quinalphos, terbufos.
50-70	chlorpyrifos-methyl, chlorthiophos, dimethoate, phoxim, pyridaphenthion.
0-30	pirimicarb, carbophenothion, chlorfenvinphos, ethoprophos, famphur, formetante, isazophos, tetrapropyldithropyrophosphate, 2-methoxy-1,3,2-benzodioxaphosphorin-2-sulphide, temephos, thiometon.

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Within the highly active pyrethroid group, decamethrin and Dowco 417 were more active than either cypermethrin or permethrin which in turn were more active than fenvalerate (P◄ 0.01). Quick knockdown on contact is also a characteristic of a number of carbamates (Kuhr and Dorough 1976). Although bendiocarb, carbofuran and methomyl at dose rates above their KD 50 values affected beetles within half an hour of treatment, none of them matched the knockdown activity of the synthetic pyrethroids. In fact, bendiocarb subsequently applied at 1 kg/ha in a 2-spray treatment against grass grub beetles was ineffective in the field (Henzell and Lauren, unpublished data), whereas synthetic pyrethroids at one-tenth this rate have given good control (Lauren *et al* 1979). The general trend of the results suggested the knockdown activity of the carbamates was greater than the organophosphates. This latter class would therefore be unlikely to provide suitable materials for foliar treatments against grass grub.

In general, the LD 50 values for the insecticides in groups A, B and C were higher than the corresponding KD 50 values which indicated that beetles were able to recover from doses, around the LD 50 level, that initally affected them. The LD 50 values which are a measure of the kill activity of individual insecticides may be more relevant to the choice of possible candidate materials for soil treatment.

The results of the soil bioassays are given in Table 3. The insecticides can be divided into four groups on the basis of the LC 50 values. Lindane was signifcantly more toxic in the soil (P◄ 0.01) than the next most active material, isazophos. The results for these chemicals are in good agreement with previous work (du Toit *et al* 1979). Carbofuran, diazinon and phorate have similar activity to isazophos while isofenphos, bendiocarb and pirimiphos-ethyl were significantly less toxic. Carbofuran and bendiocarb have very similar chemical structures and contact LD 50s (Table 1) and it is interesting to note the difference in activity in the soil. Fenamiphos and fensulfothion gave significantly higher LC 50 values than the other materials. The poor performance of fensulfothion in these tests was consistent with field trials (Watson *et al* 1978) and soil bioassays (Holland and Watson, unpublished data) against another adult scarab, black beetle (*Heteronychus arator*). This material is only effective in the field due to its toxicity to larvae probably via soil ingestion.

TABLE 3: Effect of ten soil incorporated insecticides against grass grub beetles.

Compound	% beetles affected at concn. in soil (mg/kg) 2.8	5.6	11.2	22.4	LC 50 (mg/kg)
lindane	96	100	100	100	2.1
isazophos	38	98	100	100	3.2
carbofuran	20	74	100	100	4.3
diazinon	4	74	100	100	5.3
phorate	8	46	100	100	6.0
isofenphos	0	10	60	100	9.8
bendiocarb	4	12	22	77	16.7
pirimiphos-ethyl	2	10	22	70	16.7
fenamiphos	8	4	6	45	29
fensulfothion	0	4	2	34	30

In relating contact activity to soil activity, factors such as degree of penetration of the cuticle, degree of fumigant or stomach action and the extent of soil adsorption must be taken into account. In general, there appears to be very little relation between the contact and soil activity data reported here. For example, isazophos was one of the least active compounds in contact tests but was one of the most active in the soil. A similar conclusion was reached by Harris and Turnbull (1977) in a survey of insecticide activity using the field cricket (*Acheta pennsylvanicus*) as the bioassay insect. The good performance of lindane, diazinon, isazophos and phorate in the soil bioassays (Table 3)

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can be partially attributed to fumigant action. This property is desirable in a good soil insecticide (Harris and Turnbull 1977) but not essential, as shown by carbofuran which has low volatility.

In further extrapolating soil bioassay results to the field situation, the persistence of the chemicals in the soil, the method of application, the extent of movement into the soil profile and the location of the target insect must also be considered. Field trials have shown that adult grass grub populations can be controlled by lindane at 1-2 kg/ha provided the organic matter content is not too high (Henzell *et al* 1981). Isazophos at the same rate did not lead to satisfactory control probably due to its more rapid breakdown in the soil than lindane. From the soil bioassay results reported here, carbofuran, diazinon or phorate may be effective adulticides but higher rates and more accurate timing with respect to adult emergence would be necessary than with the more persistent lindane. It appeares that contact bioassay results are of no value in screening insecticides for soil use.

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