BORDER PLANTING TO ENHANCE BIOLOGICAL CONTROL OF BRASSICA PESTS BY HOVERFLIES (DIPTERA: SYRPHIDAE)

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SUMMARY

Pollen resources for hoverflies were provided in a replicated design in the form of border strips of *Phacelia tanacetifolia* around a paddock of cabbages. Numbers of adult hoverflies were assessed in transects of yellow pan traps extending into the crop from the four control and four *Phacelia* borders. Hoverfly eggs were counted on a block of unsprayed cabbages opposite each of the eight borders, as were aphids and Lepidoptera larvae. Approximately seven times as many individuals of the hoverfly *Melanostoma fasciatum* were captured in *Phacelia* bordered plots than in controls. There was no significant difference in hoverfly egg numbers or numbers of Lepidoptera larvae but aphid numbers were significantly lower in *Phacelia*-bordered plots.

Keywords: hoverflies, pollen, aphids, *Phacelia tanacetifolia*, habitat manipulation, diversity

INTRODUCTION

A range of hoverfly species (Diptera: Syrphidae) occur as larvae in agricultural and horticultural crops. In Europe, for instance, *Episyrphus balteatus* (Degeer) and *Metasyrphus corollae* (Fabricius) are the most abundant species on arable land (Dean 1982) and their voracious aphidophagous larvae have been identified as being economically important, having the potential to halt aphid population growth (Chambers and Adams 1986).

Adult hoverflies feed on nectar (or aphid honeydew) and pollen. Nectar is used to provide energy while the pollen provides the protein necessary for sexual maturation, and is especially important in female hoverflies for maturing successive batches of eggs (Schneider 1948).

Quantitative assessment of the use of non-crop plants by *E. balteatus* in the United Kingdom (Cowgill *et al.* 1993) showed that this hoverfly exhibited considerable positive and negative selectivity for native flowering species. However, because many of the 'preferred' plants are agronomically difficult to manage, potential alternatives which are agronomically more tractable have been sought. One such alternative is a North American annual plant *Phacelia tanacetifolia* Benth. (Hydrophyllaceae). The favoured use of *Phacelia* as a pollen resource for hoverflies has been due to availability and cheapness of the seed (Harwood *et al.* 1994; Hickman and Wratten 1995), ease of managing the plants agronomically (Stevenson 1991), its long flowering period over the summer (Wratten *et al.* 1995) and also because the easily distinguished pollen of *Phacelia* is a good biological marker when determining how far flower-visiting adults have penetrated crop fields (Lövei *et al.* 1993a). *Phacelia* has been used as a pollen resource to enhance hoverfly populations in cereal fields in the U.K. (Harwood *et al.* 1994; Hickman and Wratten 1995). This work showed that provision of border strips of *Phacelia* in three fields enhanced the numbers of adult hoverflies, increased the number of syrphid eggs and led to lower numbers of aphids in the crop compared with the control fields.

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In New Zealand, however, little is known about the potential of hoverflies for biological control. The commonest species in agricultural land are *Melanostoma fasciatum* (Macquart) and *Melangyna novaeseelandiae* (Macquart) (Early 1984), both of which are abundant throughout the country, although *M. fasciatum* is more common, especially in the North Island (Miller 1921). These species lay their eggs close to aphid colonies, but they also lay them on leaves of plants infested with lepidopteran larvae (Miller 1921). When the hoverfly larvae emerge from eggs, as well as preying on large numbers of aphids (Rohitha *et al.* 1985), they also account for a large proportion of arthropod predation on early-instar lepidopteran larvae such as white butterfly *Artogeia rapae* (L.) and diamond-back moth *Plutella xylostella* (L.) (Valentine 1967; Miller 1971; Ashby and Pottinger 1974).

Studies carried out in New Zealand have demonstrated that *Phacelia* is attractive to the native hoverfly species (Lövei *et al.* 1993b) and that local densities of the adult flies can be increased by planting strips of the plant across fields (Lövei *et al.* 1992).

Because the labia of hoverflies are not long enough to remove nectar from the corollae of *Phacelia* flowers the plant is likely to be only a pollen resource for these predators; however honeydew from aphids within crops can provide an alternative source of energy for the flies, so the absence of nectar is not thought to militate against the use of *Phacelia* in biological control work (Harwood *et al.* 1994; Hickman and Wratten 1995). Other minor crops, such as coriander (*Coriandrum sativum* (L.)), and buckwheat (*Fagopyrum esculentum* (Moench)) provide both pollen and nectar, but under conditions in southern New Zealand, these flower too late to provide spring resources for hoverflies (Wratten *et al.* 1995).

