GRASS-GRUB CONTROL IN PROBLEM SOILS

W. M. KAIN AND R. W. CHRISTIE

Research Division, Department of Agriculture, Hamilton

Summary

Diazinon and fensulfothion have been shown to give efficient control of grass-grub (*Costelytra zealandica*) in the season of application and in two trials this reduction of numbers was carried into the second season. Heptachlor gave excellen. control of grass-grub in the season following application at rates of ½ lb a.i./acre. DDT formulations gave delayed control and damage was observed in the season after application. Differences in efficiency of DDT formulations were observed for which no explanation can be offered.

INTRODUCTION

IT IS CURRENTLY held by farmers of the Central Plateau and other areas that control of grass-grub *Costelytra zealandica* with DDT applied to newly developed areas suffering from grass-grub attack gives poor control.

As the major part of these areas are in various stages of development, the main aim of which is the introduction of desirable grass species, much development work is negated by severe grass-grub damage.

The ineffectiveness of DDT does not seem to apply to other organo-chlorine insecticides such as heptachlor, dieldrin and isobenzan, all of which have given excellent control following surface application of the prilled formulation (R. Clare, B. Mills, pers. comm.), although other workers in this area are of the opinion that heptachlor and chlordane are also ineffective.

Farm advisory officers have recognized this problem for many years and have carried out soil sampling of areas treated with DDT in which poor control has resulted. Chemical analyses of these soil samples (cores) have revealed that there is little or no penetration of DDT past the top inch of these soils (R. Gordon, pers. comm.). From such results it would seem that DDT failure is due to the fact that the grass-grub lives beneath this toxic layer. Fenemore and Perrott (1965) observed this poor penetration of DDT on a trial site where poor control was recorded and the grubs were susceptible to DDT.

Gallaher and Evans (1961) noted that certain volcanic New Zealand soils promote catalytic degradation of DDT at elevated temperatures. These authors also noted that the downward migration of DDT within the soil was completed at three months whether DDT was formulated as wet or as dry mix DDT superphosphate. This work was carried out on Papatoetoe silt loam. From the work of these authors it was concluded that there was little difference in the rate of penetration of these two formulations under high rainfall. Breakdown of DDT in this soil type over a period of 52 weeks was noted only in the top inch. As the speed of breakdown was not affected by application rates, it was assumed that the process was unimolecular in nature which would indicate bacterial breakdown rather than adsorption, to the soil colloids.

Bourke (1963) in a review article cited literature which pointed out that certain soils in Germany are able to adsorb DDT, rendering it biologically inactive to a *Drosophila* bioassay but ingestion of this soil by scarabs results in high mortalities, suggesting that the gut is capable of extracting the adsorbed DDT.

METHODS AND MATERIALS

Trials reviewed in this paper were laid out in 1965 and 1966. All trials were sited in two localities, Broadlands near Taupo on Taupo sandy silt loam and at Puahue near Te Awamutu, on Pukerata clay loam, the parent material of which is Mairoa ash. Both soil types are free working and are favoured by grass-grub.

The two 1965 trials sited at Taupo were adjoining each other. These were initiated to screen all available DDT, pelleted formulations, to assess two short residual insecticides, namely, diazinon and fensulfothion, and also to assess heptachlor. The 1965 trial at Puahue was to assess a prilled and granulated formulation of DDT and two Bayer organophosphate insecticides, fensulfothion and S4400.

For convenience, the 1965 Taupo trials were designated Taupo Trial A and Taupo Trial B and the Puahue trial, Puahue Trial A.

Taupo Trial C and Puahue Trial B were set out in 1966 as screening trials to screen various organophosphate insecticides with diazinon and fensulfothion.

The insecticides rates and formulations are shown in the ensuing tables.

Applications were made in all trials to moist soil when rain was threatening. All trials were set out in a typical randomized block layout. Plot size was 16.5 ft × 16.5 ft, giving a plot area of 1/160th of an acre. No untreated areas were left between plots.

All treatments were spread by hand usng a pumice filler; insecticide rates of application are given in lb a.i. per acre.

