NOVEL CROPS IN CEREAL FIELDS: HABITAT REFUGES FOR ARTHROPOD NATURAL ENEMIES

D. J. HODGSON¹ and G. L. LÖVEI

*The Pastoral Agriculture Research Institute of New Zealand Ltd., Flock House
Agricultural Centre, Private Bag 1900, Bulls 5452, New Zealand*

SUMMARY

Pitfall trap and sweep-net catches were used to assess the importance of the novel crops tansy leaf (*Phacelia tanacetifolia*), buckwheat (*Fagopyrum esculentum*), quinoa (*Chenopodium quinoa*) and coriander (*Coriandrum sativum*) as reservoirs of natural enemies in a cereal crop. The four novel crops were planted on central strips in cereal fields at two locations on the lower half of the North Island. Pitfall trap data showed the importance of quinoa, which provided good ground cover early in the season, forming colonization islands for ground-dwelling predators and parasitoids. Sweep-net samples indicated preference for coriander and buckwheat by plant-dwelling arthropod natural enemies. Consistently high catches of both plant-active and ground-active beneficial arthropods in the novel crop strips indicated that these strips serve as habitat refuges throughout the season.

Keywords: novel crop, natural enemies, habitat refuge, alternative food source.

INTRODUCTION

Agricultural practices frequently make cultivated habitats hostile environments for beneficial arthropods. Natural enemies of pests require shelter and/or alternative food to survive or maximise reproductive rates. Adult hoverflies (*Syrphidae*), for example, require pollen as food for egg maturation (Schneider 1948).

Field margins are often sites of high natural enemy densities, as the weeds and grasses which grow there can provide shelter, overwintering sites and alternative food (Coombes and Sotherton 1986). Predators and parasitoids may then move into the crop and attack pests (Powell 1986). Such habitat patches must be managed to minimize potential damage to crops and maximize benefits (Way and Grieg-Smith 1987). A possible alternative to weedy strips is to plant crops attractive to natural enemies (Lövei *et al.* 1993a).

This study tested whether selected novel crops, tansy leaf (*Phacelia tanacetifolia*), buckwheat (*Fagopyrum esculentum*), quinoa (*Chenopodium quinoa*) and coriander (*Coriandrum sativum*) attracted potential natural enemies of cereal pests.

METHODS

Strips of tansy leaf, buckwheat, coriander and quinoa (hereafter referred to as 'novel crops') were drilled on cereal fields at Flock House, Bulls, and at the Horticultural Research Centre, Levin, during spring, 1991. All fields were managed organically, conforming to their registered Bio-Gro status. No pesticide was applied at either site; weeding was by tine weeder in the cereals during early crop development (November), and by hand-weeding in the novel crop strips. No fertilizer was applied at either site in the year of the experiment.

The Levin field was 0.4 ha in size, divided into three cereal blocks of 15 m x 72 m, with a 4 m wide strip between each block. The field was surrounded by paddocks grazed by cattle and sheep. Each strip was divided into four contiguous blocks of 18

¹Present address: Department of Ecology, Massey University, Private Bag 11222, Palmerston North

m each. On 10 October 1991, four novel crops were hand-drilled in a 3 m wide row to leave a narrow path on both sides between the cereal and the flowering crops. The novel crops were sown 1-2 cm deep, with a row distance of 15 cm. The sowing rates were 40 kg/ha for coriander, 5 kg/ha for quinoa, 14 kg/ha for tansy leaf, and 80 kg/ha for buckwheat. The sequence of the novel crops was randomized. During December, some blocks suffered stock grazing and a third strip was established at the edge of the field; this row did not come to flower until mid- January (Table 1). In total, the novel crops occupied about 15% of the area of the cereal field.

The two wheat fields used at Flock House were 3.5 ha and 3.2 ha in size and were surrounded by other organically and conventionally managed pasture and crop paddocks. The novel crops were sown into 2 m wide contiguous blocks; the length of the field was divided into four (except a 15 m wide headland at the edges), allowing for one strip for each of the four novel crops. The strip length was 60 m on field 1, and 100 m on field 2. Buckwheat, tansy leaf and quinoa were sown on 11 October, coriander on 17 October 1991, at the same depth, row distance and sowing rate as at Levin. The novel crop strips occupied a total of 1.5% of field 1, and 2.5% of field 2.

In Levin, two pitfall traps (500 ml plastic cups, 10 cm diam., half-filled with 70% ethylene glycol) were placed in each established block of novel crops. Traps were emptied weekly and the catches identified to taxa and counted.

Weekly sweep-net samples were taken from the novel crops, from the onset of flowering (see Table 1) until early February, when the major crop was harvested. Sampling took place during the morning in still, dry weather. The collector walked slowly along the edge of the novel crop, with every sweep covering the whole width of the block. Each sample consisted of 20 sweeps, brushing the flowers of the novel crops. At Levin, this resulted in one sample per novel crop block per sampling occasion; at Flock House, two samples were collected from each block. Numbers of taxa recognised as important natural enemies of crop pests were recorded.

