INSECTICIDE CONTROL OF GRASS GRUB (*COSTELYTRA ZEALANDICA*) IN THE MID NORTH ISLAND REGION OF NEW ZEALAND

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Summary

DDT formulations applied to pasture at 2 lb a.i. per acre to non-DDT-resistant populations of grass grub (*Costelytra zealandica*) gave delayed control. Differences in the speed of action and efficiency have been noted between formulations. Granulated DDT-superphosphate formulations have given faster and more efficient control than prilled formulations.

Applications of lindane applied at 2 lb in September resulted in efficient control in the ensuing season, but application in January did not give efficient control until the following season.

Fensulfothion at 2 lb has given more consistent results than diazinon applied at the same rate. September applications of fensulfothion compared with January applications gave earlier pasture responses and greater grass grub control.

Heptachlor applied at 8 oz and 1 lb has shown excellent and persistent control and has a speed of action similar to lindane.

INTRODUCTION

MANY CHEMICALS have been evaluated under field conditions for grass grub (*Costelytra zealandica*) control, some with remarkable success, but the majority, especially those of the organophosphate group, with negative or variable results.

There appears to be little published literature on the control of grass grub with granulated DDT-superphosphate and DDT prills. Kelsey and Read (1967) screened four formulations of DDT 2 lb* and recorded a significant pasture response in the season after application which was not attended by a reduction of grass grub numbers. No significant differences were noted between formulations.

Excellent control of grass grub has been recorded with heptachlor at 2 lb (Fenemore, 1963; Kelsey and Read, 1966; Rastrick and Mason, 1966). Taylor (1967) reported excellent control in the season of application on silt soils with rates as low as 1 and 2 oz.

Rastrick and Mason (1966) have observed a reduction in grass grub numbers in the season of application, but in other trials this reduction has not been evident until the following season. These different rates of action of heptachlor are probably related to climatic and soil differences.

Lindane, at 2 lb, formulated as prills has given a significant reduction in both susceptible and DDT-resistant grubs in the season of application (Kelsey and Read, 1966).

*All rates are given in lb a.i. per acre.

TABLE 1: TAUPO TRIAL 1

<i>Treatment</i> (lb)	<i>No. of Grass Grub/sq ft</i>		
	(8 wk)	(52 wk)	(105 wk)
DDT prills 20% 2	46.8 abAB	18.0 bcBC	5.5 bB
DDT Stauffer pellets 33% 2	24.8 bBC	27.6 abAB	25.2 aA
DDT gran. 0.9% super. pan 2	42.0 abAB	15.6 cBC	2.7 cCD
DDT gran. 0.9% super. blunger 2	70.8 aA	18.0 bcBC	3.2 cC
heptachlor gran. 3.25% 1/2	50.4 aAB	1.2 dD	0.15 dD
fensulfothion gran. 2.5% 2	4.8 cC	13.2 cC	65.8 aA
Control	49.2 aAB	31.2 aA	29.8 aA

*Figures in parenthesis denote number of weeks after insecticide application.

TABLE 2: TAUPO TRIAL 2

<i>Treatment</i> (lb)	<i>No. of Grass Grubs/sq ft</i>		
	(8 wk)	(52 wk)	(105 wk)
DDT prills 20% 2	54.0 aA	15.6 bcAB	5.0 bB
DDT Stauffer pellets 33% 2	43.2 aA	26.4 abA	27.2 aA
DDT gran. 0.9% super pan 2	50.4 aA	6.0 dC	1.5 cdCD
DDT gran. 0.9% super. blunger 2	48.0 aA	8.4 cdBC	2.5 cBC
diazinon granules 5% 2	7.2 bB	13.2 bcAB	45.5 aA
heptachlor granules 3.25% 1	51.6 aA	0 eD	0 dD
Control	54.0 aA	30.0 aA	27.2 aA