Assessment of all trials with the exception of Puahue Trial A was carried out by using a 3 in. diameter soil corer cutting to a depth of 8 in. Sixteen cores were taken per plot in a stratified manner (4 rows × 4 rows) giving a total sample area per plot of approximately 0.8 sq. ft. The repeatability of results using this method of sampling were very encouraging as the soil depth and texture in newly developed pumice areas is not uniform, and this, allied with the characteristic spatial distribution of grass-grub, calls for adequate pre-sampling and a large number of small samples per plot.

Soil sampling in Puahue Trial A was carried out by digging three spade spits per plot. Grub counts given in this table are in grubs per 3 sq. ft.

Prior to analysis all grub numbers were transformed by log +1, with the exception of Puahue Trial A where the grub numbers were so low that a square root transformation was used.

All results were evaluated by the Duncan's Multiple Range Test.

All chemicals used were donated by various agricultural chemical firms.

DISCUSSION

In all trials laid down in 1965, control was only registered in the season of application with diazinon, fensulfothion and S4400 treatments, fensulfothion and diazinon appearing the more promising. The difference in numbers in the Taupo trials between

TABLE 1: TAUPO TRIAL A, TWO SEASONS' RESULTS
Mean Grub Counts per 0.8 sq. ft

Treatment (lb)	*Mid-Late 3rd Instar (8 wk)**	*Prepupal Stage (21 wk)*	*1st Instar (37 wk)*	*Mid 3rd Instar (52 wk)*
DDT prills 20% 2	39 abAB	17 aA	50 aA	15 bcBC
DDT Stauffer pellets 33% 2	20 bBC	20 aA	63 aA	23 abAB
DDT gran. 0.9% super. pan 2	35 abAB	17 aA	60 aA	13 cBC
DDT gran. 0.9% super. blunger 2	59 aA	20 aA	64 aA	15 bcBC
Heptachlor granules 3.25% ½	42 aAB	19 aA	9 cB	1 dD
Methidathion 5% 1	35 aAB	16 aA	95 aA	31 aA
Fensulfothion 2.5% 1	4 cC	4 bB	15 bB	11 cC
Control	41 aAB	22 aA	69 aA	26 aA
CV	15.3%	5.4%	9.0%	5.8%

* Figures in parentheses denote number of weeks after application of insecticides.

TABLE 2: TAUPO TRIAL B, TWO SEASONS' RESULTS
Mean Grub Counts per 0.8 sq. ft

Treatment (lb)	*Mid-Late 3rd Instar (8 wk)**	*Prepupal Stage (21 wk)*	*1st Instar (37 wk)*	*Mid 3rd Instar (52 wk)*
DDT prills 20% 2	45 aA	24 aA	38 abA	13 bcAB
DDT Stauffer pellets 33% 2	36 aA	19 aA	49 aA	22 abA
DDT gran. super. pan 0.9% 2	42 aA	18 aA	15 bcAB	5 dC
DDT gran. 0.9% super. blunger 2	40 aA	21 aA	30 abA	7 cdBC
Diazinon granules 5% 2	6 bB	5 bB	8 cdBC	11 bcAB
Heptachlor granules 3.25% ½	43 aA	18 aA	4 dC	0 eD
Heptachlor granules 3.25% 1	33 aA	18 aA	5 dC	0 eD
Control	45 aA	23 aA	38 abA	25 aA
CV	6.97%	10.1%	13.2%	11.3%

* Figures in parentheses denote number of weeks after application of insecticides.

TABLE 3: PUAHUE TRIAL A, TWO SEASONS' RESULTS
Mean Grub Counts per 3 sq. ft

Treatment (lb)	*3rd Instar (8 wk)**	*Late 3rd Instar (20 wk)*	*Early 2nd Instar (43 wk)*	*Mid 3rd Instar (52 wk)*
DDT prills 20% 2	103 aA	41 aA	9 abA	5 aA
S4400 2.5% 1	58 bB	21 bB	9 abA	3 aA
DDT gran. super. pan. 0.9% 2	110 aA	42 aA	5 bB	2 bA
Fensulfothion 2.5% 1	17 cC	5 cC	7 bA	3 aA
Control	116 aA	52 aA	15 aA	4 aA
CV	22.6%	29.5%	17.6%	4.89%

* Figures in parentheses denote number of weeks after application of insecticides.

