GRASS-GRUB CONTROL: FIVE SEASONS' RESULTS

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Summary

Results from five years' field trials for the control of grass-grub (*Costelytra zealandica*) are discussed. Complete control from one application of heptachlor at 2 lb has been maintained for five seasons. Variable results with diazinon are presented, and the specific conditions under which successful control may be obtained are discussed. The consistent failure of DDT at the standard treatment of 2 lb to give complete control is noted. Limited results with some other insecticides are presented.

INTRODUCTION

GRASS-GRUB (*Costelytra zealandica*) is accepted as New Zealand's most important pasture pest. Chemical control with DDT has been widely practised over the last fifteen years but, owing to signs of ineffectiveness, either from the development of tolerant strains or from the lack of penetration of the DDT in certain allophane clay soils, there has been an increasing need for alternative insecticides.

Since 1961, ten small plot trials and thirty-four large-scale field trials have been conducted to investigate a range of potential chemicals for the control of grass-grub on sites ranging from the North Island volcanic plateau to the silt loams of Southland. Application times have varied from the early second instar stage in March to the pre-pupation stage in late August, for both DDT susceptible and resistant strains of grass-grub. The most effective treatments have been heptachlor at 0.5 to 2 lb (expressed as active ingredient per acre) for long-term residual control and at not less than 2 lb diazinon for high initial kill.

EXPERIMENTAL

All large-scale treatments were applied as granule formulations based on calcite, limestone, walnut shell or attapulgate clay cores.

In 1963, applications were made with a 12 ft Gandy Lo-Hi Granular applicator, and since 1964 a landrover-mounted Vicon Vari-Spreader Mark I with a swath width of 18 ft was used. Assessment of these trials was made by a visual estimate (0 to 10 scale: 0 = no response, 10 = complete response) of pasture recovery.

The plot size of the small-scale trials was normally 15 ft × 14 ft 6 in. Treatments were randomized and replicated seven to ten times. The granules were applied with a New Zealand manufactured modification of the precision granular applicator described by Henderson (1962) using the application technique reported by Fenemore and Fleming (1964). Any spray treatments were made in the rain with an Oxford precision sprayer applying 30 gal of water per acre at 30 lb/sq. in. pressure. Larval counts were made on three

TABLE 1: LARGE-SCALE TRIALS SHOWING PASTURE RESPONSE TO TREATMENTS

<i>Treatment Date</i>	<i>Location</i>	<i>Soil Type</i>	<i>Treatment Showing Response (lb)</i>
Apr. 2, 1963	Halkett, Canterbury	Silt loam	diazinon (5%) 0.5, 1, 2 DDT (10%) 2
Apr. 6, 1963	Cheviot, Canterbury	Clay loam	diazinon (5%) 1, 2
May 30, 1963	Tataraimaka, Taranaki	Sandy loam	heptachlor (10%) 1, 2 DDT (10%) 2
Jun. 7, 1963	Normanby, Taranaki	Volcanic loam	heptachlor (10%) 1, 2 DDT (10%) 2
Jun. 11, 1963	Normanby, Taranaki	Volcanic loam	DDT (10%) 2
Mar. 6, 1964	Turangi, Taupo	Pumice	diazinon (5%) 1
Apr. 10, 1964	Okaiawa, Taranaki	Volcanic loam	diazinon (10%) 2
Apr. 23, 1964	Atiamuri, Rotorua	Pumice loam	diazinon (10%) 1, 2 diazinon (5%) 1

randomized samples of 1/6th sq. ft and 6 in. deep, taken from each plot using a soil coring device.

RESULTS AND DISCUSSIONS

LARGE-SCALE APPLICATIONS

Of the 34 large-scale trials laid, only 8 contained treatments which showed a visual pasture response compared with the growth in the untreated control plots (Table 1).

Although DDT at 2 lb and diazinon at 0.5 to 2 lb were included in all trials, a visible pasture response was observed from DDT in only four trials, and from diazinon in five trials. Heptachlor was used in six trials, the two laid in 1963 showing excellent visual responses the next season when growth conditions in the untreated controls were poor. However, none of the four trials laid in 1964 showed a visual response over that in the untreated controls in the following seasons when all treatments, including the controls, carried an abundance of pasture growth.

SMALL PLOT TRIALS

In the ten small plot trials laid, twelve insecticides were used at various rates (Table 2). Only six compounds showed activity towards grass-grub, namely the organophosphate compounds, bromophos-ethyl, diazinon and Stauffer N 2790, and the organochlorine compounds, DDT, heptachlor and isobenzan.

TABLE 2: INSECTICIDE TREATMENTS USED IN SMALL PLOT TRIALS

<i>Treatment (lb)</i>	<i>Treatment (lb)</i>
bromophos-ethyl 2	isobenzan 0.0625, 0.25, 0.5
carbophenothion 1	lindane 2
DDT 2	Stauffer N2790 1, 2
diazinon 0.5, 1, 2	phorate 1
endosulfan 2	Union Carbide 16888 (UC8035) 1, 2
heptachlor 0.5, 1, 2	zinophos 1

From all the trial results listed in Table 3, DDT at 2 lb, the standard treatment, did not give more complete control than 82% reduction of grass-grub in any trial.