TABLE 3: TAUPO TRIAL 5

<i>Treatment</i> (lb)	<i>No. of Grass Grubs/sq ft</i>	
	<i>March</i> <i>Sampling</i>	<i>August</i> <i>Sampling</i>
Early fensulfothion gran. 2.5% 2	22.4 dC	2.4 eC
Late fensulfothion gran. 2.5% 1	42.3 cdBC	7.3 deBC
Late fensulfothion gran. 2.5% 2	22.4 dC	6.7 deBC
Early lindane prills 20% 1	64.1 bcABC	10.3 cdB
Late lindane prills 20% 1	115.1 abAB	20.5 abcA
Early lindane prills 20% 2	30.2 dc	4.1 eC
Late lindane prills 20% 2	106.4 abAB	14.2 bcAB
Early DDT prills 20% 2	155.4 abAB	23.3 aA
Late DDT prills 20% 1	135.6 aA	21.8 abcA
Early heptachlor gran. 3.5% 1/2	37.2 cdBC	4.3 eC
Control	125.4 abAB	34.3 aA

TABLE 4: HAWKE'S BAY TRIAL 2

<i>Treatment</i> (lb)	<i>No. of Grass Grubs/sq ft</i>	
	(23 wk)	(45 wk)
fensulfothion gran. 2.5% 2	7 bB	4.0 bB
DDT prills 20% 2	27 aA	4.5 bB
lindane prills 20% 2	25 aA	2.0 cC
Control	25 aA	10.3 aA

The activity of organophosphate insecticides against grass grub was first reported by Fenemore (1963). Fenemore (1965) reported that, following complete elimination of grass grub with diazinon in small plot field trials, little reinfestation was noted over the following two seasons in spite of the immediate surroundings offering a source of infection. Bioassay of soil from these plots showed the absence of any material toxic to grass grub suggesting that reinfestation of an area by grass grub is slow.

Since this, many authors have reported varying degrees of success in controlling grass grub with diazinon (Kain and Christie, 1966; Rastrick and Mason, 1966, 1967). However, none of these authors have recorded sub-economic populations the season after the application.

The ability of fensulfothion to control grass grub in pot trials (Fenemore, 1965) has been shown under field conditions (Kelsey and Read, 1966; Rough and Haeske, 1966).

Two very transient insecticides, trichlorphon and fenitrothion at 2 lb, have given average control of grass grub (Kelsey and Read, 1966; McKee, 1967). However, methidathion, another transient insecticide, applied at 2 lb under field conditions appears to have little activity against this insect.

The purpose of this paper is to present, in summary, results of insecticide trials carried out within the mid North Island region of New Zealand. It is not intended to present all trial results, but results of specific trials which may illustrate particular points of interest.

METHODS AND MATERIALS

All insecticide applications were made to moist soil when rain was threatening, with the exception of Hawke's Bay Trials 1, 2 and 3.

Grass grub populations, with the exception of Hawke's Bay Trial 3, were not DDT-resistant.

Trials were set out in typical randomized block design. Plot size was 16.5 ft square (1/160th acre). No untreated areas were left between plots. All treatments were applied with an inert spreader through a perforated lidded jar.

Assessments of trials were made with a 4 in. diameter soil core or an 8 in. square spade spit. Soil samples were taken at random within plots.

Prior to analyses, all numbers were transformed to $\log(x + 1)$ and means were evaluated by Duncan's Multiple Range Test.

Soil cores for chemical analysis were taken at random from plots with a 1 in. diameter soil corer. Cores were sliced at the required levels. Between samples the corer was washed in hexane.

Particulars of the trials are summarized in Table 7.

DISCUSSION

ORGANOCHLORINES

DDT formulated as prills or granulated with superphosphate has been screened in 17 trials. In areas where the population has not been resistant, control has been efficient but extremely delayed.

In no case has a marked pasture response been observed that has not been attended by a reduction in grass grub numbers.

The delay in control following DDT application is demonstrated in Tables 1 to 4. Efficient control may not be obtained until the second

or third season following application. In only one trial, at Wairoa, have the authors recorded a significant reduction of grass grub in the season of application.

This delayed action of DDT is affected by soil type, rainfall, and the formulation of DDT.

It is well known that certain pumice soils have the ability to adsorb DDT, thus impeding its movement downward through the soil (Kain and Christie, 1966; Matthews, 1967). This phenomenon is illustrated in Table 6, which shows that DDT is concentrated in the top ¼ in. of soil nearly two years after application. This zone of soil is not usually frequented by a large proportion of the grass grub population.

Climatic conditions, such as rainfall, also have an important bearing on the speed of action of DDT. In the low rainfall areas or in dry seasons, the speed of action of DDT is much slower. For instance, in the Hawke's Bay area, DDT, as gauged by a reduction in grass grub numbers and pasture response, takes longer to work than in the Waikato area.

