THE FIELD TESTING OF INSECTICIDES FOR THE CONTROL OF GRASS GRUB

P. C. PALMER

ICI NZ Ltd., Palmerston North

J. G. TATTERSFIELD

Biometric Consulting Services

Summary

An appraisal is made of the strategy used in a project for the field evaluation of an insecticide against grass grub (*Costelytra zealandica*). The spread of the 28 trials gave an adequate measure of the general effectiveness of the insecticide, according to district, time and method of application, and also year-to-year variation. Improvements in trial design are suggested. A review of components of variance due to plots and samples within plots indicated how the labour of grub counting could be reduced and the sensitivity improved.

INTRODUCTION

GRASS GRUB (*Costelytra zealandica*) is undoubtedly one of the most important pests of New Zealand pastures. In the "post-DDT" era, there has been an increased allocation of resources, both from Government and industry for research work on grass grub.

Within the agricultural chemical industry, much of the research work has been concerned with field-testing of candidate insecticides, frequently of the organophosphate type.

This paper outlines the strategy adopted and the experience gained by the Research & Development Department of I.C.I. N.Z. when field testing a new insecticide in comparison with others.

PLANNING THE PROGRAMME

A consideration of the current knowledge (1969) about the pest and its control gave the following guide-lines for the project.

- (1) As grass grub was of greatest economic importance in parts of Canterbury, Hawke's Bay, Kimbolton, South Taranaki and Rotorua-Taupo, there was a need to cover these districts, especially since it had been observed that some organophosphates gave poorer results in the North Island than in Canterbury (R. L. Taylor, pers. comm.).
- (2) Knowledge of the life-cycle indicated that the time to apply relatively short-lived insecticides of the organophosphate type would be between February and April, when a large number of active larvae would be present. Because there can be changes in soil moisture and in the size and distribution of larvae within this period, differences might

be expected between "early" and "late" applications. Hence, at a number of sites, three similar trials were laid down at monthly intervals.

- (3) Because organophosphates are generally short-lived and also likely to be costly, any effects beyond the first year would be important.
- (4) Although the presence of grass grubs in a paddock can be recognized in a general way, the density of infestation is notoriously patchy. The programme would need to try to site the trials on areas that were reasonably evenly infested.
- (5) The economics of chemical control of grass grub must be decided in terms of increased pasture production, not merely reduction in grub numbers. To provide further data on the relationship between grub numbers and pasture production, the programme planned to include some pasture measurements, and these were taken on about one-third of the trials.
- (6) Because liquid formulations might be cheaper and also less weather-dependent, and because drilling of granules into the soil might be more effective than broadcasting and might lessen the possibility of damage to birds and other wildlife, comparisons of formulation and methods of application were made in some trials.
- (7) Field experience with other new insecticides, including organophosphates, had shown the need for knowledge of their effect on other species before they could be released for general use. Consequently, counts of earthworms were taken and observations made on any effects on birds.
- (8) Although the need for a study of pasture residues and toxicity to grazing animals was recognized, this was not included at the early field testing stage.

DETAILS OF TRIALS AND EVALUATION OF PROGRAMME

The trials included in the project are listed in Table 1.

TABLE 1: TIME AND LOCATION OF TRIALS

<i>Year</i>	<i>Location</i>	<i>No. of Trials</i>
1969	Mid-South Canterbury	2
1970	Hawke's Bay	3
	Kimbolton	1
	Mid-South Canterbury	5
1971	Rotorua	2
	Hawke's Bay	2
	Dannevirke	1
	Kimbolton	1
	South Taranaki	2
	Mid-South Canterbury	6
1972	Dannevirke	1
	South Canterbury	1
	Southland	1

From this range of trials it was possible to determine the general conditions under which some of the treatments were better or worse than others. It was also possible to make some judgement on the repeatability of results.

Accepting that several samples per plot would be needed at every time of counting and that several treatments were to be included in the trial design, it was considered that six replications were the maximum that could be handled. In the event, the amount of work turned out to be much greater and the precision much less than expected. In some later trials, the replication was increased to eight.

Each trial was a randomized block design, containing from six to eleven treatments, including an untreated control.

Several relatively similar rates, drilled and broadcast, were included in the hope that, should the insecticide prove effective, this programme alone would indicate the method and exact rate at which it should be recommended for use. Very sensitive trials are needed to make such comparisons and, as discussed later, these trials did not approach such sensitivity, even with a very large amount of work in counting grubs. A better approach would have been to establish first whether the material was effective at a fairly high rate, then, only if warranted, further trials of a different type would have explored the most economic rate. This principle is likely to apply to many projects of field testing new chemicals where often an attempt is made to answer too many questions in the same trial.

FIELD TECHNIQUES

The distribution of grass grubs is known to be aggregated and signs of their presence were not always clearly visible by early February when trials sites were being chosen for this project. The criterion was, therefore, to choose a site where grass grubs had been recorded the previous year and where some signs of damage, however slight, in the current year indicated that a reasonably even distribution might be expected. The technique was to select an area larger than required for the trial, mark it out into plots 12 to 18 m by 3 m wide, and count grub numbers in samples from each. Based on these counts, blocks were made up each containing enough plots for one replicate, these plots being as similar as possible and contiguous or nearly so. Thus, there were often gaps between the replicates of a trial, these being the patches of few grubs. Larvae populations on the plots included in the trials ranged from 23 to 75 per plot (*i.e.*, 230 to 750 per square metre).

