FURROW APPLICATION OF INSECTICIDE AS A METHOD OF CONTROLLING WIREWORMS IN POTATO LAND

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ABSTRACT

Three methods of applying insecticides for the control of the wireworm, *Agriotes obscurus* L., were tested using fonofos and terbufos. Most treatments gave significantly more marketable tubers than the control. The furrow treatment gave more consistent results than broadcast or side-dress and, at 1.1 or 2.2 kg a.i./ha, gave control equal to, or better than, the broadcast treatment at 5.6 kg a.i./ha. Analyses by gas chromatography using a flame photometric detector for residues in potatoes grown in treated soil showed residues to be less than 0.02 ppm.

INTRODUCTION

Fonofos is one of the most widely and used insecticides for wireworm control in potatoes. It is usually applied as granules, broadcast at 5 to 6 kg a.i./ha and mixed into the soil by discing and rototilling before planting. Broadcast treatments are expensive because of the extra cultivation to apply and mix the insecticide into the soil, and the expense increases with increasing rates of application. This high cost is acceptable only if control is good. Efficacy varies, however, even at a high rate of application, especially in heavy infestations of wireworms (Wilkinson *et al.* 1977). Costs are lower with either side-dressings or furrow treatments because the insecticide can be applied at planting time. Side-dress has been tested more often than furrow treatments.

The effectiveness of side-dress treatments also varies. Onsager *et al.* (1975) found side-dressings of fonofos nearly as effective as broadcast treatments. Carpenter and Scott (1974) found no significant difference between fonofos broadcast at 4.5 kg a.i./ha and post-planting side-dress at 7.8 kg a.i./ha to control the wireworm *Limonius californicus* (Mann.). in 3 experiments, Scott and Carpenter (1976) testing methods of application to control *L. californicus* found no significant difference between fonofos broadcast at 4.5 kg a.i./ha and side-dressed at 7.1 kg a.i./ha. In one of these tests there was no significant difference between side-dress treatments at 7.1 and 2.7 kg a.i./ha. Toba *et al.* (1976) found that both terbufos and fonofos, side-dressed at about 2.2 kg a.i./ha, gave significantly better control of a light infestation of *L. californicus* than when broadcast at 4.0 kg a.i./ha. However, Toba *et al.* (1977) found that a broadcast treatment at 6.7 kg a.i./ha gave significantly better control than a side-dress treatment at 2.2 kg a.i./ha.

The furrow treatment has not been tested extensively. Lilly (1973) found fonofos at 2.2 kg a.i./ha gave good control of *L. californicus* and was as effective as the broadcast treatment at 5.6 kg a.i./ha. Scott and Carpenter (1976) found the furrow method at 7.1 kg a.i./ha gave significantly better control than the broadcast treatment of 4.5 kg a.i./ha in one experiment but in another found no significant difference.

The two experiments reported here were designed primarily to test the furrow method of application to control wireworms and to compare it with the broadcast and side-dress methods.

MATERIALS AND METHODS

The experiments were conducted in silt infested with *A. obscurus* L. Fonofos and terbufos were tested by 3 methods of application at several rates (Tables 1, 2). Potatoes grown in 1976 at the site of the first experiment were severely damaged despite a broadcast treatment of fonofos at about 5.6 kg a.i./ha made by the farmer. Both fonofos and terbufos were tested at this site in 1977. The site of the 2nd experiment had been in sod for several years and here only fonofos was tested. The experimental plots were 8 x 2 m. In the broadcast treatment the insecticide was spread evenly over the soil surface then rototilled to a depth of 10 cm. Side-dressings were applied in furrows made on each side of the row and the insecticide was placed 7 cm from the centre, 2.5 cm below the level of the seed. In the furrow treatments, the insecticide was applied with the seed. Each treatment was replicated 4 times. Potatoes, cv. Netted Gem, were planted the same day the treatments were made.

At harvest, 50 tubers from each plot were examined for wireworm damage and the number of feeding holes in each tuber was recorded. Statistical significance of the data was deter-

TABLE 2. A comparison of 3 methods of applying fonofos to control *A. obscurus* in soil recently in sod, Cloverdale, B.C. 1977

Insecticide	Method of Application	Rate a.i. kg/ha	Marketable tubers %	Reduction of unmarketable tubers %
Fonofos 10 G	Broadcast	5.6	93.5 a[1]	80.9
Fonofos 10 G	Furrow	1.1	93.0 a	79.4
Fonofos 10 G	Furrow	2.2	92.0 a	76.5
Fonofos 10 G	Side-dress	2.2	87.0 a	61.8
Check	—	—	66.0 b	—

[1]Means followed by the same letter are not significantly different at the 5% level of probability.

mined by analysis of variance and Duncan's multiple range tests (Duncan 1955).

