EFFECTS OF INSECTICIDES ON THE ABUNDANCE OF ARTHROPOD PREDATORS IN CARROTS IN CANTERBURY, NEW ZEALAND

W. SIVASUBRAMANIAM and S.D. WRATTEN

*Department of Entomology and Animal Ecology,
P.O.Box 84, Lincoln University, New Zealand*

ABSTRACT

Predator populations were assessed by pitfall trapping from November 1993 to March 1994 in two experimental carrot fields in Canterbury, under a range of insecticide regimes. Staphylinids, carabids, spiders and Opiliones (harvestmen) were the most abundant arthropod predators. Linyphiids (80%) and lycosids (19%) were the main families in the spider community. Abundance of predators was greatly reduced by the field rates of diazinon and phorate (by 92% and 52% respectively), but at lower rates reductions were not statistically significant. The recovery of predator numbers depended on dose rate and predatory group, and most of the predator populations had recovered by 40 days after treatment. It is likely that insecticide use in commercial carrot crops will substantially reduce predation of the carrot fly.

Keywords: arthropod predators, phorate, diazinon, carrot rust fly

INTRODUCTION

Carrot rust fly (*Psila rosae* F.) has been a pest of carrots in New Zealand since 1942 (Harrison 1959). In Canterbury, recent monitoring of the adult flies' flight activity, using sticky yellow traps, has shown that there are three generations of the fly per year, with the highest numbers being captured in the third generation (March to May) (Sivasubramaniam *et al.* 1995). In New Zealand, carrot growers apply broad-spectrum insecticides, such as phorate and diazinon, at drilling to control larval damage. These insecticides may kill the predators of the carrot fly as well as the pest itself, especially if they are applied inefficiently.

An integrated approach to pest management, including the use of a combination of insecticides and natural enemies, is one way of lowering insecticide inputs. Mortality of natural enemies may be minimised by using insecticides at a reduced rate (Hickman *et al.* 1992) which may still reduce pest populations sufficiently to benefit the pest/natural enemy ratio (van Emden 1988; Poehling 1989). In Europe, the occurrence of carabids, staphylinids and spiders in agro-ecosystems and their role in the suppression of insect pests have been well documented (Luff 1983; Nyffeler and Benz 1987). These polyphagous predators play a significant role in the population dynamics of several dipteran pests, for example *Eriochia brassicae* (Bouché) (Coaker and Finch 1971). Carabids and staphylinids can predate 60% of carrot rust fly eggs (Burn 1982).

There is no information on the arthropod predators in carrot crops in New Zealand. The purpose of this study was to obtain information on the composition of the arthropod predatory fauna in carrots and to evaluate the short-term effect of insecticides applied for carrot rust fly control on the abundance of the predatory fauna. It is part of a project designed to find the lowest application rates for two insecticides (phorate and diazinon) that would control carrot rust fly and cause the least harm to the associated arthropod predators.

Proc. 48th N.Z. Plant Protection Conf. 1995: 302-307

METHODS

One study site was an experimental carrot crop, grown at the Lincoln University Henley research farm on a Tempelton silt loam soil with a pH of 6.5. Carrots (cv. Chantenay Red Core) were drilled at a 30 cm row spacing on 3 November 1993. Thirty-six plots (10 x 5 m) were arranged in a randomised block design with four replicates of each of two insecticides at four different rates plus an untreated control. Plots were separated by a 2 m-wide weed-free fallow. Treatments were phorate (Thimet 20G) and diazinon (Gesapon 800 EC). Each insecticide was applied at the recommended field rate and at 0.5, 0.33 and 0.125 field rate; viz. phorate at 2.2, 1.1, 0.73 and 0.27 kg/ha; diazinon at 0.8, 0.4, 0.26 and 0.10 kg/ha. Phorate granules were applied with the seeds at drilling, via a tractor-mounted 'cone seeder', at a depth of 2 cm. Diazinon spray was applied on 4 March 1994 (17 weeks after sowing), at a water volume of 220 litres/ha using a knapsack sprayer equipped with a hollow cone nozzle.

Weeds were controlled with two post-emergence sprays of 1.5 kg/ha of linuron (Linuron 50 WP), applied on 29 November and 20 December 1993, and later by hand weeding as necessary.

A second study site was a commercial carrot crop, grown at Killinchy, Canterbury, New Zealand, on a Tempelton silt loam soil with a pH of 7.0. Carrots (cv. Chantany Red Core) were drilled at a 45 cm row spacing on 4 November 1993. Thirty-five plots (10 x 5 m) were arranged in a randomised block design with five replicates of an insecticide at two different rates and applied at two different times, together with an untreated control (Table 1). Phorate granules were applied at the recommended field rate (2.2 kg/ha) and at half field rate (1.1 kg/ha), on 17 January 1994 and again on 11 March 1994. The granules were delivered into the soil at a 2 cm depth, using a hand granule applicator along the existing carrot row.

