DIFFERENCES IN SUSCEPTIBILITY OF GRASS GRUB IN TARANAKI TO ORGANOPHOSPHATE INSECTICIDES

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SUMMARY

Laboratory topical testing with insecticides was undertaken to determine if resistance to fensulfothion had developed in grass grub (*Costelytra zealandica*) larvae in Taranaki. Populations from three farms with a history of extensive use of fensulfothion were found to be significantly less responsive to this insecticide than a population that had not been exposed to fensulfothion. The differences may suggest that a proportion of these populations is resistant to fensulfothion. There was no difference in response to two other organophosphate insecticides tested — diazinon and isazophos.

INTRODUCTION

Since DDT was banned in 1968, organophosphate insecticides, particularly fensulfothion, have been extensively used to control grass grub on dairy farms in New Zealand. Due to the inability of these insecticides to suppress grass grub populations below damaging levels for, in many cases, more than a season some farmers resorted to annual treatments.

It has been recognised that these short lived insecticides have given variable results for control of grass grub due in part to their dependence on soil moisture (Carpenter *et al* 1981). Recently, however, some farmers in Taranaki who have used fensulfothion regularly have felt that the success of their treatments was declining. This raised the possibility that grass grub were becoming resistant to fensulfothion. Grass grub have, in the past, developed resistance to DDT (Perrott and Allen 1968) and to lindane (Trought and Brumley 1978) but not, as far as is known, to organophosphates.

This paper reports on a series of laboratory tests undertaken to determine if grass grub in Taranaki were developing resistance to organophosphate insecticides.

METHODS

Four experiments were conducted during the late summer/autumn periods between 1982 and 1984. Each test involved randomly collecting grass grub larvae from within selected paddocks in the Taranaki area. Collection dates, sites and insecticide history of each paddock are given in Table 1. These larvae were maintained in cool damp conditions until treatment within 2 days of their collection. Injured and weak larvae were discarded.

Each larva was weighed individually, instar recorded and randomly allocated to a treatment. Treatment involved dosing each larva by topical application of insecticide. Various concentrations of the insecticides (Table 1) in the solvent acetone were applied in 0.82 microlitre droplets onto the dorsum of larvae using an Arnold Burkhard microapplicator. All four experiments included a control using acetone only. Numbers of larvae per treatment are given in Table 1.

After treatment larvae were placed individually in plastic ice cube trays covered with damp paper towels. After 1 day surviving larvae were transferred to clean ice cube trays and observed daily for 1 week. Over the test period larvae were assessed for vitality by prodding with forceps. Grass grub usually respond to such a stimulus by wriggling vigorously. Those larvae that showed little or no movement were considered to have received a lethal dose of insecticide.

Proc. 38th N.Z. Weed and Pest Control Conf.

TABLE 1: Summary of tests.

Collection site	Insecticide history ¹	Grass grub		Treatment	
		Instar	No./trt. ²	Chemical ³	Dose (μgm/larva)
Collection date: 1 April 1982					
Allerman	None	Third	35-45	Fensulfothion	0.01
Nicholas	75, 77, 79, Broad				0.10
					0.50
Collection Date: 1 May 1982					
Allerman	None	Third	14-23	Fensulfothion	0.025
Tars	None				0.10
Nicholas	75, 77, 79, Broad			Diazinon	0.25
Willis	73, 74, 76, Broad				
WWDF29	None				
WWDF7	77, 79, 80, 81, Drill				
Collection Date: 3 Feb 1983					
Allerman	None	Seconds & Thirds	32-54	Fensulfothion	0.01
Nicholas	75, 76, 79, 82, Broad			Isazophos	0.05
Langridge	Treated 5 out of last 10 years				0.10
Burke	76, Broad; 77, 78, 80, Drill				
Collection Date: 4 Feb 1984					
Allerman	None	Seconds	39-51	Fensulfothion	0.01
Nicholas	75, 76, 79, 82, Broad				0.025
					0.05
					0.075
					0.10

¹ Insecticide history — gives dates (year) of treatments with fensulfothion. Broad — broadcast at 2 kg ai/ha; Drill — drilled at 1 kg ai/ha.

² No./treatment — numbers given are for healthy larvae only and vary according to incidence of disease in each sample.

³ All chemicals used were technical grade at the following concentrations: fensulfothion — 940 and 500 g ai/litre; diazinon — 950 g ai/litre; isazophos — 500 g ai/litre.