The aim of the present work was to investigate the effect of border-planting with *Phacelia tanacetifolia* on hoverfly populations in a cabbage crop, and any consequent effects on penetration into the crop by adult hoverflies, oviposition and pest numbers in the cabbage crop.

MATERIALS AND METHODS

The site was a field of cabbages on a market garden at Prebbleton, Mid-Canterbury. The experimental part of the field measured 180 x 35 m and was bordered on one long side by shrubs and trees and on the other long side by more cabbages. There was a 1 m gap between the experimental area and the remaining cabbages. The short sides were bordered by a poplar shelterbelt and a road respectively. The experimental site was divided into eight plots each measuring 45 x 17.5 m. A 0.5 m wide boundary-strip of *Phacelia* was sown by hand on two dates, at an approximate seed sowing rate of 10 kg/ha along the central 25 m of the long margins (45 m) of four alternating plots, while the outer margins of the four alternating control plots were left bare. The first sowing was carried out on 11 September 1993 to allow the *Phacelia* to develop before the cabbage crop was transplanted in early December. The second sowing adjoining the first was drilled on 22 November to ensure continuous flowering over the period while the cabbage crop was growing. Row spacing was 60 cm and within-row spacing 43 cm. On 17 December cabbage, cultivars Summercross and Gourmet, seedlings were transplanted into the experimental area. A block (2 x 3 m) of cabbage plants to remain unsprayed (blocks were covered with polythene when the field was sprayed) was marked out with pegs in each of the eight plots, with one 2 m edge adjacent to the edge of the experimental area. Aphids and white-butterfly eggs and larvae, and hoverfly eggs were counted twice-weekly on five marked plants within each of these blocks. The aphids were the cabbage aphid *Brevicoryne brassicae* (L.) and the green peach aphid *Myzus persicae* (Sulzer). On December 3, when the first sowing of *Phacelia* was starting to flower, yellow traps were placed in each plot at distances of 0.5, 1.5, 3.5, 7.5 and 12.5 m from the edge.

The traps were yellow plastic two-litre containers (170 x 170 x 85 cm). Yellow has been shown by Finch (1992) to be highly attractive to hoverflies. In the field, one container was used as a trap base and anchored to the ground with a bent metal rod through its centre; a second container was inserted into the base, and was two-thirds filled with water to which a few drops of detergent were added, along with approxi-

mately 5 g of sodium benzoate as a preservative. The traps were first emptied on 10 December, and subsequently twice-weekly. For each trap, adults of *M. fasciatum* and *M. novaezelandiae* were removed with forceps and transferred to 70% alcohol in labelled plastic vials. Flies were counted in the laboratory.

RESULTS

The number of adult hoverflies caught in control and experimental plots between 3 December 1993 and 18 February 1994 was 695, of which 468 were *M. fasciatum* and 227 were *M. novaezelandiae*. *M. fasciatum* and *M. novaezelandiae* comprised 67% and 33% of the hoverflies captured, respectively. The numbers of flies captured in control and experimental plots were significantly different ($F=30.57$; $df=1,3$; $P<0.01$) over the entire trapping period of 77 days. Furthermore, a significant interaction was observed between the experimental and control plots, and the distance of the traps from the border ($F=4.29$; $df=4,3$; $P<0.01$). This interaction was mainly due to the large numbers of flies captured in the traps situated 0.5 m away from the *Phacelia* border; however all the traps in the experimental plots captured more flies than those at the equivalent distances in the control plots (Fig. 1).

Very low numbers of hoverfly eggs were observed on the marked plants prior to late January (Fig.2). However, from that date, numbers of eggs increased although there were no consistent differences between treatments; an average of up to 6 eggs per plant were observed on a single occasion in the experimental plots. Over the entire period, 685 hoverfly eggs were counted. Of this, 369 and 306 eggs were counted on the marked plants in the control and experimental plots, respectively; this difference was not significant ($F=0.35$; $df=1,3$; $P>0.05$). Samples of eggs which were taken from the field and identified indicated that the proportion of *M. fasciatum* and *M. novaezelandiae* eggs found was approximately similar to the proportions of these species captured in the yellow traps.

Figure 1: Total numbers of hoverflies caught at different distances into the cabbage crop between 3 December 1993 and 18 February 1994.

