DO SOIL APPLIED INSECTICIDES CONTROL GRASS GRUB BEETLES?

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SUMMARY

Lindane applied at 1 and 2 kg/ha to the soil surface in early spring against adult grass grub (*Costelytra zealandica*) at a Rotorua site gave significantly greater control than early autumn or summer treatments against mature and immature larvae. Bioassays confirmed lindane is much more active against adults than larvae. Isazophos at 2 kg/ha was effective against mature larvae, but failed when applied against beetles or immature larvae. On a considerably higher organic matter soil near Ngaruawahia both lindane and isazophos were ineffective when applied at any of the above periods. Insecticide residues were concentrated in the upper 10 mm of the soil profile at both sites.

INTRODUCTION

Soil applied isazophos and lindane have been shown in laboratory bioassays to be very effective against grass grub beetles (du Toit *et al* 1979; Holland *et al* 1981). Isazophos has given effective control of grass grub larvae (O'Connor and Hart 1976). Lindane is currently recommended for grass grub control on sheep and beef farms and is permitted to be applied as a surface broadcast treatment between 1 April and 30 June only. This period was selected as larvae were possibly considered to be more vulnerable to soil applied insecticides and with the reduced grazing pressure at this stage, stock would have less chance of accumulating lindane residues.

Kelsey (1951), Kain and Atkinson (1968) and Taylor (1968) observed a delay in the effect of lindane on grass grub infestations. Reasons for this delay were not identified and it appeared the authors failed to appreciate that adult beetles were very susceptible to lindane. Because lindane has a soil persistence of about a year, applications directed against mature larvae in autumn/winter could conceivably affect beetles, eggs and early instar larval stages.

This paper describes the effect of lindane and isazophos on grass grub when used as larvicides and adulticides. To assist in the interpretation of the results, bioassays against larvae and beetles were carried out in association with residue studies which showed the distribution of the chemicals in the soil profile.

METHODS

Trial layout and soil sampling

The trials were carried out on two sheep farms. One site on flat land near Rotorua was on Rotomahana shallow sandy loam (9.6% organic matter); the other site on hill country 20 km west of Ngaruawahia contained a Dunmore silt loam (32% organic matter).

Pre-treatment soil sampling was carried out at both sites in March 1979 by sampling the inner 6 x 6 m of all the 10 x 10 m plots. The treatments were randomly allocated in six replicated rows. Grass grub larval populations ranged between 127 and 750/m² on the Rotorua plots and between 29 and 151/m² on the Ngaruawahia plots. Each treatment had a set of plots covering the full population range.

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Treatment effects were assessed by taking at least 25 cores (10 cm dia.) from the inner 6 x 6 m of each plot. Treatments applied in April 1979 were assessed in August 1979 and in April 1980, while all other treatments were assessed in April 1980.

Treatments

In an attempt to obtain an even distribution of the insecticides in the soil most of the treatments were sprayed onto short pasture (2.5 cm) at a high water rate (600 litres/ha) with a wetter added to the spray mix. The treatments were generally applied either in the rain or onto damp or wet grass with rain imminent. The emulsifiable concentrate formulations used contained 20% lindane or 50% isazophos. Applications were made with a hand-held precision sprayer fitted with Spraying Systems 730154 nozzles spaced at 0.4 m intervals along a 2 m boom which was pressurized to 207 kPa.

At the Rotorua site, both insecticides were applied at 1.0 and 2.0 kg/ha at the dates shown in Table 1. Lindane was also applied at these 2 rates as 20% granules on 2 October 1979, and in addition, it was drilled at a rate of 1 kg/ha into the pasture around the trial site in April 1979. Soil moisture in the upper 10 mm soil layer was above 55% (on a dry weight basis) on all application dates. Major grass grub mating flight activity on this site started on 28 October 1979. Similar foliar treatments were applied at the Ngaruawahia site.

Bioassays

Soil samples for bioassays (four 10 cm dia. cores from each replicate) were taken to assess the effect of autumn treatments on grass grub larvae, at 3 and 12 months after application, and on beetles at 27 weeks after application. The effects of spring treatments on beetles at 4 weeks after application and on larvae in the following autumn were also assessed.

The upper section of each core was divided into a 0-10, 10-20 and 20-50 mm soil layer and the 0-10 mm soil layers diced with a knife and forced through a coarse sieve (10 mm). The other two soil layers were sieved similarly. Subsamples of the soil layers were taken for bioassays and residue analyses.