TABLE 4: PUAHUE TRIAL AND TAUPO TRIAL C, FIRST SEASON'S RESULTS
Mean Grub Counts per 0.8 sq. ft

Treatment (lb)	*Puahue Trial B (6 wk)**	*Samplings Taupo Trial C (7 wk)*
Chlorfenvinphos 10% 1	19 abcAB	37 abAB
Chlorfenvinphos 10% 2	24 aA	47 abA
Fensulfothion 2.5% 1	9 dD	13 cdD
Fensulfothion 2.5% 2	7 dE	7 dE
Diazinon 5% 1	16 bcBC	26 bcBC
Diazinon 5% 2	13 cC	18 cCD
N2790 5% 1	22 abA	51 aA
N2790 5% 2	—	46 abA
Control	18 abcAB	44 abA
CV	4.72%	7.79%

* Figures in parentheses denote number of weeks after application of insecticides.

the two 1965 samplings of fensulfothion and diazinon treatments is negligible, indicating that after eleven weeks these insecticides have been broken down and/or dissipated from the soil. This situation appears parallelled at Puahue where the fall off in numbers in both fensulfothion and S4400 is approximately equal to the fall off in numbers in the untreated plots. This reduction was due to a severe infestation of the native milky disease. Grub numbers in the Taupo trials where this disease was absent and the grub numbers were much higher, fell in the controls and all other treatments (which did not register a reduction in the first sampling) in approximately the same proportions. Fensulfothion, diazinon and DDT Stauffer pellets (in Taupo Trial A only) did not register this reduction. Stauffer pellets in Taupo Trial A exemplifies this situation where, after first 1965 sampling, some measure of control was achieved (50%). However, in the second 1965 sampling, numbers were not significantly different from the untreated nor had they exhibited a further decrease. It would therefore appear that the decrease in numbers in these plots was due to a density dependent factor, probably cannibalism, the incidence of which would be reduced with a reduction in density. This trend was absent in treatments where a reduction was induced by the insecticide.

Heptachlor and DDT formulations (with the exception of Stauffer pellets in Taupo Trial A) gave no control in the year of application.

In the first sampling of the second season (1966) in Taupo Trial A, the grub numbers of fensulfothion-treated plots rose to a mean of 15 per 0.8 sq. ft which is significantly better than all other treatments with the exception of heptachlor at ½ lb. In the second sampling, which was carried out on the third instar, it was not significantly different from DDT prills, or pan and blunger granulated DDT superphosphate.

In Taupo Trial B at the first sampling of the second season diazinon, treatments did not differ from the heptachlor treatments or DDT pan granulated super. In the second sampling in this season diazinon was not significantly different from all DDT formulations except DDT pan granulated superphosphate.

DDT formulation treatments on these two Taupo Trials with the exception of DDT pan granulated superphosphate did not give a significant reduction of grub numbers compared with the untreated control plots until 37 weeks after laying down, but had given a significant reduction after 52 weeks.

In Puahue Trial A in the second season grub numbers were below control (significant at 5% level) but in the second sampling this trend was not significant. DDT pan granulated superphosphate gave significant control in both samplings although only at the 5% level in the second sampling. DDT prills in this trial gave no significant reduction. Results in this trial must be treated with certain reservations as numbers in this trial were low owing to a severe infestation of milky disease.

From trials laid down in 1965 it is apparent that heptachlor in the season after application gave excellent results at the first instar stage, as did fensulfothion and diazinon.

Three questions arise from Taupo Trials A and B concerning DDT.

(1) Why did DDT not give a suppression of beetles emerging and re-entering the soil as shown by 1st instar larval numbers?

(2) Why was there not a significant reduction in first instar larvae, as observations during sampling showed that a large number of these were in the turf mat while an equally large number were in the top inch of soil? A significant reduction in grub numbers became apparent only at the second and third instar stage in the season after application.

(3) Why were some formulations of DDT better in one trial than in the other when trial sites were adjoining each other, on the same soil type and aspect?

