GLASSHOUSE EVALUATIONS OF SEED TREATMENTS FOR PROTECTION OF RYEGRASS SEEDLINGS FROM INSECT PESTS

G.M. BARKER, P.J. ADDISON and L.N. ROBERTSON[1]

Ruakura Agricultural Centre, Private Bag, Hamilton, New Zealand
[1]Present address: Department of Primary Industries, P.O. Box 81, Emerald, Queensland, Australia

SUMMARY

Furathiocarb, isofenphos and carbofuran were applied to ryegrass (*Loluim perenne*) at 0.5 to 10% of seed weight. Isofenphos was phytotoxic at the high application rates. All three chemicals provided protection of ryegrass seedlings from grass grub (*Costelytra zealandica*), but only furathiocarb and isofenphos reduced grub numbers. Carbofuran and furathiocarb were effective in reducing numbers of adult Argentine stem weevil (*Listronotus bonariensis*) and cereal aphids (*Rhopalosiphum padi*) and improved seedling growth. All chemicals were ineffective in reducing soldier fly (*Inopus rubriceps*) larval numbers but carbofuran and furathiocarb increased seedling growth.
Keywords: seed treatment, insecticides, ryegrass, insects

INTRODUCTION

The treatment of seed with chemical additives is a long-established practice to protect crops, especially from diseases and pests that affect establishment. With seed treatment, pesticides are ideally placed for effective pest control either in the plant or the soil. For such treatments to be effective, pesticides must be loaded securely onto seed in adequate amounts, and with sufficient accuracy. Seed treatment is also an economical method of treating crops as considerably smaller amounts of material are needed compared to field application methods.

In recent years, several pesticides have been introduced for seed treatment which offer the potential to control a wide spectrum of pest organisms, and extend the protection phase further into the life of the crop. In pastures renovated by direct drilling, seedlings are frequently attached by a complex of invertebrate species rather than a single pest species (Barker *et al* 1989; Barker 1990). To be effective in these situations, the pesticide seed treatment must be active against a wide spectrum of pests. This paper reports on preliminary glasshouse evaluations of three pesticide seed treatments for activity against four insect pests of perennial ryegrass (*Lolium perenne* L.).

MATERIALS AND METHODS

Glasshouse pot trials were conducted during 1986 using furathiocarb, carbofuran and isofenphos seed treatments on perennial ryegrass to determine their phytotoxicity and activity against four insect pests.

All seed, ('Grasslands Nui', 32% *Acremonuim lolii* infection) with the appropriate pesticide treatments, was provided by Coated Seeds Limited, Christchurch. Technical grade insecticide was applied in combination with sufficient inert absorbents and polymer stickers to produce a uniform treatment. The untreated seed received absorbents and polymers. For each seed treatment, 12 seeds were sown into each of 10 replicate pots (80 mm dia) containing sieved, steam sterilised, insect-free soil.

Experiment 1: Soldier fly larvae (*Inopus rubriceps* (Macquart))

Ten medium sized soldier fly larvae were placed in each of five replicated pots per treatment at the time of sowing. The remaining five pots per treatment served as insect-

Proc. 44th N.Z. Weed and Pest Control Conf. 1991: 189-194

free controls. After 41 days, seedling establishment, seedling weights and larval survival were recorded.

Experiment 2: Grass grub larvae (*Costelytra zealandica* (White))

Four third instar grass grubs were placed in each of five replicate pots per treatment immediately prior to sowing seed. The remaining five pots per treatment served as insect-free controls. After 25 days, seedling establishment, seedling weights and grass grub survival were recorded.

Experiment 3: Argentine stem weevil adults (*Listronotus bonariensis* (Kuschel))

At seedling emergence five adult weevils were confined by mesh covers to each of five replicate pots per treatment. The remaining five pots per treatment served as insect-free controls. After 6 days, the pots were sampled for weevil survival, seedling establishment, seedling damage and seedling foliar dry weight data.

Experiment 4: Cereal aphid (*Rhopalosiphum padi* (L.))

When the seedlings reached an average height of 20 mm (day 6) five mature apterous aphids were confined by mesh covers to each of five replicate pots per treatment. The remaining five pots per treatment served as insect-free controls. After 8 days the numbers of seedlings, seedling weights and numbers of aphids were recorded.