For the larval bioassays a procedure similar to that outlined by Fenemore (1970) was used. Larvae were removed from pots of treated soil after 2 weeks. Affected larvae were unable to burrow into firmly packed soil within 1 hour of placement on the surface.

Beetle bioassays were carried out as described previously (du Toit *et al* 1979).

Residue analyses

To check the efficiency of the insecticide application methods under the different weather and pasture conditions prevailing at each application time, the three soil layers from treated plots were analysed for either lindane or isazophos at 2 weeks after application. Residue analyses were also carried out in conjunction with each bioassay and at several other times up to a year after application.

Lindane and isazophos residues were extracted by standard techniques and analysed by gas chromatography (Lauren *et al* 1980; Watson *et al* 1978).

RESULTS

Field trials

The effects of isazophos and lindane directed against grass grub larvae and beetles are summarised in Table 1. Only the Rotorua results are shown as all treatments at the Ngaruawahia site failed to give significant reductions in larval numbers.

Isazophos applied at 2 kg/ha gave effective larval control but had little effect on grass grub beetles.

Lindane formulated either as an emulsifiable concentrate or as granules when applied specifically against adults in early October gave effective grass grub control at both 1 and 2 kg/ha. In fact, lindane applied at 1 kg/ha in spring was at least as effective as double the rate applied in autumn while the same rate applied in early December after the mating flights was ineffective. Although comparable lindane residues (approximately 3 ppm in the top 10 mm soil layer) were present in the soil in mid-December following the early October and early December applications of lindane at 2 kg/ha, the former treatment gave more effective grass grub control, suggesting that

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TABLE 1: Grass grub control with autumn and spring applications of isazophos and lindane at two rates on a Rotorua site.

Application time (1979)	Assessment time	Grass grub control ¹ (%) with			
		Isazophos (kg/ha)		Lindane (kg/ha)	
		1.0	2.0	1.0	2.0
23 April	14 August 1979	45	85	4	23
	2 April 1980	43	75	49	54
2 October	2 April 1980	0	20	76	98
2 October	2 April 1980			67 ²	92 ²
7 December	2 April 1980	0	16	0	34

1. % reduction compared with populations of untreated plots (250 and 212 larvae/m² in August 1979 and April 1980 respectively).

2. Granule formulation results.

lindane was mainly affecting beetles rather than young larvae.

Lindane drilled at a rate of 1 kg/ha into pasture around the trial site had not affected larval numbers in the August sampling but by the following April, an 86% reduction in larval numbers had occurred.

Residues

In both soils isazophos degraded at a 2-4 fold faster rate than lindane and most of the residues for both insecticides were concentrated in the top 10 mm soil layer. More recent trials with lindane have indicated it mostly remains (>60% residues) in the turfmat for up to 4 months after application.

Degradation of surface applied lindane was reasonably rapid and appeared to be similar for both sites. At 12 months after the autumn application at the Rotorua site, lindane residues in the soil from the 2 kg/ha treatment dropped from 5.0 to 0.3 ppm. By comparison, residues from the 1 kg/ha drilled treatment were 0.6, 6.0 and 2.5 ppm in the 0-10, 10-20 and 20-50 mm soil layers respectively. This increased degradation associated with surface application was also noted by Watson *et al* (1978).

In addition, the spray application method was an inefficient way to transfer insecticide to the soil surface. For the 2 kg/ha lindane treatments, for example, the residues in the 0-10 mm layer at 5 weeks ranged between 3 and 14 ppm. For lindane granules applied at this rate to short, dry pasture, residues of the order of 35 ppm have been determined.

The low soil residues associated with the spray applications aided this study as the biological activity of lindane against actively feeding larvae had disappeared within 3 to 5 months of application. This factor, along with data on the distribution of lindane in the soil profile, allowed the separate insecticidal effects on grass grub larvae and beetles to be identified.

Larval bioassays

Only the top 10 mm soil layer affected larvae, and the results are shown in Table 2. As the larvae at 12 weeks after the April application were not feeding as actively as those 2 weeks after the application, the results presented may not be directly comparable.

Both insecticides were generally more active against larvae on the Rotorua soil than on the Ngaruawahia soil. Isazophos residues of 0.9 ppm on the former soil were effective at 2 weeks although similar residue levels found in the 12 week samples were inactive against more mature larvae. On the high organic matter Ngaruawahia soil about five times as much isazophos was required to obtain a biological activity comparable with the Rotorua soil. Only the high lindane rate affected more than 50% of larvae in the bioassays. In addition, lindane residues of 5 ppm in the top soil at Rotorua killed over 50% of the larvae while at Ngaruawahia lindane residues of up to 6.5 ppm were almost ineffective.