In a DDT-resistant strain on a Lismore silt loam soil, bromophos-ethyl 2 lb and Stauffer N 2790 1 and 2 lb along with diazinon 2 lb all gave significant reduction of larvae within seven weeks of application.

Ideal moisture conditions occurred in this trial with treatments applied to moist soil and with adequate rain following for soil penetration of the insecticides. No doubt these conditions greatly aided the rapid response observed in the form of significant reduction in larval infestation and in pasture response, especially in the case of the diazinon 2 lb. However, in general, diazinon 1 and 2 lb has tended to give variable control of grass-grub. When applied as a spray with light rain only at the time of application, or as a granule in fine weather, followed by rainfall within one week, the 2 lb rate gave between 22% and 89% reduction in larval counts. Diazinon at 1 lb has given between 30% and 50% reduction in numbers and this rate appears insufficient for consistent field results.

TABLE 3: SUMMARY OF SMALL PLOT FIELD TRIALS

TRIAL 1: WAVERLEY, WANGANUI: Treated March 13, 1962 (primarily *Pyronota* sp. with subsequent re-infestation of *Costelytra zealandica*)

Treatment (as sprays) (lb)	Larval Counts (grubs per sq. ft)					
	2	4	7	Months		
				13	26	38 50
Heptachlor 2	8.5	5.2	1.5	0.3	0.0	0.0 0.2
DDT 2	27.3	15.9	6.0	4.7	7.8	4.3 2.2
Diazinon 2	22.1	27.4	14.2	26.4	32.0	11.7 5.7
Lindane 1	36.6	26.8	17.6	19.0	29.8	13.4 5.4
Untreated	42.1	40.1	21.8	22.9	27.2	10.8 5.5
	*9.1	8.1	5.5	9.1	11.3	4.7 3.4
	**12.1	11.8	7.4	12.1	15.1	6.3 4.5

Rainfall: Rain at treatment; 0.20 in. (1 day); 0.20 in. (7 days)

TRIAL 2: OMATA, TARANAKI: Treated April 24, 1963

Treatment (lb)	Larval Counts (grubs per sq. ft)			
	3	12	Months	
			25	37
Heptachlor 2	10.2	0.0	0.0	0.0
Heptachlor 1	11.4	0.6	0.0	0.6
Isobenzan 0.5 (spray)	1.2	0.0	0.0	0.3
Isobenzan 0.25 (spray)	2.4	0.0	0.0	0.0
DDT 2	16.8	18.4	1.2	5.1
Diazinon 1 (spray)	8.4	7.7	2.6	2.3
Diazinon 2	19.2	10.6	4.3	3.6
Untreated	13.8	12.9	2.9	5.4
	*6.6	8.7	1.6	2.6
	**8.8	12.3	2.1	3.5

Rainfall: Rain at treatment; 0.30 in. (1 day); 2.30 in. (7 days)

TRIAL 3: HALKETT, CANTERBURY: Treated May 2, 1963

Treatment (lb)	Larval Counts (grubs per sq. ft)		
	3	Months	
		5	12
Heptachlor 2	20.4	9.8	0.4
Heptachlor 1	21.6	6.8	0.4
Isobenzan 0.5	14.4	2.4	0.2
Isobenzan 0.25	16.5	2.2	0.2
DDT 2	26.4	16.8	2.4
Diazinon 2	13.0	2.6	3.0
Diazinon 1	20.0	6.2	2.8
Untreated	38.1	15.8	3.8
	*8.4	5.6	2.0
	**11.1	7.4	2.7

Rainfall: Fine at treatment; 0.30 in. (1 day); 0.50 in. (7 days)

TRIAL 4: TATARAIMAKA, TARANAKI: Treated May 28, 1963

Treatment (lb)	Larval Counts (grubs per sq. ft)			
	2	13	Months 25†	37‡
Heptachlor 2	14.0	0.0	0.0	0.0
Heptachlor 1	14.0	0.2	0.0	0.0
Heptachlor 0.5	15.0	0.4	0.18	0.0
Isobenzan 0.5	9.0	0.0	0.0	0.0
Isobenzan 0.25	13.0	0.0	0.36	0.4
DDT 2	9.0	7.0	0.18	0.8
Diazinon 2	16.0	13.4	1.56	0.6
Untreated	15.0	16.8	0.6	1.2
	*7.5	6.1		
	**9.9	8.1		

Rainfall: Showery at treatment; 0.87 in. (1 day); 1.59 in. (7 days)

† Only 20 larvae found in whole trial area

‡ Only 24 larvae found in whole trial area

TRIAL 5: HALKETT, CANTERBURY: Treated July 2, 1963

Treatment (lb)	Larval Counts (grubs per sq. ft)		
	1	3	10
Heptachlor 2	19.9	9.4	0.0
Heptachlor 1	15.4	6.7	0.25
Heptachlor 0.5	16.5	7.2	2.25
Isobenzan 0.5	15.4	5.2	0.0
Isobenzan 0.25	16.1	4.9	0.0
DDT 2	24.0	13.1	2.75
Diazinon 1	15.4	4.5	9.25
Untreated	19.9	9.4	14.25
	*11.2	7.6	7.5
	**14.8	10.1	9.9

