RESIDUAL ACTIVITY OF TWO INSECTICIDES AGAINST BLACK BEETLE

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Summary

Reductions of 70 - 90% in summer larval populations of black beetle (*Heteronychus arator*) resulted from surface broadcast applications of fensulfothion and isazophos (2 kg/ha) in the previous winter and early spring. They were caused by insecticide remaining effective against the larvae from November onwards, rather than from mortality of adults prior to oviposition. Chemical analysis and bioassay showed that toxic residues of these two insecticides in the soil declined to less than 20 - 50% of the applied material 4 weeks after application, with a corresponding decline in activity against adults. Isazophos was less persistent than fensulfothion but was much more toxic to adults. Both insecticides were apparently effective black beetle larvicides at very low concentrations.

INTRODUCTION

In small scale screening trials (Watson and Webber 1975) and subsequent field trials (Watson and Webber 1976) it was shown that fensulfothion and isazophos were the best of a number of chemicals tested for control of black beetle larvae in pasture. Broadcast applications of these two chemicals (2 kg/ha) against overwintering adults before the onset of oviposition (July and September) and against the early larval stages (December) gave similar levels of control of the subsequent summer larval population. Satisfactory control with the other chemicals tested and with isazophos at 1 kg/ha was only obtained with December applications.

It was not known if the success of the winter and early spring treatments of fensulfothion and isazophos were dependant on a high initial kill of adults, with negligible subsequent immigration; a high initial kill with residual activity still effective against immigrant adults in November and December; or residual activity effective against larvae from late November onwards regardless of the presence of adults. To find answers to these questions, field trials were repeated with applications of fensulfothion and isazophos at 2.0 kg/ha. In addition, the toxic residue levels of fensulfothion or its oxidation product, sulphone, and isazophos, under natural weathering conditions, were determined by chemical analysis and bioassay.

METHODS

Field trials

In 1976 and 1977 five trials were conducted using the method of Watson and Webber (1976). Granular formulations of fensulfothion and isazophos were broadcast at 2.0 kg/ha in October and December. In one trial diazinon granules were also applied. Black beetle numbers, eggs and

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larvae, were assessed in December, during the egg laying period (October treatments only) and in February, after the period of most intensive larval feeding and prior to the emergence and dispersal of adults in autumn. Black beetle populations were sampled with a 10 cm diameter corer, using the extraction method of Kain and Atkinson (1976), in December and hand sorting in February.

The best treatments (2.0 kg/ha fensulfothion and isazophos applied in December) of a trial laid down at Huntly in 1975 (Watson and Webber 1976) were reassessed in February 1977 and compared to previously untreated to see if treatment effects remained after one year.

Residue studies

Eight 5 x 5 m plots were established at each of three sites in Northland and one site at the Otakanini research area, Helensville. Fensulfothion and isazophos granules were broadcast at 1.0 and 2.0 kg/ha onto one plot at each site in September and early December 1976.

Soil samples were taken at 1, 4, 8 and 12 weeks after application to enable a progressive analysis of toxic residues under natural weathering conditions. For bioassays five 10 cm diameter x 15 cm deep cores were taken from treated plots and placed in sections of plastic pipe set vertically on trays in a greenhouse. Cores taken from the area surrounding the plots served as untreated controls. Four or five black beetle adults were placed into the cores before covering the tops with gauze to prevent escape. The cores were assessed after 4-5 days and the beetles classified as dead, affected or unaffected using the criteria of Watson and Webber (1975).

For chemical analysis ten 2.5 cm diameter cores were taken from treated plots at each assessment and sectioned into 0-3, 3-6 and 6-9 cm depth fractions. These were bulked into plastic bags for each plot and stored at -12 °C for later analysis.

The frozen cores were thawed and broken up by crushing and sieving. Duplicate sub-samples were taken for extraction and analysis. Fifteen g of moist soil was titrated with 10 g of granular anhydrous sodium-sulphate and 70 ml of chloroform/methanol (9:1) added. Extraction proceeded for 16 hours in a rotary shaker. Following filtration the extracts were taken just to dryness on a rotary evaporator at 50 °C and transferred to a volumetric flask with cyclohexane/acetone (4:1). These extracts were analysed by gas-chromatography in a column of 4% QF1 + 1% OV17 on 80/100 Gaschrome Q and using alkali flame ionization detection.

RESULTS

Field trials

Table 1 shows the combined results from the field trials. October treatments did not significantly affect the number of eggs and first instar larvae present in December. However in February both the October and December treatments of fensulfothion and isazophos gave similar reductions in larval numbers below the untreated populations.

Reassessment of the best treatments of the Huntly trials 14 months after insecticide application showed that there was no effective carry-over of control from one year to the next following application of fensulfothion and isazophos at 2 kg/ha.

Residue studies

Table 2 shows the recovery of toxic residues from the core sections at various intervals following the September insecticide applications. Similar trends were apparent between sites and chemicals for the December applications, but the level of fensulfothion recovery was generally higher.

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TABLE 1: Control of black beetle by granules broadcast (2 kg/ha) in October and December.