Proportions of insects surviving and of seeds established were analysed by generalised linear regression using a binomial distribution with a logit link. Numbers of aphids and seedling weights were subjected to an analysis of variance using square root transformed and untransformed data respectively.

RESULTS

Experiment 1: Soldier fly larvae

Assessment at 6 weeks indicated that all three chemicals were ineffective in increasing soldier fly larval mortality, with maximum reductions of only 22-32% at 10% seed coating (Table 1). All chemicals exhibited a rate effect ($P<0.001$) on larval survival.

TABLE 1: Effect of furathiocarb, isofenphos and carbofuran seed treatments on seedling weights of perennial ryegrass and on soldier fly larval survival in pots.

	Percentage of soldier fly larvae surviving (SEM)	Foliage dry wt (mg)		Root dry wt (mg)	
		No soldier fly	With soldier fly	No soldier fly	With soldier fly
Untreated seed	90	69.5	58.8	38.3	39.2
Furathiocarb					
0.5%	96 (3)	82.8	70.2	43.8	54.8
1.0%	86 (4)	76.5	59.6	44.3	52.0
2.0%	82 (4)	76.8	68.2	44.5	56.2
4.0%	80 (5)	91.5	68.2	53.8	56.2
10.0%	68 (6)	69.8	62.6	39.3	55.0
Isofenphos					
0.5%	98 (2)	83.3	65.4	48.0	42.8
1.0%	90 (4)	84.2	67.4	48.8	62.0
2.0%	84 (4)	64.7	41.0	33.0	33.4
4.0%	86 (4)	68.7	62.8	54.8	50.2
10.0%	78 (6)	43.5	53.6	40.0	39.2
Carbofuran					
0.5%	84 (4)	76.3	65.2	52.5	58.0
1.0%	84 (5)	96.3	82.0	47.5	56.0
2.0%	80 (4)	83.2	86.8	38.8	53.2
4.0%	70 (6)	92.2	68.4	43.3	56.4
10.0%	72 (6)	77.8	80.0	38.8	60.2
SED		9.7		7.8	6.0

There were no consistent effects of the treatments on seedling survival or vigour. Seed treatments and the presence of insects did not influence the proportions of seedlings established in the pots (with larvae: untreated 0.87, treated 0.89). In the absence of larvae all chemicals increased foliage weights at low to mid rates, compared to untreated seed, but tended to lower yields at high coating rates ($P<0.01$). In the presence of larvae carbofuran was the only chemical effective ($P<0.01$) in increasing foliage yield over untreated seed. Seedling root weights, in the absence of soldier fly larvae, were unaffected by seed treatment. In the presence of larvae, the treatments tended to increase root weights to yields higher than achieved in the absence of soldier fly larvae.

Experiment 2: Grass grub larvae

Assessment at 25 days indicated that all treatments reduced grass grub survival ($P<0.001$) with furathiocarb and isofenphos more effective than carbofuran, particularly at the low seed coating rates (Table 2).

In the absence of grass grub, the treatments (with the exception of isofenphos 10%) had no influence on seed germination and seedling establishment. With grass grub present all treatments significantly ($P<0.001$) improved seedling survival compared to the untreated seed.

The treatments had no significant influence on seedling foliage or root weights in the absence of grass grub. Seedling weights were significantly reduced by the presence of grass grub, with all treatments increasing yield compared to untreated seed. There was no chemical rate effect on seedling yields, except for the trend of isofenphos at 10% to reduce yields.

TABLE 2: Effect of furathiocarb, isofenphos and carbofuran seed treatments on establishment and seedling vigour of perennial ryegrass and on grass grub larval survival in pots.