Two pitfall traps, each consisting of one white plastic cup (9 cm diameter x 10 cm depth), inside another, were placed in the centre of each plot so that their rim was level with the soil surface. Sodium benzoate solution with a little detergent was added to each inner cup and a galvanised iron plate was fixed 10 cm above each trap, to deflect rain and reduce evaporation. The inner cups were collected at 10-day intervals from mid November 1993 (pre-treatment samples: see Table 1) until the end of March 1994. In the insecticide-treated plots, traps were removed before pesticide application and were replaced as soon as residues had dried. Arthropod samples were rinsed with water on a 250 micron sieve, sorted and preserved in 70% ethanol.

Specimens from the two traps within each plot on the same collection date were pooled, and analyses of variance were carried out on the data using 'Statistix' software, version 4.1.

RESULTS

Composition of the predatory fauna

More than 12,000 predatory arthropods were trapped in the two carrot fields (Lincoln and Killinchy) during the season. At the Lincoln site, the most abundant predatory taxa were Araneae (spiders, 67%), Staphylinidae (rove beetles, 12%), Carabidae (ground beetles, 2.6%) and Opiliones (harvestmen, 11%), and together they comprised 94% of the predatory arthropods captured. At Killinchy, these four taxa were again the most abundant, but higher numbers of carabids and lower numbers of Opiliones were captured than at Lincoln. The most abundant spiders captured were from the Linyphiidae (80%) and Lycosidae (19%). The linyphiids were dominated by two genera, *Leptyphantes* spp. and *Erigone* spp. Staphylinids and carabids comprised respectively 59 and 12% of the insect predator complex at Lincoln and 39 and 28% at Killinchy, so the main faunal difference between the two sites was in the three spider groups.

Effect of insecticides on predator abundance

The mean numbers of predatory arthropods trapped at the two sites before and after treatment are given in Table 1. Pre-treatment differences were not significant ($P > 0.05$) for all predatory groups (Table 1, Figs 2 and 3), suggesting relative homogeneity between the plots before the insecticides were applied.

FIGURE 1: Mean number of predators trapped after phorate granules were applied at sowing at Lincoln in 1993/94.

TABLE 1: Mean number of predatory arthropods in plots treated with insecticides at different rates for carrot rust fly control.

Site	Insecticide applied	Application rate (kg ai/ha)	Time of application	Pre ¹ treatment	Post treatment (days)			
					0-10	10-20	20-30	30-40
Lincoln	phorate	2.20	At sowing	-	-	6.7 a ²	6.7 a	11.2 a
		1.10		-	-	8.7 b	9.0 b	14.2 b
		0.73		-	-	9.0 b	9.5 b	15.2 b
		0.27		-	-	10.2 b	10.7 b	16.5 b
		Control		-	-	14.0 b	13.7 b	19.5 b
	diazinon	0.80	17 W.A.S. ³	11.2 a	3.2 a	0.5 a	1.5 a	
		0.40		9.0 a	3.5 a	2.7 a	3.7 a	
		0.26		10.5 a	4.5 a	3.0 b	3.7 b	
		0.10		11.0 a	4.5 a	6.2 b	3.5 b	
		Control		9.5 a	5.2 a	6.0 b	5.2 b	
Killinchy	phorate	2.2	10 W.A.S.	14.8 a	6.6 a	5.8 a	8.0 a	
		1.1		17.2 a	6.4 a	6.6 a	7.4 a	
		Control		19.0 a	9.6 a	13.7 b	11.8 a	
	phorate	2.2	18 W.A.S. ⁴	3.2 a	1.8	0.4	1.4	
		1.1		4.0 a	2.8	0.6	2.0	
		Control		3.6 a	2.8	1.6	2.6	

¹ Samples were taken in pitfall traps over a ten-day period immediately prior to insecticide application

² Means marked by the same letter are not significantly different ($P < 0.05$; orthogonal comparison; Chew 1976)

³ W.A.S = weeks after sowing.

⁴ later season trap catches too low for statistical analysis

At Lincoln, fewer predators ($P < 0.05$) were caught in the plots which had received phorate granules at field rate, for up to 40 days after treatment, but the reduction was not significant ($P > 0.05$) at lower insecticide rates (Table 1), although there was a trend in the reductions. The abundance of linyphiids, lycosids and staphylinids was affected to a varying degree by phorate granules at field rate (Fig. 1), the reduction lasting from 20 to 40 days after treatment. The number of staphylinids caught in the phorate plots did not recover fully until 40 days after treatment; thereafter trap catches were more or less similar in all treatments (Fig. 1c). However, linyphiids recovered within 30 days (Fig. 1a). Number of carabids and harvestman did not appear to be affected by phorate.

For the diazinon treatments at Lincoln, total predator numbers (predominantly linyphiids) were reduced ($P < 0.01$) by diazinon sprays, and the catches were reduced by 92% in the field rate treatment, 54% in the half rate and 50% in the third rate, during the 10-20 day trapping period after treatment (Fig. 2). Total trap catches recovered in all diazinon treatments, except field rate, within 30 days after treatment. Late season trap catches were too low to analyse individual predator groups.

