SOME EFFECTS OF PHORATE ON EARTHWORM POPULATIONS

D.G. SAUNDERS and C.D. FORGIE

Ivon Watkins-Dow Limited, Hamilton and Hastings

Summary

Results of one trial where phorate was drilled into pasture at 1 and 2 kg/ha at a period of high earthworm activity are presented. Reductions in the earthworm numbers were greatest from the 2 kg/ha rate, reaching a maximum of 55% 4 months after application which reduced to 25% after 1 year. The total earthworm population in the untreated plots doubled over this period. *Allolobophora* species, particularly the immature stages, appeared more susceptible than *Lumbricus rubellus*. Field measurements made 2-4 months after application showed that 1 kg/ha phorate had no effect on earthworms when drilled with brassica crops in summer (7 sites); but caused significant reductions (36-82%) with autumn-sown crops (7 trials).

INTRODUCTION

Earthworms play a major role in recycling and decomposing organic matter in the soil and any effect insecticides may have on their survival is therefore important.

Phorate is one insecticide reported as being toxic to earthworms (Edwards 1969), but it was not included in a detailed earthworm toxicity study undertaken in New Zealand (Martin 1976). Since phorate is widely used in New Zealand for pest control it was necessary to gather some information on its effects, particularly when drilled into the surface with small-seeded crops such as green-feed brassicas and ryegrass, cereals or pasture grasses, where it presented the greatest potential hazard.

The information was gathered initially by measuring changes in earthworm populations during field trials designed to study the effectiveness of phorate for pest control under commercial use conditions. Once the main problem areas were identified, more detailed trials were laid specifically to measure the effect on individual earthworm genera and their stages of development. This paper presents the results from one of these detailed trials as well as a summary of the field trial measurements.

METHOD

Population study

This trial was laid down near Hastings in July 1975 using a Duncan Seedliner disc drill which placed phorate 20% w/w granules to a depth of 35 mm at 150 mm spacing. The soil type was a silt loam

Proc. 30th N.Z. Weed and Pest Control Conf.

Pasture Pests

and the site a clover dominant pasture. At the time of treatment, soil moisture was 23.5% and earthworms were present in the top 100 mm of the soil profile. Soil moisture remained high throughout the duration of the trial.

To minimise the effect of migration of earthworms, each plot was 10 x 30 m, subdivided to give four subplots per treatment. One soil sample 300 mm square and 200 mm deep was taken from each subplot at six sampling times over a 12 month period. Earthworms were extracted by hand, washed with a 0.5% solution of formaldehyde and then preserved in 70% ethyl alcohol until the species could be classified using the system of Gerrard (1964). Three species occurred in the trial; *Allolobophora caliginosa*, *Allolobophora rosea* and *Lumbricus rubellus*. *A. caliginosa* and *A. rosea* were considered together because of difficulty in differentiating between the immature stages of the two species.

Although the classification of development stages within genera identified four development groups (Gerrard 1967), for the purposes of this paper all the immature stages were included in one group. The two groups were differentiated by secondary sexual characteristics:

Mature (M)	possessing fully developed clitellum
Immature (I)	without fully developed clitellum

Field trials

The drill types, granule placement and sampling techniques in the field trials were similar to those in the population study, except that all the trials were on cultivated land in Canterbury. There were two main groups of trials, and in each the phorate granules were mixed and applied with the fertilizer.

1. Large-scale (0.25-0.5 ha) single replicate blocks were sown with phorate granules and brassica seed in the summer (January-March) 1974 and 1975, to study weevil control at seedling emergence. Twelve spade-square samples (180 x 180 mm) per plot were taken for earthworm counts and treatments compared by a *t*-test on the standard error of the mean difference.

2. Smaller-scale, 3-replicate trials with 3-4 m x 20 m plots were sown with granules plus cereals or ryegrass in the autumn (April/May) 1974 and 1975 to study grass grub (*Costelytra zealandica*) control. Five earthworm samples per plot were analysed by analysis of variance.

RESULTS AND DISCUSSION

Population study

Fig. 1 shows the effect of phorate at both 1 and 2 kg/ha on the two earthworm genera. *Allolobophora* spp were the most affected, with the highest reduction (68%) occurring from 2 kg/ha 4 months after application. By comparison, the effect on *L. rubellus* was minimal.

From the first month after application there was a steady increase in the earthworm population in the untreated plots. In the case of *Allolobophora* spp, this amounted to 68% at 4 months and 98% at 12 months. Gerrard (1967) states soil moisture and soil temperature as

Pasture Pests

Fig 1. Effect of phorate on populations of two earthworm genera.
(U = untreated; P₁ = phorate 1 kg/ha; P₂ = phorate 2 kg/ha)

major population-limiting factors over the summer period. It is most likely that the increase in earthworm numbers experienced in this trial over the summer period were due to the unusually high soil moisture levels which prevailed.

In contrast to the populations in the untreated plots, populations in the phorate treatments did not begin to increase until after 4 months. By the end of 12 months, a reduction from phorate of 20% at 1 kg/ha and 37% at 2 kg/ha was still evident. However, during this time the total populations in the phorate plots had increased by 37% and 29% respectively. In this trial, therefore, the long term effect from applying phorate was to limit the potential population.

Table 1 shows that the greatest reduction of individual development stages occurred among the immature group of *Allolobophora* spp, reaching a maximum of 76% at 18 weeks. There was compara-

TABLE 1: Percent reduction of developmental stages of *Allolobophora* spp and *L. rubellus* from 2 kg/ha phorate.