	Percentage of larvae surviving (SEM)	Percentage of seeds established (SEM)		Foliage dry wt (mg)		Root dry wt (mg)	
		No grass grub	With grass grub	No grass grub	With grass grub	No grass grub	With grass grub
Untreated seed	85	81	37	15.4	6.4	12.9	4.2
Furathiocarb							
0.5%	44 (9)	81 (6)	67 (8)	15.0	12.7	12.8	9.9
1.0%	44 (8)	88 (5)	72 (7)	13.9	11.0	12.2	9.8
2.0%	62 (8)	81 (6)	80 (6)	14.7	13.4	12.3	11.6
4.0%	44 (10)	88 (6)	77 (7)	14.2	13.2	12.9	11.8
10.0%	69 (7)	79 (6)	83 (5)	15.7	15.9	13.8	13.5
Isofenphos							
0.5%	31 (10)	83 (6)	70 (7)	15.1	12.5	13.1	11.3
1.0%	31 (8)	92 (5)	73 (6)	15.8	13.5	11.9	11.3
2.0%	44 (8)	88 (5)	58 (7)	15.6	11.1	11.8	9.5
4.0%	50 (8)	85 (6)	78 (6)	14.8	12.8	10.8	12.0
10.0%	44 (9)	67 (7)	73 (7)	12.5	11.2	9.2	9.6
Carbofuran							
0.5%	81 (4)	83 (5)	68 (7)	15.3	12.8	12.7	11.6
1.0%	56 (5)	85 (5)	83 (6)	15.3	13.7	12.8	12.1
2.0%	69 (4)	88 (5)	78 (6)	15.4	12.4	13.2	11.6
4.0%	50 (6)	92 (4)	83 (5)	16.0	12.1	13.4	10.7
10.0%	44 (7)	83 (6)	83 (6)	14.9	13.9	12.9	11.9
SED				2.7		2.1	

Experiment 3: Argentine stem weevil adults

After 6 days exposure to seedlings, all chemical treatments reduced stem weevil survival, with furathiocarb and carbofuran more effective than isofenphos ($P<0.001$) (Table 3). There was a significant rate effect ($P<0.001$) for furathiocarb and isofenphos.

In the absence of stem weevil there was no effect of the seed treatment on the proportion of seedlings established. Isofenphos exhibited a rate effect ($P<0.01$) on seedling foliar weight, with a significant reduction at the 10% rate.

Stem weevil reduced the establishment and foliar yield of untreated and isofenphos treated seed ($P<0.001$). Furathiocarb and carbofuran seed treatments significantly ($P<0.001$) improved the percentage of seedlings established and foliage yields compared to untreated seed.

A large proportion of seedlings established from untreated seed were damaged by weevil feeding. This damage was reduced by all treatments ($P<0.001$), with furathiocarb and carbofuran most effective.

TABLE 3: Effect of furathiocarb, isofenphos and carbofuran seed treatments on establishment and seedling vigour of perennial ryegrass and on Argentine stem weevil numbers in pots.

	Percentage of stem weevil surviving (SEM)	Percentage of sown seeds established (SEM)		Percentage of seedlings undamaged (SEM)	Foliage dry wt (mg)	
		No weevil	With weevil		No weevil	With weevil
Untreated seed	80	97	25	13	6.9	1.5
Furathiocarb						
0.5%	16 (7)	81 (5)	80 (5)	73 (6)	7.0	5.2
1.0%	20 (8)	88 (5)	83 (5)	77 (5)	7.0	5.4
2.0%	16 (7)	80 (4)	83 (5)	72 (6)	6.5	5.0
4.0%	12 (6)	83 (5)	92 (4)	80 (5)	7.1	5.5
10.0%	04 (4)	90 (4)	85 (5)	82 (5)	6.8	6.1
Isofenphos						
0.5%	64 (10)	83 (5)	53 (6)	35 (6)	7.1	2.3
1.0%	88 (6)	93 (5)	30 (6)	27 (6)	7.1	2.3
2.0%	44 (10)	83 (5)	52 (6)	37 (6)	6.6	2.6
4.0%	50 (11)	93 (4)	38 (7)	25 (6)	6.4	2.3
10.0%	28 (9)	82 (5)	33 (6)	23 (5)	5.9	2.5
Carbofuran						
0.5%	8 (5)	94 (4)	85 (5)	70 (6)	7.2	5.9
1.0%	12 (6)	97 (4)	77 (5)	62 (6)	7.0	5.5
2.0%	12 (6)	92 (4)	90 (4)	87 (4)	6.8	6.2
4.0%	12 (6)	97 (3)	82 (5)	77 (5)	6.7	5.9
10.0%	8 (5)	85 (4)	83 (5)	78 (5)	7.2	6.3
SED					0.45	0.38