Rainfall: Fine at treatment; 0.10 in. (1 day); 1.70 in. (7 days)

TRIAL 6: WAVERLEY, WANGANUI: Treated August 24, 1963

Treatment (lb)	Visual Pasture Response 10 Months	Larval Counts (grubs per sq. ft)		
		Months 10	21	33†
Heptachlor 2	9.6	2.6	0.18	0.4
Heptachlor 1	9.2	5.2	1.4	0.0
Isobenzan 0.5	9.7	0.0	2.2	0.0
Isobenzan 0.25	9.4	0.8	4.8	0.2
DDT 2	8.4	18.0	5.4	0.4
Diazinon 2	7.1	41.8	17.4	2.4
Untreated	6.8	38.4	13.2	2.8
		*14.6	8.8	
		**19.4	11.7	

Rainfall: Fine at treatment: Nil (1 day); Nil (7 days)

† Only 55 larvae found in the whole trial area

TRIAL 7: CAREW, CANTERBURY: Treated April 2, 1966 (DDT-resistant strain)

<i>Treatment (lb)</i>	<i>Visual Pasture Response Months 2</i>	<i>Larval Counts (grubs per sq. ft) Months 2</i>
Diazinon 2	9.5	12.6 aA
Heptachlor 1	5.5	55.4 bB
Bromophos-ethyl 2	5.6	62.6 bcB
Stauffer N 2790 2	4.7	70.0 bcB
Heptachlor 0.5	3.9	72.2 bcB
Stauffer N 2790 1	4.2	82.0 cB
Endosulfan 2	1.7	115.6 dC
Untreated	2.4	110.6 dC
		CV 25.5%

Rainfall: Overcast at treatment: 0.25 in. (1 day); 0.5 in. (7 days)

It has been shown that, unless very high initial control is obtained with diazinon, control is not likely to continue into the next season because of the soil degradation of the active ingredient (Fenemore, 1964).

Isobenzan included in the trials for four seasons maintained a population reduction of 80 to 100% at the low rates of 0.25 and 0.5 lb.

Heptachlor at 0.5, 1.0 and 2.0 lb has given excellent results irrespective of weather and soil conditions at time of, and following application.

In Trial 1 the heptachlor 2 lb has maintained 96 to 100% reduction in population for five seasons. The initial toxicity effects of heptachlor appears slow, with only limited reduction of populations occurring in the season of application but with a consistent lack of development of an infestation in the following season, probably due to control of hatching first instar larvae.

CONCLUSIONS

It is evident that adequate control of grass-grub can be obtained under specific conditions with insecticides alternative to DDT. The recommended treatment of DDT 2 lb (Kelsey, 1955) appears to exert less than perfect control, as in no instance in the present trials were larval populations reduced by more than 82%, often with only limited to nil pasture response.

In laboratory screening trials, N 2790 has been shown to have an initial toxicity rating of 1.6 times that of diazinon and to be of equal soil persistence over a 14-day test period (Fenemore, 1965). Although in one trial significant initial larval toxicity was obtained with N 2790 along with bromophos-ethyl, both were clearly inferior to diazinon in elimination of larvae and pasture response.

Although a visual pasture response has been gained from diazinon application as low as 0.5 lb, it is believed that 2 lb is the minimum rate likely to give acceptable control on a practical basis. It appears that, to obtain maximum effectiveness from this rate, the soil must be moist at the time of treatment and there must be

sufficient rainfall within one week of application to carry the toxicant down to the zone of larvae, as was evident in the very moist soil in Trial 7. This may be achieved more easily when the larvae are actively feeding close to the surface. It has been shown (Fenemore, 1964) that, if an initial mortality of nearly 100% can be achieved, a high level of control for three generations of grass-grub may be maintained, even though bio-assays of the soil failed to demonstrate toxicity from any residual diazinon. However, the inconsistency of diazinon to give an initial kill of larvae in excess of 66% makes treatment economically justifiable only where heavy infestations of DDT-resistant grass-grub occur.

Although isobenzan has given excellent control of grass-grub at 0.25 and 0.5 lb, its use will probably be unacceptable because of its very high mammalian toxicity through both oral and dermal routes. It also appears highly toxic to earthworms (Fenemore, 1964).

The results show heptachlor at 2 lb to be effective for the control of grass-grub for at least five seasons, giving at least 80 to 100% reduction in larval populations. Excellent control of DDT-tolerant strains has also been achieved in Nelson and in field-scale applications in Taranaki and Canterbury with heptachlor 1 lb. With the announced abandonment of the concept of zero tolerance by the U.S. authorities, and the present endeavours to secure a finite tolerance (C. C. Billington, pers. comm.), and despite the known possibility of residue hazards, this compound should not be ignored.

It is evident that grass-grub control is most easily obtained with the persistent insecticides of the organochlorine type, as the transient compounds such as diazinon appear incapable of giving prolonged control unless the high initial kill of larvae can be achieved.

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