Different rates of action have been noted between DDT formulations. Apart from Stauffer pellets, which gave little control over three seasons, prilled formulations appeared to be slower acting and less efficient than granulated DDT-superphosphate. These trends were significant and are recorded in Tables 1 and 2.

TABLE 5: HAWKE'S BAY TRIAL 3

<i>Treatment</i> (lb)	<i>No. of Grass</i> (25 wk)	<i>Grubs/sq ft</i> (45 wk)
fensulfothion gran. 2.5% 2		4.1 bB
DDT prills 20% 2		16.0 aA
lindane prills 20% 2		16.6 aA
Control		25.6 aA

TABLE 6: RESULTS FROM DDT AND LINDANE ANALYSES OF SOIL CORES TAKEN FROM TAUPO TRIAL 5

<i>Weeks</i> <i>After</i> <i>Treatment</i>	<i>Lindane</i>		<i>DDT</i>	
	<i>Depth</i> <i>within</i> <i>Profile</i> (in.)	<i>ppm</i> <i>Air Dry</i> <i>Soil</i>	<i>Depth</i> <i>within</i> <i>Profile</i>	<i>ppm</i> <i>Air Dry</i> <i>Soil</i>
43	0—½	2.1	0—½	5.5
	½—1	8.1	½—1	2.5
	1—2	0.1	1—2	trace
			2—3	nil
103	0—½	0.2	0—¼	7.2
	½—1	nil	½—1	1.05
	1—2	nil	1—2	0.1
			2—3	0.1

Heptachlor applied at 1 lb or 8 oz has been observed to give excellent control in all trials. Although it appears to be slow acting, application in September gave excellent control in the ensuing season.

Lindane has been screened in five trials and has given extremely good results. However, it is apparent from the results in Tables 3, 4 and 5, that it is slower acting than fensulfothion and has a speed of action similar to heptachlor. Both lindane and heptachlor are much faster acting than DDT, even in pumice soils. This may be attributable to the higher water solubility of both chemicals. Like heptachlor, lindane applications should be made in early September if control is to be expected in the ensuing season. Results have shown that lindane has performed better at a 2 lb than a 1 lb rate.

How long lindane persists in the soil is not known, but unlike heptachlor, which seems to exert control over a five-year period (Rastrick and Mason, 1966), lindane appears to be much more transient. From Table 8 little seems present after two years and in some soils it is probable that the active life of this chemical may be no more than 12 to 16 months.

ORGANOPHOSPHATES

Control of grass grub with diazinon at 2 lb has ranged from good to extremely poor. The most efficient results have been obtained on the pumice soils, while on the heavier, more humic soils of the Waikato diazinon has not given a significant depression in grass grub numbers. Failure of diazinon on heavy soils may be caused by the adsorption of the chemical by the soil organic matter. The adverse effect of organic matter on the performance of this chemical has been documented by Harris (1966).

Results gained with fensulfothion have been much more consistent than diazinon, with the 2 lb rate proving more efficient than the 1 lb rate. The percentage reduction in grass grub has ranged from 95% to 62% for the 2 lb rate, and 86% to 50% for the 1 lb rate. Fensulfothion at 2 lb gave remarkable results in the Hawke's Bay trials in view of the fact that no rain fell for a fortnight following application.

September or prepupal-pupal application of fensulfothion gave exceptionally good results, indicating that this insecticide is particularly persistent for an organophosphate. Applications made at this stage gave earlier pasture responses than the mid-January application and a numerically lower grass grub population in August.

Theoretically, application at this time should be more efficient as it enables the insecticide to be present in the soil over the pupal, beetle, egg and first instar larval stages. These stages may be more susceptible to control than the more mature larval stages.

N2790 and trichloronate at 1 and 2 lb have proved very disappointing. The former did not give a significant depression in grass grub numbers in any trials. Trichloronate, on the other hand, gave a significant reduction and pasture response in one trial, although the degree of control was poor.

The more transient chemicals, such as trichlorphon, methidathion and chlorfenvinphos, appear, under the conditions of screening, to have little activity against grass grub.