Treatment (% granular)	Application time	No. trials	December* No/m ²	February*	
				No/m ²	% reduction
untreated		5	10.1 ± 1.3	13.9 ± 4.5	0
isazophos	October	5	10.6 ± 4.6		70 ± 13
(10)	December	5			88 ± 5
fensulfothion	October	4	8.3 ± 5.0		90 ± 5
(10)	December	4			75 ± 10
diazinon	October	1	9.3		25
(10)	December	1			9

* December: eggs and 1st larval instars

* February: 2nd and 3rd larval instars, pupae and teneral adults

For example, recovery of fensulfothion 1 week after December application was 82% at Punakitere and 91% at Otakanini. The results are expressed as percentages of applied chemical and for fensulfothion are the sum of the parent compound and its insecticidally active oxidation product, the sulphone. The two rates of each insecticide application gave similar percentage recoveries and the figures were therefore pooled. Exhaustive soxhlet extraction of selected samples showed that the shaker method recovered > 95% of the active insecticides present. The sulphone was

TABLE 2: Recovery levels of toxic insecticide residues at intervals after application to pasture in September.

Location and Soil type	Weeks after application	Toxic residues (% of applied, 0-6 cm)	
		isazophos	fensulfothion
Hikurangi	1	34	51
Otonga peaty loam	4	17	28
	8	11	9
	12	5	8
Punakitere	1	19	41
Waiotu friable clay	4	8	22
	8	3	13
	12	1	8
Otakanini	1	39	69
Tangitiki/Redhill	4	11	42
sandy loam	8	8	20
	12	5	11
Kaikohe	1	49	77
Wharekohe silt loam	4	20	35
	8	20	21
	12	14	14

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usually the major form of fensulfothion present after 2 weeks, reaching a maximum concentration at 3-5 weeks and then decaying at a similar rate to the remaining parent compound. Less than 5% of the isazophos or fensulfothion was detected below 3 cm on any of the sites except Otakanini where 6 weeks following the December application of 2 kg/ha of fensulfothion 35% appeared in the 3-6 cm section, mostly as the parent compound.

The amount of insecticide recovered was low, especially for isazophos, where after one week less than 50% of the applied chemical could be recovered. The amounts recovered were slightly higher from the sand and podzolised soils than from the peat and volcanic clay (Table 2).

In the laboratory study the effects of the treated soils on black beetle generally reflected the residue measurements in the field. Adult bioassay mortalities showed a rapid decline from 1-4 weeks after application, reflecting the 2-3 fold drop in residues over this period. Fig. 1. shows the bioassay mortalities of beetles in respect to chemically analysed residues. Each point is the mean of the 1 and 2 kg/ha rates. The beetle mortality with isazophos was much greater than with fensulfothion despite the lower levels of isazophos present.

FIG. 1 Effect of toxic residue levels of fensulfothion and isazophos on adult black beetles.

DISCUSSION

The initial rapid loss of insecticide (Table 2) was probably due to volatilization or photochemical degradation of insecticide on the surface. Soil moisture at application, and the nature of granules are important in influencing removal of chemical from the granules (Udy *et al* 1974). The improved recoveries of fensulfothion from the December applications corresponded with soil moisture levels at application 20-30% higher at all sites than they had been for the September treatments.

A range of organophosphorus insecticides including phorate (Schulz *et al* 1973) and fensulfothion (Read 1976) have a longer residual life when surface incorporated compared to surface applied, especially when banded beneath the surface. Toxic metabolites of some of these chemicals have been shown to remain in the soil for periods in excess of one year (Read 1976; Read and Chisholm 1977). However this study indicates that for surface applied granules, at maximum recommended application rates for pasture pest control in New Zealand, control adult black beetles for less than a month. Larval control continues at least 2 months and possibly up to 4 months after winter and early spring insecticide applications (Table 1; Watson and Webber 1976), even though very low levels of toxicant apparently remain (Table 2). The fact that very low concentrations were effective for larval control is an indication of the inefficiency of surface applied granular formulations.

Control of the adult black beetle by surface broadcast granules occurs rapidly and apparently is caused by contact activity, whereas larval control probably results from stomach poisoning following ingestion of soil and plant roots. As with larvae, stomach poisoning of adults is effected by relatively low concentrations of insecticide, since pot trials have revealed that isazophos is effective against adults at greatly reduced application rates when taken orally from baits (du Toit 1978). The superiority of isazophos over fensulfothion as an adulticide (Fig. 1) has been confirmed in a recent pot trial (Holland and Watson, unpublished) and by contact activity measurements (du Toit pers comm).

The results in Table 1 show that the control achieved from early (October) insecticide applications, prior to egg-laying, results from long lived residues effective against the larvae. These treatments are therefore effective regardless of subsequent immigration by adult beetles. Isazophos and fensulfothion are apparently both very effective larvicides. Chemicals with shorter residual activity such as phorate, diazinon and ethoprophos may only be effective if applied when egg laying is practically complete. In the cool moist spring conditions of recent years oviposition has continued from the usual November-December period into January, when soil moisture conditions are likely to become less favourable for insecticide activity.

ACKNOWLEDGEMENTS

To Miss O. F. Johnson and K. J. Webber for technical assistance, Dr N. R. Cox for biometrical analysis and to co-operating farmers in Northland.

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