TABLE 1: Flowering dates and numbers of samples taken from four novel crops at two experimental sites (Levin and Flock House), between December 1991 and January 1992.

Novel crop		Flock House			Levin	
		Field 1	Field 2	Strip 1	Strip 2	Strip 3
Tansy leaf	Flowering date ¹	4 Jan	4 Jan	22 Dec	22 Dec	15 Jan
	No. of samples	6s ²	6s	2s,8p	5s,8p	1s,4p
	Pitfall trap start	-	-	3 Dec	3 Dec	7 Dec
Buckwheat	Flowering date	F ³	F	F	15 Dec	20 Jan
	No. of samples	0	0	1s,1p	2s,8p	3s,4p
	Pitfall trap start	-	-	25 Nov	3 Dec	7 Dec
Coriander	Flowering date	10 Jan	10 Jan	F	F	4 Feb
	No. of samples	6s	6s	1s	1s,4p	1s
	Pitfall trap start	-	-	-	7 Jan	-
Quinoa	Flowering date	10 Jan	10 Jan	23 Dec	23 Dec	F
	No. of samples	6s	6s	2s,8p	5s,8p	1s
	Pitfall trap start	-	-	3 Dec	3 Dec	-

¹ Date when >25% of plants had flowers; ² s = sweep-net, p = pitfall trap; ³ "F" indicates crop failed to germinate or flower.

RESULTS AND DISCUSSION

Sweep-net samples

At Levin, the dominant natural enemy taxa were hoverflies (*Syrphidae*), rove beetles (*Staphylinidae*), parasitoid wasps (*Hymenoptera*) and spiders (*Araneae*) (Fig. 1). Adult hoverflies (mainly *Melanostoma fasciatum*) were common on tansy leaf,

buckwheat and coriander. Parasitoid wasps showed a distinct preference for buckwheat over the other novel crops. Rove beetles were caught in greatest numbers in the buckwheat strips, but were absent in catches from quinoa and coriander. The highest numbers of spiders were in the quinoa and buckwheat and were notably absent in the coriander strips.

Figure 1: Average catch ($\pm$ standard error) of natural enemy taxa per sweep-net samples from tansy leaf (TL), quinoa (Q), buckwheat (B), and coriander (C) at Levin, December 1991–January 1992 (note different y-axes of each graph).

Figure 2: Average catch ($\pm$ standard error) of natural enemy taxa per sweep-net samples from tansy leaf (TL), quinoa (Q), and coriander (C) at Flock House, January 1992 (note different y-axes of each graph).

At Flock House, hoverflies, parasitoid wasps and spiders were the most common classes of natural enemies (Fig. 2). The highest catches of hoverflies were in the coriander; quinoa was virtually not visited by hoverflies. Parasitoid wasps were also caught in the greatest numbers in coriander (Fig. 2). In contrast to the situation in Levin (where coriander stands were less dense), spiders were caught in largest numbers on coriander at Flock House.

Hoverflies and some parasitoid wasps are known to feed on pollen and nectar of many flowers (Jervis *et al.* 1993) and probably were attracted to these on the novel crops. Their desired site of action is, however, mostly on the crop plants. We have some evidence (Lövei *et al.* 1993b) that hoverflies disperse into the crop after feeding on pollen offered in the novel crop strips. Rove beetles are attracted to the strips either because of increased prey availability, or because they feed on pollen as was occasionally observed (Lövei, personal observation). Spiders, on the other hand, probably use the flowers as hunting grounds and may diminish the density of beneficial insects. The significance of this at the population level is not known.

Pitfall traps

The five most represented taxa of natural enemies in the pitfall trap catches were ground beetles (*Carabidae*), rove beetles, parasitoid wasps, harvestmen (*Opiliones*) and spiders.

Average weekly catches of natural enemy taxa are presented in Table 2. Coriander did not germinate until late in the season. Before flowering, three of the six major taxa of natural enemies had their highest active density in quinoa strips (Table 2). Harvestmen strongly preferred buckwheat; spiders were the most active in tansy leaf and buckwheat.

TABLE 2: Active density (total numbers caught / trap weeks) of the major natural enemy taxa in each novel crop. Pitfall trap catches, Levin.