The high degree of control given by diazinon and fensulfothion (Taupo Trials 1 and 2) in the year of application was carried into the following

TABLE 7: DETAILS OF TRIALS

<i>Trial</i>	<i>Soil Type & Ref. No.*</i>	<i>Weather after Application</i>	<i>Stage of Life-cycle</i>	<i>Weeks from Application to Assessment</i>
Taupo:				
1	Taupo sandy silt 18	Rain after 48 hr	3rd instar	8, 52
2	Taupo sandy silt 18	Rain after 48 hr	3rd instar	105
3	Taupo sandy silt 18	Rain after 24 hr	Pupae and 2nd instar	10
4	Taupo sandy silt 18	Treated in rain	3rd instar	6
5	Taupo sandy silt 18	Rain after 72 hr	3rd instar	
Puahue:				
1	Pukerata clay loam 60 eh	Treated in rain	3rd instar	12
2	Pukerata clay loam 60 eh	Rain after 48 hr	3rd instar	12
3	Pukerata clay loam 60 eh	Rain after 12 hr	3rd instar	8
Morrinsville:				
1	Hamilton clay loam 83	Treated in rain	3rd instar	12
2	Tauwhare sandy loam 44C	Rain after 72 hr	3rd instar	12
3	Tauwhare sandy loam 44C	Rain after 12 hr	3rd instar	12
Putaruru:				
1	Tirau sandy loam, hill soil 574	Rain after 4 days	3rd instar	10
Hawke's Bay:				
1	Takapau silt loam 75	No rain for a fortnight	mixture of 2nd & 3rd instar	23
2	Taupo light sandy loam 18g			23
3	Takapau stony loam 75b			23

*Reference Nos. as found in *Soil Bureau Bulletin No. 5.*

TABLE 8: PERCENTAGE REDUCTION OF GRASS GRUB RESULTING FROM ORGANOPHOSPHATE INSECTICIDES IN THE SEASON OF APPLICATION

Treatment (lb)	Taupo			Puahue			Morrinsville			Putaruru		Hawke's Bay		
	1	2	3	4	5	1	2	3	1	2	3	1	2	3
fensulfothion 2.5% gran. 1				70.5	78.8†							83.2	72.0	84.9
fensulfothion 2.5% gran. 2	90.3			84.1	81.5									
diazinon 5% gran 1				NS*					NS					
diazinon 5% gran. 2		86.4		60					NS					
trichloronate 5% gran. 1									NS					
trichloronate 5% gran. 2									NS					
trichlorophon 2.5% gran. 1									NS					
trichlorophon 2.5% gran. 2									NS					
N2790 5% gran. 1									NS					
N2790 5% gran. 2									NS					
chlorfenvinphos 5% gran. 1														
chlorfenvinphos 5% gran. 2														
methidathion 5% gran. 1														

*NS=Not significant at the 1% or 5% level.

†Results are the late treatments from Table 3.

season as a significantly lower number than control. Although lower, the numbers of 13.2 grass grubs per square foot, present in both treatments in the season following application, were economically important, while in the second season following application, numbers were numerically higher than the controls.

Fenemore (1965) demonstrated on small plot trials that reinfestation of an area following complete elimination of a population is extremely slow, and that two seasons following application grass grub numbers in these areas were very low. The attainment of this situation is an extremely important factor in the economics of grass grub control with organophosphates. Therefore work into the degree of control needed to obtain this effect and how this can be obtained on a paddock basis with the present chemicals and spreading equipment merits attention.

Further work on the prepupal or pupal applications of the more persistent organophosphates, such as fensulfothion, may contribute to increasing the efficiency of control and the attainment of this vacuum effect as described by Fenemore (1965).

CONCLUSIONS

Results obtained from lindane at 2 lb are most encouraging, especially where DDT-resistant populations are present. Applications of this material should be made prior to the beetle season in September or October as lindane appears relatively slow acting.

DDT formulated in superphosphate granules or as prills, whether gauged by pasture response or grass grub numbers, has a slower action than either lindane or heptachlor. When compared with organophosphates such as diazinon or fensulfothion, the organophosphates were better in the season of application, equal to DDT in the season following application, and markedly inferior in the following season.

On the basis of these findings, in the non-dairying areas where grass grub is not resistant to DDT, and is a recurring problem, the organophosphates are a poor substitute for proofing pastures with DDT.

In situations where no alternative exists, such as on dairy farms, organophosphates should be used with the knowledge that only one season's depression of grass grub is likely.

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