In March 1980, soil from all lindane treatments was ineffective when bioassayed against larvae. The maximum soil residue level in these samples was 0.6 ppm.

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TABLE 2: Insecticidal activity against grass grub larvae of the top 10 mm soil layer from two sites treated with isazophos and lindane at two rates.

Insecticide rate (kg/ha)		Weeks after treatment	Insecticide residues (ppm)*		Larvae** affected (out of 50)	
			Rot.	Nga.	Rot.	Nga.
isazophos	1.0	2	0.9	2.2	27	3
isazophos	1.0	12	0.2	0.3	0	9
isazophos	2.0	2	1.2	4.3	42	28
isazophos	2.0	12	0.8	0.7	0	4
lindane	1.0	2	4.5	3.9	15	4
lindane	1.0	12	1.4	3.5	8	4
lindane	2.0	2	5.0	6.5	29	4
lindane	2.0	12	3.0	14.3	18	26

* Figures for the 2 week estimation represent residues in the soil content only of the 0-10 mm layer. The turf content of these samples was discarded in error, and would have added significantly (*ca* 2-fold) to the total residue level recorded.

** Numbers are corrected for control mortality.

Beetle bioassays

Beetle bioassays were carried out in early November and as with the larval bioassays, only the top 10 mm soil layers affected beetles. Soils from both sites treated with isazophos in early October, were inactive in the beetle bioassays.

The results (Table 3) show the marked difference in the toxicity of soils to beetles when lindane is applied in autumn or spring. For instance, soil from the Rotorua site that had been treated in autumn (27 weeks earlier) with 2 kg/ha lindane affected 24 % of beetles exposed to the soil for 4 days. On the other hand, soil from the same site treated in spring (4 weeks earlier) with 2 kg/ha lindane started to affect beetles within 5 hours and the majority of beetles were affected after 2 days' exposure.

The greater contact activity of lindane against grass grub beetles compared with larvae is apparent by comparing Tables 2 and 3. On the Rotorua soil, 1.4 ppm lindane affected 16% of larvae after 14 days' exposure while 1.5 ppm lindane affected 26 and 68% of beetles after 2 and 4 days respectively. At the Ngaruawahia site, lindane appeared to be only about half as effective as at Rotorua. In fact, lindane residues of 3.6 ppm in the Ngaruawahia soil were almost ineffective against beetles.

TABLE 3: Insecticidal activity against grass grub beetles of the top 10 mm soil layer from a Rotorua and Ngaruawahia site treated with lindane at two rates.

Lindane formulation and rate (kg/ha)	Weeks after treatment	Lindane residues (ppm)	Beetles affected (out of 50) at days in soil.		
			1	2	4
<i>Rotorua site</i>					
EC: 1.0	27	0.5	1	1	3
EC: 2.0	27	0.9	0	3	12
EC: 1.0	4	1.5	4	13	34
G: 1.0	4	4.3	4	11	25
EC: 2.0	4	3.7	15	34	40
G: 2.0	4	5.5	29	36	45
Untreated	0	0	1	3	3
<i>Ngaruawahia site</i>					
EC: 2.0	27	3.6	1	2	4
EC: 1.0	6	1.7	0	2	5
EC: 2.0	6	4.7	1	7	20
Untreated	0	0	0	0	2

CONCLUSIONS

This study has shown that lindane applied to the soil surface can give very effective control of grass grub beetles. Surface applied lindane, which is almost insoluble in water, tends to remain localised in the upper 10 mm soil layer and becomes effective when beetles move up into the turf mat prior to and during their mating activities. Current regulations for lindane preclude its use as a broadcast treatment at the most effective time in spring. Only the long residual life of lindane allows the recommended autumn/winter applications to have a marked effect on grass grub populations. These results explain the delayed action of conventionally applied lindane applications. Lindane may be direct drilled into pasture at any time of the year but the effectiveness of sub-surface applications against beetles still needs to be evaluated.

Isazophos was an effective larvicide against grass grub but was inactive when applied prior to the start of beetle mating activity. A more efficient application method might overcome this problem. The marked differences in control obtained between the two sites illustrate the influence soil organic matter can have on insecticidal activity.

The development of more selective soil adulticides for grass grub should be given priority.

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