The answer to these questions may be explained by the fact that DDT, as has already been stated, is retained in the top inch of soil in this area (R. Gordon, pers. comm.) probably owing to adsorptive forces characteristic of these soils. These adsorptive forces may render DDT biologically inactive. However, at the second and third instar stages, grubs may ingest large amounts of organic matter and with the breakdown of organic matter in the grubs' gut DDT may be released. At the first instar stage, grubs may ingest less organic matter in relation to their body size and may feed largely on living material. Miller (*lit. cit.* Dumbleton, 1942) observed that second and third instar grubs may be cultured to adults solely on organic matter, but first instar larve could not. Bourke (1963) reported an instance where DDT contaminated soil had no contact toxicity, but killed scarabs which ingested it.

No explanation can be offered for the differing efficiencies of DDT formulations with the exception of Stauffer pellets. With this formulation DDT may be bound within the formulation and not released and the immediate reduction of grub numbers shown shortly after application is probably due to free DDT adhering to this formulation.

The differing trends of treatments applied to two adjoining trials at Taupo are characteristic of the pattern of DDT failure found within this area (R. Moody, pers. comm.). Localized areas within paddocks may show no reduction in grub numbers following DDT application. However, chemical analysis of the soil for DDT has shown no difference in DDT content between areas exhibiting good control and poor control.

In early June, 1966, an assessment of the treatments was made on Taupo Trials A and B after the site had been heavily grazed. The criterion of assessment was turf pulling. Prilled and Stauffer formulations of DDT were showing turf pull while pan and blunger DDT formulations also exhibited pulling in Taupo Trial A but not in Taupo Trial B. Heptachlor, diazinon and fensulfothion treatments possessed good turf mats, and exhibited no pulling.

The results of Taupo Trial C and Puahue Trial B showed that fensulfothion was the most promising organophosphate for control of grass-grub and in fact no significant reduction was noted for any other chemicals except diazinon. On Puahue Trial B, diazinon applied at 1 lb gave no significant reduction in grub numbers while at 2 lb a significant (at the 5% level) reduction in grub numbers was recorded. The performance on Taupo Trial C of diazinon showed that at the 1 lb and 2 lb rates grub numbers were reduced (significant at 5% level and 1% level, respectively).

Farm use of organophosphate insecticides for control of grass-grub in the Taupo area without further knowledge on the rate of grass-grub reinfestation, could not be recommended. Fenemore (1965) has shown that in the Nelson area the rate of reinfestation on a small plot basis following a 100% kill was extremely slow. However, machine applied treatments are unlikely to give this high degree of control, and the reproductive potential of grass-grub is such that it is capable of attaining numbers of economic consequence in the following season from 1 mated female per square foot.

Organophosphate insecticides appear to be very reliant on weather conditions, especially rain, for maximum efficiency. Two unreported trials showed differing efficiencies of fensulfothion under varying weather conditions.

CONCLUSION

The delayed action of DDT formulations is backed up with farm observations within this area in which appreciable damage has been observed the season following application. In view of Gallaher and Evans' (1961) observations and the heavy rainfall on the trial areas, maximum penetration is probably reached six months after application. Therefore delayed control of grass-grub by DDT formulations in the subsequent season would appear to be tied up with the activitv of the grubs.

Heptachlor appears to be an excellent material for pumice soils and this is substantiated by Clare and Mills (pers. comm.). Whether this is due to better penetration is not known, as no soil cores for chemical analysis were taken. Control of adults passing through the soil may be a possible explanation.

Diazinon and fensulfothion gave a reduction in grub numbers and subsequent trials Taupo C and Puahue B show the latter to be more efficient.

Before widespread use of these chemicals is made for grass-grub control, more ecological data are needed on this pest.

ACKNOWLEDGEMENTS

The valuable assistance of R. Gordon, Department of Agriculture, Taupo, is acknowledged. Thanks are extended to A. Lees, D. Pollock and E. Payne for their technical assistance.

REFERENCES

Bourke, T. V., 1963: *Insecticide Residues in Soils.* Conference on Chemical Residues in Agricultural Products 1963: Australian Institute of Agricultural Science, and Entomological Society of Australia.

Dumbleton, L. J., 1942: *N.Z. Sci. Tech., 23A*: 305.

Fenemore, P. G., 1965: *N.Z. J. Agric. Res., 8* (1): 172.

Fenemore, P. G.; Perrott, D. C. F., 1965: *N.Z. J. Agric. Res., 8* (4): 832.

Gallaher, P. J.; Evans, N., 1961: *N.Z. J. Agric. Res., 4* (2): 466.