To detect residues of fonofos and fonofos oxygen analogue shredded potato was extracted first with acetone then with ethyl acetate. The solvent was evaporated leaving water which had been co-extracted from the potato. This was re-extracted with ethyl acetate. Following solvent reduction, clean-up was by column chromatography on a mixed bed of alumina, silica gel, Florisil and charcoal. Analysis was by gas chromatography using a flame photometric detector (P mode). To detect terbufos and its oxygen analogue sulfone, potato tissue was extracted by acetone followed by 2 extractions with ethyl acetate. Acetone was removed by partitioning into a large volume of water and the remaining ethyl acetate was concentrated to a suitable volume. A sample aliquot was cleaned up by column chromatography on Florisil, silica gel, alumina and charcoal. Analysis was by gas chromatography using a flame photometric detector (P mode). A more detailed description of these analytical procedures will be published later.

TABLE 3. Insecticide residues found in potatoes grown in soil treated by 3 methods of application

Method	Rate a.i. kg/ha	Fonofos 10 G		Terbufos 15 G	
		Fonofos	Oxygen analogue	Terbufos	Oxygen analogue sulfone
		PPM	PPM	PPM	PPM
Experiment 1					
Furrow	1.1	.002[1]	ND[2]	T[3]	ND
Furrow	2.2	.017	ND	ND	ND
Broadcast	5.6	.004	ND	ND	ND
Side-dress	2.2	ND	ND	ND	ND
Check	—	ND	ND	ND	ND
Experiment 2					
Furrow	1.1	.001	ND		
Furrow	2.2	.004	ND		
Broadcast	5.6	.004	ND		
Side-dress	2.2	.002	ND		
Check	—	ND	ND		

[1]Values given are averages of two analyses
[2]ND=none detected
[3]T=trace

RESULTS AND DISCUSSION

In the first experiment (Table 1) all treatments except tuberfos granules side-dressed at 2.2 kg a.i./ha gave significantly more marketable tubers than the control. The furrow treatments gave the best control with no significant difference between fonofos and terbufos nor between the 1.1 and 2.2 kg a.i./ha rates. Terbufos broadcast at 5.6 kg a.i./ha was as effective as the furrow treatments but fonofos at 5.6 kg a.i./ha gave significantly fewer marketable tubers. Terbufos side-dressed at 2.2 kg a.i./ha was significantly more effective than fonofos side-dressed at the same rate.

In the second experiment (Table 2) only fonofos was tested. Again, all treatments were significantly better than the check, with no significant difference between treatments.

Our results show that the furrow, side-dress, or broadcast treatments were equally effective. The efficiency of the lower rates tested suggests that the rate of 7.1 kg a.i./ha, tested by Scott and Carpenter (1976), and possibly 2.24 kg a.i./ha tested by Lilly (1973), were unneces-

TABLE 1. Relative effectiveness of 2 insecticides applied by 3 methods for controlling *A. obscurus*, Cloverdale, B.C. 1977

Insecticide	Method of Application	Rate a.i. kg/ha	Marketable tubers %	Reduction of unmarketable tubers %
Terbufos 15 G	Furrow	2.2	93.0 a[1]	84.8
Fonofos 10 G	Furrow	1.1	90.0 ab	78.3
Fonofos 10 G	Furrow	2.2	89.5 ab	77.2
Terbufos 15 G	Furrow	1.1	89.5 ab	77.2
Terbufos 15 G	Broadcast	5.6	86.5 ab	70.6
Terbufos 15 G	Side-dress	2.2	79.5 bc	55.4
Fonofos 10 G	Broadcast	5.6	70.5 cd	35.9
Fonofos 10 G	Side-dress	2.2	60.5 de	14.1
Check	—	—	54.0 e	—

[1]Means followed by the same letter are not significantly different at the 5% level of probability.

sarily high. However, different soil types and different species of wireworms may require heavier rates and each should therefore be tested to determine the optimum rates. Onsager (1969) reported symptoms of phytotoxicity in foliage and a reduction in yield when potatoes were side-dressed with fonofos at 2.1 kg a.i./ha after the foliage appeared. We observed no phytotoxicity.

Lilly (1973), and Scott and Carpenter (1976) did not give residue data for fonofos granules. The results of our residue analyses (Table 3) show that even at 2.2 kg a.i./ha, fonofos residues were negligible in tubers harvested 128 days after treatment and the fonofos oxygen analogue was not detected. Results were similar with terbufos. Although furrow treatment at 2.2 kg a.i./ha gives a concentration of about 15 times greater than broadcast treatment at 5.6 a.i./ha fonofos, residues in tubers from furrow-treated plots were 0.02 ppm or less, only slightly more than from the other treatments. No residues were found in potatoes from the control plots in the field that had been broadcast-treated with fonofos in 1976. Most of the insecticides would break down in a year but any residue would be diluted further by ploughing to a depth of 20 cm.

Either insecticide at 1.1 kg a.i./ha in the furrow gave control equal to that of broadcast at 5.6 kg a.i./ha at about 20% of the cost. Furthermore, furrow treatment eliminates the extra expense of spreading and incorporating the insecticide in the soil.

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