Experiment 4: Cereal aphid

There was approximately an 8 fold increase in the aphid population on seedlings established from untreated seed. Carbofuran seed treatment reduced aphid population growth at all rates ($P<0.001$), with complete arrest of population growth through kill of the founder population at rates above 1.0% (Table 4). There was a strong rate effect for furathiocarb, ranging from 17% control (not significant) at the 0.5% rate to 100% control ($P<0.001$) at rates above 2.0%. Isofenphos was generally ineffective in preventing aphid population growth, except at the 10.0% rate.

TABLE 4: Effect of furathiocarb, isofenphos and carbofuran seed treatments on establishment and vigour of perennial ryegrass and on aphid population growth in pots.

	Number of aphids per pot[1]	Percentage of sown seeds established (SEM)		Foliage weights (mg)	
		No aphids	With aphids	No aphids	With aphids
Untreated seed	6.38 (41.0)	92 (4)	85	9.3	6.2
Furathiocarb					
0.5%	5.77 (34.0)	92 (4)	88 (4)	8.9	6.2
1.0%	2.97 (9.6)	90 (4)	92 (4)	9.6	7.4
2.0%	0.45 (0.2)	90 (4)	88 (5)	9.3	8.8
4.0%	0.0 (0.0)	92 (4)	88 (4)	9.0	9.1
10.0%	0.0 (0.0)	95 (3)	95 (3)	9.0	8.9
Isofenphos					
0.5%	6.45 (42.0)	85 (5)	88 (4)	9.4	5.9
1.0%	6.01 (36.4)	90 (4)	83 (5)	7.8	6.2
2.0%	5.94 (35.4)	83 (5)	77 (5)	7.0	6.5
4.0%	5.73 (33.4)	73 (6)	85 (5)	7.0	6.4
10.0%	4.19 (19.2)	80 (5)	87 (4)	5.9	7.1
Carbofuran					
0.5%	2.53 (6.4)	92 (4)	90 (4)	9.4	7.5
1.0%	0.0 (0.0)	88 (4)	90 (4)	8.9	9.0
2.0%	0.0 (0.0)	90 (4)	95 (3)	9.1	9.3
4.0%	0.0 (0.0)	90 (4)	93 (3)	10.2	9.3
10.0%	0.0 (0.0)	97 (2)	92 (4)	9.1	9.2
SED	0.54			1.02	0.42

[1] Square root transformed (untransformed)

DISCUSSION

In the absence of pests, furathiocarb and carbofuran had little or no adverse effect on ryegrass germination or early seedling growth. Furathiocarb has been shown to be of low phytotoxicity and is being developed as a seed treatment in a range of crops (Bachmann and Elmsheuser 1986; Salter and Smith 1987). Responses to seed treatment with carbofuran varies according to the plant species, with neutral, inhibitory and stimulatory effects having been noted (e.g. Ruppel 1971; Benjamini 1986). Isofenphos seed treatments reduced germination and seedling growth. Dixon and Parr (1975), Dixon and Holland (1977) and Dixon (1977) did not observe any phytotoxicity of isofenphos seed treatment on ryegrass in field trials but any adverse effect may have been masked by responses from pest control.

Furathiocarb, carbofuran and isofenphos were chosen for the current work because of their broad spectrum of activity. However, only furathiocarb and carbofuran have significant systemic activity and this was reflected in their greater insecticidal and protectant properties as seed treatments against the foliar feeding insects, Argentine stem weevil adults and cereal aphid. The present work confirms earlier glasshouse studies by Trought (1976) which indicated that ryegrass may be protected from adult Argentine stem weevil by 1-1.5% w/w carbofuran seed treatments. Trought (1976) achieved protection of ryegrass in the field using 5 and 10% carbofuran seed treatment. However, Barker *et al* (1990) were unable to demonstrate any effect of either furathiocarb or carbofuran, applied as 1% seed treatments, against Argentine stem weevil in their field work.

The present results with carbofuran treated ryegrass seed against cereal aphid are consistent with earlier reports on cereal treatments (e.g. Araya and Foster 1987).