Taxon	Before flowering			During flowering			
	TL	Q	B	TL	Q	B	C
<i>Carabidae</i>	1.1	1.8	1.5	0.4	1.2	1.0	0.3
<i>Coccinellidae</i> (larvae)	0.5	1.3	0.5	0	0	0	0
<i>Staphylinidae</i>	0.4	0.6	0.1	1.0	1.5	2.0	0.8
<i>Hymenoptera</i>	0.4	0.1	0.1	4.7	10.8	3.9	1.8
<i>Opiliones</i>	0.4	0.6	1.7	0.7	0.5	1.3	0.9
<i>Araneae</i>	3.1	2.6	3.0	4.5	7.0	4.9	4.8

"TL" = tansy leaf, "Q" = quinoa, "B" = buckwheat, "C" = coriander.

During flowering, catches of rove beetles, parasitoid wasps, harvestmen and spiders increased. This cannot be solely attributed to the attractiveness of the flowers; confounding factors are the general seasonal increase in arthropod activity, and the development of the plant canopy, providing more shelter. The coccinellid larvae disappeared, but adults were not trapped in large numbers. Parasitoid wasps showed a big increase in numbers and a clear preference for the quinoa strips. Harvestmen retained their preference for buckwheat. Judging from their active density, spiders changed their preferred habitat during the season. Before flowering, their active density in quinoa was the lowest of the three novel crops; during flowering, they were most active in that novel crop.

Overall, the pitfall trap catches indicated a preference by ground-active natural enemies for quinoa, which provides good ground cover soon after germination. It is likely that ground-dwelling invertebrates used these plants for shelter. These natural enemies are, however, different from the flower-visiting or plant-dwelling ones, and the two methods of sampling collected different groups or different species within the same order/family. Ground-dwelling spiders like money spiders (*Lyniphiidae*) and

wolf spiders (*Lycosidae*) do not frequently occur on plants; the plant-dwelling spiders like crab spiders (*Thomisidae*) are not collected by pitfall traps. Certain species of parasitoid wasps also restrict their activity to the ground level; especially species of *Synacra* and *Trichopria* (Diapriidae) were common in pitfall traps but rare in the sweep net samples.

Our results show that any manipulation of the habitat affects entire insect communities. Flowers and shelter may attract not only beneficial insects but also their own natural enemies. They may also act as reservoirs for pests or other undesirable insects. For example, *Calliphoridae* (blowflies) were often observed feeding on coriander plants (Hodgson, personal observations).

Considering its attractiveness to both ground-level and flower-visiting beneficial arthropods, buckwheat seemed to be the most suitable of the crop plants tested for attracting natural enemies. However, its sensitivity to harsh conditions was demonstrated at Flock House where it failed to tolerate strong winds. From the limited data available from Flock House, coriander was the most attractive novel crop to flower-visiting arthropods. However, with the varied needs of different beneficial groups, a mixture of attractant crop patches may be desirable. This, based on our results, would consist of quinoa for ground-dwelling natural enemies, and buckwheat or coriander for plant-dwelling ones. Agronomic factors will clearly be decisive concerning the choice of an attractant crop at a certain location.

ACKNOWLEDGEMENTS

We thank G. Bramley, D. McDougall, F. Kell, A. MacLeod, E. Sorensen, W. Stiefel, and M. Schellkes for their field and laboratory assistance. This study was funded by the Foundation for Research, Science and Technology, and by the former MAF Technology Horticultural Research Centre, Levin (DJH).

REFERENCES

- Coombes, D.S. and Sotherton, N.W., 1986. The dispersal and distribution of polyphagous predatory Coleoptera in cereals. *Ann. Appl. Biol.* 108: 461-474.
- Jervis, M.A., Kidd, N.A.C., Fitton, M.G., Huddleston, T. and Dawah, H.A., 1993. Flower-visiting by hymenopteran parasitoids. *J. Nat. Hist.* 27: 67-105.
- Lövei, G.L., Hodgson, D.J., MacLeod, A. and Wratten, S.D., 1993a. Attractiveness of some novel crops for flower-visiting hoverflies (Diptera: Syrphidae): comparisons from two continents. Pp. 1-8 In: *Pest Control and Sustainable Agriculture*, S.A. Corey, D.J. Dall and W.M. Milne (Eds); CSIRO Publications, Canberra.
- Lövei, G.L., Hickman, J., McDougall, D. and Wratten, S.D., 1993b. Field penetration of beneficial insects from habitat islands: hoverfly dispersal from flowering crop strips. *Proc. 46th N.Z. Plant Protection Conf.*: this volume.
- Powell, W., 1986. Enhancing parasitoid-host interactions, and the implications for biological control. Pp. 319-340. In: *Insect Parasitoids*, J.K. Waage and D.J. Greathead (Eds); Academic Press, London.
- Schneider, F., 1948. Beitrag zur Kenntniss der Generationsverhältnisse und Diapause rauberischer Schwebfliegen. *Mitt. schweiz. Entomol. Ges.* 21: 249-285.
- Way, J.M. and Grieg-Smith, P.W., 1987. (Eds) *Field Margins*. British Crop Protection Conference Monog. No. 35. BCPC Publ., Thornton Heath.