At Killinchy, total trap catches were lower in the plots which received phorate granules at full and half rate at 10 weeks after sowing, but were significantly lower only 10-20 days after treatments ($P < 0.05$) (Fig. 3). Phorate granules applied later in the season (18 weeks after sowing) appeared to reduce the trap catches to some extent, but the catches were too low for statistical analysis.

FIGURE 2: Mean number of predators trapped after application of diazinon, mid-season, at Lincoln in 1993/94.

FIGURE 3: Abundance of common predators captured by pitfall traps in phorate-treated plots (a) 10 weeks after sowing, and (b) 18 weeks after sowing, at Killinchy in 1993/94.

DISCUSSION

The insecticides phorate and diazinon at higher rates depressed the activity / density of predators initially to differing degrees. Thereafter the numbers of some groups captured in pitfall traps increased, often for the remainder of the growing season, although the rate of recovery differed between predator groups and dose rates. Of the two insecticides applied, diazinon at field rate had the greatest effect on predators, causing a relatively severe, short-term reduction in their abundance. Phorate granules at full and half field rate reduced the trap catches by 52 and 37% respectively, within 20 days, but the diazinon mid-season sprays at field and half field rate reduced the catches by 92 and 54%. The numbers of staphylinids were reduced by 50 - 54% following phorate application at field rate, but reduction was around 20-30% at lower rates. The abundance of linyphiids tended to be affected less by insecticides than were the staphylinids. In terms of pest control, phorate at half and third field rate has successfully controlled carrot rust fly damage (Sivasubramaniam and Wratten, unpublished).

Interpretation of these results is obviously compounded by the fact that pitfall traps were used. Their capture rate depends on predators' activity and density (Halsall and Wratten 1988). The small plot sizes also affected predator population recovery rates. However, although granular formulations are thought to control pests selectively (Croft 1990), this work has shown effects of granules on predator numbers which were statistically significant even within the limitations of the experimental methods. It would be expected that pesticide effects on mobile predators would persist for a longer time in whole paddocks; for cereals in the UK, the effect of the size of area treated has been clearly demonstrated (Duffield and Aebischer 1994).

The above results have indicated an effect of phorate granules on invertebrate predators, and a greater effect from diazinon sprays. Parallel work has shown predation rates of carrot fly eggs to be high in and around 'organic' carrot paddocks (Berry *et al.* 1995) and it is likely that insecticides used on conventionally-grown commercial crops would severely reduce any predation.

ACKNOWLEDGEMENTS

We thank A. McErlich, Wattie Frozen Food for technical assistance; P. Birkett for providing the trial site; and C. Vink and A. McLachlan for identifying spiders. Financial support was received from the Entomology and Animal Ecology Department Research Committee and materials support from Wattie Frozen Foods Limited.

REFERENCES

- Burn, A.J., 1982. The role of predator searching efficiency in carrot fly egg loss. *Ann. appl. Biol.* 101: 154-159
- Berry, N.A., Wratten, S.D. and Frampton, C., 1995. The role of predation in carrot rust fly (*Psila rosae* F.) egg loss. *Proc. 48th N.Z. Plant Protection Conf.* : this volume
- Chew, V., 1976. Comparing treatment means: A compendium. *Hortscience* 11 (4): 348-356
- Coaker, T.H., and Finch, S., 1971. The cabbage root fly, *Erioschia brassicae* (Bouché). *Rep. Nat. Veget. Res. Station for 1970* : 23-42
- Croft, B.A., 1990. Arthropod Biological Control Agents and Pesticides. John Wiley & Sons, New York, P 187
- Duffield, S.J. and Aebischer, N.J., 1994. The effect of spatial scale of treatment with dimethoate on invertebrate population recovery in winter wheat. *J. Appl. Ecol.* 31: 263-281
- van Emden, H.F., 1988. The potential for managing indigenous natural enemies of aphids on field crops. *Philosophical Trans. Royal Soc. London (B)* 318: 183-201
- Halsall, N.B. and Wratten, S.D., 1988. The efficiency of pitfall trapping for polyphagous predatory Carabidae. *Ecol. Ent.* 13: 293-299
- Harrison, R.A., 1959. Acalypterate Diptera of New Zealand. *N.Z. DSIR. Bulletin* 128: 132
- Hickman, J.M., Macleod, A., Turner, D., Wratten, S.D. and Longley, M., 1992. Prospects for the compatible use of biological agents and insecticides in arable crops. *Pesticide Outlook* 3: 11-14
- Luff, M.L., 1983. The potential of predators for pest control. *Agri. Ecosystem Environ.* 10: 159-181
- Nyffeler, M. and Benz, G., 1987. Spiders in natural pest control: A review. *J. Appl. Entomol.* 103: 321-339
- Poehling, H.M., 1989. Selective practices for insecticides and agricultural crops. Pp 151-175 *In: Effects of Pesticides on Non-target Invertebrates*. P.C. Jepson (Ed), Intercept, Wimborne, U.K.
- Sivasubramaniam, W., Wratten, S.D. and McErlich, A., 1995. Monitoring the flight activity of the carrot rust fly, *Psila rosae* F., in New Zealand. *N.Z. J. Crop and Hort. Sci.* 23: in press