Figure 2: Numbers of hoverfly eggs observed in experimental and control plots between 4 January and 18 February 1994.

Figure 3: Numbers of aphids observed in experimental and control plots between 4 January and 18 February 1994.

The numbers of aphids of both species observed on the marked plants in the experimental and control plots increased steadily over the experimental period. Numbers decreased significantly ($t=3.13$; $P<0.05$) between 1 February and 4 February due to disturbance of the plants during irrigation (Fig.3). From 14 January, aphid numbers in the control plots exceeded those in the experimental plots on every occasion and over the final four observations (8.2.94 to the 18.2.94) significantly more aphids were counted in the control plots ($F=4.44$; $df=1,3$; $P<0.05$). More than 95% of aphids recorded were *B. brassicae*.

Most white-butterfly eggs were observed early in the season and of the 318 eggs counted, 60% were observed on the first four sampling occasions. Over the complete experimental period 185 and 133 white-butterfly eggs were counted in the experimental and control plots respectively; these numbers are not significantly different ($F=1.57$; $df=1,3$; $P>0.05$). Larval numbers increased and then decreased over the experimental period with the maximum average number recorded per plant being 1.35 on 25 January in the experimental plots. Totals of 130 and 102 larvae were observed in the control and experimental plots (not significantly different ($F=3.09$; $df=1,3$; $P>0.05$)).

DISCUSSION

If the presence of *P. tanacetifolia* enhances biocontrol of brassica pests by hoverfly larvae, it would be expected that there would be more adult hoverflies, a higher rate of oviposition and fewer pests in the experimental plots compared with the control plots. More hoverflies were indeed captured in the experimental plots, but the greatest effect was in the traps closest to the *Phacelia* border. This suggests that the flies, in particular *M. fasciatum*, do not disperse very far from such a pollen resource.

Large numbers of hoverfly eggs were found in the unsprayed plots and there was no significant difference between the control and *Phacelia* totals. Throughout the experiment the grower maintained a rigorous insecticide spray programme across the whole cabbage crop excluding only the relatively small areas of marked plants. Therefore these would have acted as small isolated 'islands' of insect pests 'attracting' hoverflies (perhaps via kairomones in honeydew (Budenburg and Powell 1992)) from the surrounding area, resulting in no significant difference in numbers of hoverfly eggs observed in the experimental and control plots. Hickman and Wratten (1995) worked in unsprayed cereal fields, which apart from overcoming the problem of creating isolated pest populations also enabled the number of hoverfly eggs to be counted at various distances into the crop. The present experiment was also constrained by the size of the experimental area. Hickman and Wratten (1995) overcame this problem by using whole fields as replicates. Therefore a larger experimental site, with individual fields as replicates, and with no insecticide use would have been ideal. However, the crop value/unit area of cabbages is much higher than that of cereals. This, together with the importance of 'cosmetic' damage in fresh-market brassicas, means that the complete removal of insecticides from a large area of commercial brassicas for experimental purposes is unrealistic.

Significantly more aphids were observed in the control plots on most dates, even though hoverfly egg numbers did not differ. No other invertebrate predators were found on the cabbages during routine sampling, indicating that syrphid predation was the likely cause of the aphid population differences. There was no significant difference between the numbers of aphid parasitoid 'mummies' counted in the control and experimental plots, which would indicate that the difference in aphids numbers between the two treatments was not due to parasitoids.

There was no significant difference in white butterfly populations (eggs and larvae) between the two treatments, despite suggestions (Finch, pers. comm.) that *Phacelia* may enhance these by providing a nectar source for the adult butterfly, and despite the reported predation by hoverfly larvae on butterfly larvae (see Introduction).

Other published work on habitat manipulation for Syrphidae has revealed local increases in adult fly numbers near the floral resource (see Introduction), but only the work of Harwood *et al.* (1994) and Hickman and Wratten (1995) have shown a

consequent effect on oviposition and/or prey number. That work was in European cereals. The present results show the potential of this approach for horticultural crops generally, and is the first example of this type of habitat manipulation in the southern hemisphere. For high-value crops such as brassicas, however, with very low pest 'damage' thresholds, predators alone are unlikely to replace insecticide use. However, maintaining predators' survival by avoiding broad-spectrum pesticides and/or applying the latter at reduced rates, has potential as part of an integrated pest management approach (van Emden 1987; Mann *et al.* 1991), including habitat manipulation techniques such as those described here.

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