Treatment	kg/ha	Dev. stage	2	4	8	18	40	53
<i>Allolobophora</i> spp								
phorate	2.0	M	25	35	-4	27	6	-17
		I	6	-4	58	76	40	50
untreated (No/m ²)		M	144	136	130	144	297	217
		I	403	342	539	779	781	869
<i>L. rubellus</i>								
phorate	2.0	M	50	16	47	25	-57	-24
		I	10	10	4	-14	28	8
untreated (No/m ²)		M	94	53	83	175	122	81
		I	217	186	225	78	436	572

Pasture Pests

tively little effect on the mature stages. The most likely reason for this result is that immature and small earthworms occur higher in the soil profile (Gerrard 1967; Yeates 1976) resulting in greater exposure to the insecticide. Edwards *et al* (1965) came to a similar conclusion working with chlorfenvinphos.

Martin (1976) on the other hand, using broadcast carbofuran, found mature stages were more susceptible, which he considered was because of their greater surface mobility. The difference in results is most likely due to the different application techniques employed.

The number of *L. rubellus* in Table 1 are more variable, but there appears to be no difference in effect between the two development groups. However, the overall rise in the number of immature earthworms in this genera over the later stages of the trial accounted for a large proportion of the overall population increase, indicating that there was little long term effect on their reproductive capacity.

Field trials

Although the population study above showed that the maximum effect of phorate on earthworm populations is most likely to occur 8-16 weeks after application, the counts taken over this period from the summer-sown brassica crops in Table 2 showed no significant reduction in any of the seven sites at the recommended rate of 1 kg/ha. There was however, a significant reduction where double this rate was used which was still evident after 37 weeks in trial 2.

TABLE 2: Percent reduction in earthworm populations from phorate sown with brassica crops in summer.

Trial No.	1	2	3	4	5	6	7
Month applied	Jan	Feb	Feb	Feb	Feb	Mar	Mar
weeks after treatment	16	37	34	9	10	8	12
phorate 1 kg/ha	—	5	0	7	6	0	11
phorate 2 kg/ha	50*	35*	—	—	—	—	—
untreated No./m ²	212	272	348	352	226	179	28
± S.E.	27	20	28	10	12	19	3

* Significant reduction by *t*-test (5%).

The results from the autumn-sown trials which experienced much wetter conditions than the summer trials were very different. In seven out of the nine trials in this group (Table 3), phorate at 1 kg/ha caused a highly significant reduction in earthworm numbers ranging from 36% to 82%. Two trials not included showed no reduction. The highest reductions occurred in trials 10 and 13 which experienced heavy rain and surface flooding after application. In two trials 0.5 kg/ha caused a 38% and 40% reduction. By comparison the insecticide diazinon, which has a relatively low toxicity to earthworms, only showed a significant reduction in one trial.

Pasture Pests

TABLE 3: Percent reduction in earthworm populations from phorate sown with cereals or ryegrass in autumn.

Trial No.	8	9	10	11	12	13	14
weeks after treatment	18	14	9	14	11	10	12
phorate 1 kg/ha	36**	39**	81**	57**	48**	82**	56**
diazinon 1 kg/ha	3	—	57**	0	26	—	2
untreated No./m ²	581	363	253	395	600	360	436
CV %	12	15	32	17	28	43	23

** Significantly different to untreated (1%).

CONCLUSION

Phorate was found to be toxic to earthworms when it was surface-drilled with crops or into pasture during wet conditions. This meant that phorate did not affect earthworm populations under conditions of its present major use, that is, summer-sown brassicas in Canterbury. However, if its use were extended to regions with moist summers or into autumn-drilled cereals or pastures, or if higher rates were used, then reductions of up to 80% could occur. The population study indicated that under these conditions, immature stages of *Allolobophora* spp were more affected than *L. rubellus*, but this did not prevent the population from recovering to its normal growth rate within 4 months, although initial reductions could still be apparent after one year.

The effect of phorate on earthworms in its other major area of use, deep-planted row crops (maize and potatoes), is likely to be minimal, but further attention could be given to the effects of spring applications with lucerne (*Medicago sativa*), the relative effects of reductions from cultivation versus insecticide on subsequent crop productivity, and the long-term effects of repeat applications.

ACKNOWLEDGEMENTS

The authors wish to thank the staff of the Research Division of Ivon Watkins-Dow Ltd who assisted with trial work.

REFERENCES

- Edwards, C.A., 1969. Soil pollutants and soil animals. *Sci. Amer.* April. 88-99.
- Edwards, C.A., Thomson, A.R. and Benyon, K.I., 1968. Some effects of chlorfenvinphos, an organophosphorus insecticide, on populations of soil animals. *Rev. Ecol. Biol. Soc.* 2: 199-224.
- Gerrard, B.M., 1964. Synopsis of British fauna. No. 6. Lumbricidae. Linnaen Soc. of London.
- Gerrard, B.M., 1967. Factors affecting earthworms in pastures. *J. Anim. Ecol.* 36(1) 235-252.
- Martin, N.A., 1976. Effect of four insecticides on the pasture ecosystem. V. Earthworms and arthropods. *N.Z. J. Agric. Res.* 19: 111-115.
- Yeates, G.W., 1976. Earthworm population of a pasture spray-irrigated with dairy shed effluent. *N.Z. J. Agric. Res.* 19: 387-391.