Because diseased larvae are known to be more susceptible to insecticide than healthy larvae (Miln and Carpenter 1979) all larvae were examined microscopically for disease. Disease incidence was variable but generally was less than 30% of the larvae treated. The results presented are for healthy larvae only.

RESULTS

The mortality in the control groups was not significantly different ($p < 0.05$) between farms. These data were excluded from further analyses.

Logistic response curves were fitted to the remaining data. For each year and insecticide, $\ln(p/1-p)$, where p is the probability of a larva dying, was modelled against the natural log of the insecticide rate. Instar and larval weight were included as other factors in the model as required. These models enabled farm differences to be quantified in terms of median lethal doses (LD50) and relative potencies (Finney 1962, Hewlett and Plackett 1979). The residual deviance and residual degrees of freedom (Table 2) provided a test of the adequacy of the models; a large deviance relative to its residual degrees of freedom signifies lack of fit.

The fitted curves are shown in Figure 1 for average sized larvae treated with fensulfothion. In all tests conducted, the mortality of larvae from Nicholas's farm with a history of frequent use of fensulfothion was significantly less than that from

Allerman's farm, on which no insecticide had been applied. In the May 1982 tests there were no significant differences between Allerman grass grub and the other farms tested. In 1983, mortality of Langridge and Burke grass grub larvae was significantly less than that from Allerman's ($p < 0.01$), but significantly greater than that from Nicholas's ($p < 0.05$). No differences between farms were found in tests using diazinon and isazophos.

TABLE 2: Residual degrees of freedom and deviance for the model and calculated LD 50 values and relative potency for tests with fensulfothion done on grass grub larvae from Allerman and Nicholas farms.

	April 1982	May 1982	Feb 1983	Feb 1984
Goodness of fit				
Residual df.	221	121	286	451
Residual deviance	153	57	251	492
LD50				
Allerman	0.05	0.07	0.05	0.06
Nicholas	0.10	0.13	0.12	0.10
Relative potency				
Lower bound	0.29	0.41	0.26	0.44
Estimate	0.52	0.55	0.35	0.65
Upper bound	0.91	0.73	0.53	0.91

Fig. 1: Fitted dose response curves for each test using fensulfothion. The curves are in the same order as the collection sites named for each date.

The relative potency of fensulfothion for Nicholas's grubs relative to those from Allerman's farm, together with 95% confidence limits, are given in Table 2. These indicate that approximately half the dose of fensulfothion was required to kill an Allerman grass grub relative to a Nicholas grass grub. The LD50s (Table 2) show a similar difference.

DISCUSSION

In tests such as these, the problem is deciding at what stage a population can be considered to be resistant to an insecticide. Various authors have in the past suggested a 10-fold difference in the LD50 value was necessary before a population could be classified as resistant (Chapman 1982). Anything less than this is described as vigour tolerance but as Chapman points out this figure is an arbitrary one and does not necessarily relate to control failures in the field.

Trought and Brumley (1978) in testing for lindane resistance in grass grub found a mean mortality difference of 50% between susceptible and resistant populations. Perrott (1965) considered that if a significant number of grass grub survived a certain dose of DDT which killed most of the susceptible strain then that sample could be classed as containing a proportion of resistant individuals.

The differences in response to fensulfothion between the Nicholas and Allerman grass grub populations were not great: a 2-fold difference in LD50 value and a mean mortality difference of 24% at a dose rate of 0.01 μ g of fensulfothion. On the basis of these results the Nicholas population cannot be considered to be resistant to fensulfothion. Nevertheless the differences in mortality are significant and may indicate that a proportion of the Nicholas population has developed resistance. Vigour tolerance is unlikely to be the cause since weight and stage of development of larvae tested were similar and diseased grubs have been excluded from the results. The relationship between previous history of insecticide use and response to insecticide in the four farms in the 1983 tests also suggests an increased tolerance in larvae repeatedly exposed to fensulfothion.

It is however still questionable whether this increased tolerance is responsible for control failures in the field. Field trials were conducted at the Allerman and Nicholas farms in conjunction with the laboratory tests but the results were inconclusive as satisfactory control was not obtained at either site.

There seems to be increased tolerance, at this stage, only to fensulfothion and this does not carry over to diazinon or isazophos, the other organophosphates tested.

The possibility that some grass grub have developed or are developing resistance to fensulfothion, albeit in low numbers, has implications for the future use of this insecticide. The situation should continue to be monitored on those farms which have used fensulfothion extensively and the use of alternative insecticides considered.

ACKNOWLEDGEMENTS

The authors wish to thank Lesley Bates and Ross Laurence for technical assistance and the farmers involved for their co-operation.

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