Furathiocarb and isofenphos were more effective than carbofuran as seed treatments in reducing numbers of grass grub but all treatments were effective in protecting the seed and seedlings. The field performance of carbofuran and isofenphos seed treatments against grass grub has not been tested. Barker *et al* (1990) found furathiocarb seed treatment (1% w/w) to be ineffective in reducing grass grub numbers or protecting ryegrass seedlings in the field.

Isofenphos, carbofuran and furathiocarb were generally ineffective against soldier fly, with high application rates required to effect 22-32% mortality. These mortalities are lower than observed in field trials. Dixon and Holland (1977) reported 67% and 50% reductions in soldier fly numbers from 2.5-5.0% isofenphos and 3.75-7.5% carbofuran seed treatments of ryegrass respectively. Under similar field conditions, Barker *et al* (1990) recorded 44% and 47% reductions in soldier fly numbers from 1% ryegrass treatments with furathiocarb and carbofuran respectively.

These results indicate that numbers of certain pest species, or their damage, can be effectively reduced by relatively small amounts of pesticide applied to seed. However, a single seed treatment is unlikely to be effective against the diversity of seedling pests commonly encountered in pastures. This highlights the difficulty in pasture establishment of developing control systems based on pesticides which have utility over a range of sites and pest fauna compositions (Scott 1989; Barker *et al* 1990).

ACKNOWLEDGEMENTS

This work was partially funded by Ciba-Geigy (NZ) Limited. The authors thank B. W. Dow for assistance with the statistical analysis and Coated Seeds Limited for provision of materials.

REFERENCES

Araya, J.E. and Foster, J.G., 1987. Control of *Rhopalosiphum padi* (Homoptera: Aphididae) in selected wheat and oat cultivars with seed systemic insecticides in the greenhouse. *J. Econ. Enotomol. 80:* 1272-1277.

Bachmann, F. and Elmscheuser, H., 1986. The new solution against soil pests and early season pests with furathiocarb treatment. *Proc. British Crop Protection Conf. 1986:* 1117-1124

Barker, G.M., 1990. Pasture renovation — interactions of vegetation control with slug and insect infestations. *J. Agr. Sci. 115:* 195-202.

Barker, G.M., Robertson, L.N., Watson, R.N. and Willoughby, B.E., 1989. Pasture renovation — interactions of vegetation control on pest infestations. Stahle, P.P. (Ed.), *Proc. 5th Australasian Conf. Grassland Invertebrate Ecology:* 153-162.

Barker, G.M., Addison. P.J., Robertson, L.N. and Willoughby, B.E., 1990. Interactions of seeding rate with pesticide treatments in pasture renovated by direct drilling. *N.Z. J. Agr. Res. 33:* 595-605.

Benjamini, L., 1986. Effect of carbofuran on seed germination and initial development of seven crops. *Phytoparasitica 14:* 219-230.

Dixon, G.M., 1977. Use of insecticides during autumn to control soldier fly larvae and increase pasture production. *N.Z. J. Expt. Agr. 5:* 171-175

Dixon. G.M. and Holland, P.T., 1977. Reduction of soldier fly damage to ryegrass seedlings by insecticidal seed treatments. *N.Z. J. Expt. Agr. 5:* 167-169.

Dixon, G.M. and Parr, J., 1975. The effectiveness of insecticidal seed dressing against soldier fly larvae. *Proc. 28th N.Z. Weed and Pest Control Conf.:* 248-250.

Ruppel, R.F., 1971. Effect of seed treatment with carbofuran and propoxur on germination of small grains. *J. Econ. Entomol. 64:* 1554-1556.

Salter, W.J. and Smith, J.M., 1987. Furathiocarb seed coatings: Potential replacements for topical pesticide applications. *In:* Application to Seeds and Soil. *British Crop Protection Council Monogr. 39:* 277-283.

Scott, J.M., 1989. Seed coatings and treatments and their effects on plant establishment. *Adv. Agron. 42:* 43-79.

Trought, T.E.T., 1976. Control of Argentine stem weevil in seedling ryegrass. *Proc. 29th N.Z. Weed and Pest Control Conf.:* 203-206.