The sensitivity of the trials was not usually much improved when these pre-treatment counts were used as a covariate in the analysis of later counts, and they would not have been worth while for this purpose alone. When they were used, however, to determine which plots to include, and the blocking system, they undoubtedly improved the trials. It was considered that a lower sampling intensity for these pre-treatment counts would have served as well. In future trials, the procedure would be to take 2 samples per plot and cease counting when a total of 5 grubs per sample was reached.

ASSESSMENT OF TREATMENT EFFECTS

Both the activity of the treatments and the level of the initial population were measured by counting the number of grubs in 5 samples per plot, each sample being one spade square (13.8 cm × 13.8 cm) by 23 cm deep.

Pasture production was measured by taking cuts after the trial was closed to grazing. Following each cut, the trial was grazed hard for a short period prior to closing for the next cut.

Grub counts were made one month and three months after treatment, and, on some trials, after 15 months.

The counts after one month were of little value and, in any future work, would be omitted. Usually the treatment effects were not sufficiently marked to show up as statistically significant at 5% probability although they foreshadowed the results of the 3-month counts. The variability was too great to detect possible differences in the speed of response.

SENSITIVITY OF THE TRIALS

The reliability of conclusions drawn from a trial about the relative merits of treatments depends on its sensitivity—i.e., the precision of the estimate in relation to the size of treatment effect which is of practical importance.

In analysing the counts, any treatment such as the untreated control which differed greatly from the others, was excluded and tested separately. Full details of the data analysis of the North Island trials on which the following discussion is based can be obtained from the writers. Among the treatments with homogeneous variance, the coefficient of variation tended to remain constant within each trial as the mean and standard error declined together from the precounts through to the 3-month counts. This CV ranged from 22% to 55% among trials, but by far the commonest range was between 30% and 35%. Transformation of the data to square roots or logarithms had little effect.

With an expected CV of say, 35%, a trial with 9 replicates would show as significant a difference between treatments which was 33% of the mean. For any candidate insecticide to be of practical importance, it would need to reduce grub numbers to below 50% that of control, so experiments such as these would be satisfactory for finding such treatments. However, in any single trial of this size, the relative merits of two reasonably effective treatments would not be at all well determined. One could not infer that two treatments were equivalent because they did not differ significantly, since even with 9 replicates a true difference of 30% would not necessarily be detected as significant. This shows the need for a large series of trials before a reliable assessment can be made. If one treatment is equally as often above as below another and the differences are not significant, an inference of equivalence might be possible. It also shows that a programme to estimate the best rate of a chemical needs special consideration, especially as results are expected to vary according to conditions.

PLOT SAMPLING

In most trials, increasing the number of samples per plot would not have been an efficient way of improving sensitivity since there was a component of plot variance above that due to samples. The value of increased replicates against more samples can be seen from Table 2 which shows the minimum significant difference as a percentage of the mean for combinations with similar total numbers of samples. These values are the averages from a number of trials.

Digging samples and sorting through the soil for grass grubs takes more labour than marking out plots and applying treatments. Hence, a design that gives better sensitivity for fewer samples is to be preferred even if it uses more replicates and possibly more land. However, with fewer samples per plot, it would be feasible to reduce plot size.

TABLE 2: MINIMUM SIGNIFICANT DIFFERENCE AS A PERCENTAGE OF THE MEAN

<i>No. of Replicates</i>	<i>No. of Samples Per Plot</i>	<i>Samples per Treatment</i>	<i>Minimum S.D. as % of Mean</i>
6	8	48	37.2
9	5	45	33.1
15	3	45	30.5

PASTURE PRODUCTION AND GRUB NUMBERS

There was generally a significant negative regression of dry matter yields on grub numbers among treatment means. This was because the treatments that gave large reductions in grub numbers compared with control, also showed improved pasture growth. However, relatively small differences in grub numbers, such as among similar treatments or among plots of the same treatment, were not consistently reflected in pasture production.

EARTHWORM COUNTS

The counting of the worms in the same samples as the grubs appeared to give an adequate measure of any treatment effects on these, although the analyses of these data have not been collated.

CONCLUSIONS

This project, which involved a large investment of time and labour, gave a fair assessment of the general effectiveness of the candidate insecticide according to district, time and method of application, as well as year-to-year variation. In future work, the strategy of overall scatter of trials, both in time and district, and the method of application trials, would be continued. The technique of choosing sites and of arranging blocks of plots based on prior counts was also considered to have been successful. Future work would also include the use of grub counts and pasture yields as the method of assessment. Several modifications in technique could be expected, to reduce the amount of work associated with grub counting and, at the same time, improve the sensitivity of the trials. A better strategy of treatment choice would be adopted, first establishing whether the candidate insecticide was effective at a fairly high rate, followed if warranted by further trials of a different type to explore the most economic rate. The one-month count could be omitted and the intensity of sampling in the pre-treatment counting reduced. Future trials would have more replicates, smaller plots, and have fewer samples per plot.

ACKNOWLEDGEMENTS

Thanks are due to W. F. Leonard for assistance in the preparation of this paper.