Controlling root flies with exclusion fences?

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Abstract:
Protecting crops with insect fences is currently being considered as an alternative to row cover netting and synthetic insecticides. Previous studies reported efficacies of such fences with 50-90 % reduction in crop damage by root flies. We conducted trials with a 1.70 m fence over two years to monitor carrot rust fly (*Psila rosae*) in carrots and cabbage root fly (*Delia radicum*) in radish. There was a significant reduction in cabbage root fly damage in fenced plots whereas no such effect could be found with carrot rust fly. The structure of the overhang at the top of the fence and the mobility of this particular species may be important elements to consider in fence design. The length of the overhang also seemed to be important for cabbage root fly (*Delia radicum*) control, as a statistically significant treatment effect was observed only when the overhang was 35 cm long. Using radish as a test crop, the fences reduced damage by 55 % in the second year of the trial. The population size of overwintering cabbage root flies was also an important factor, as the number of flies in the year that the fence was effective was lower than in the previous year.

Key words: *Delia radicum*, *Psila rosae*, cole crops, insect fence, vertical barrier, organic farming

Introduction

For growers who wish to produce insecticide-free crops, insect nets as row covers are available. These generally achieve a very good level of control (Konrad & Schachtle 1985; Haseli & Konrad 1987; Matthews-Gehringer & Hough-Goldstein 1988; Steene et al. 1992; Ester 1993; Hommes 1993; Kunicki et al. 1996). However, the disadvantages of this method are that it is labour intensive, expensive and, by affecting the microclimate, sometimes favours fungal diseases and weeds. Vernon and his co-workers (1998) introduced a novel control method by setting up vertical barriers to exclude root flies from host crops. Research groups in several different countries have tested insect fences for control of cabbage root fly (Vernon & Mackenzie 1998; Pats & Vernon 1999; Bomford et al. 2000; Meadow and Johansson 2003) and carrot rust fly (Vernon & McGregor 1999; Wyss et al. 2003), reporting a reduction in damage of 50-80 %. We set out to reproduce these promising results in Germany, in order to evaluate the technique for introduction into commercial vegetable growing.

Materials and methods

Experimental lay out

The experiments were conducted in 2004 – 2005 at the BBA Research Field Site near Brunswick in North Germany. The soil is a sandy clay loam. The site is 2,5 hectare in area, has some trees and shrubs at the southwest border and is sourrounded by arable land with typical agricultural crops such as wheat, rye, sugar beet and canola. In 2004, autumn sown canola was just 50 m away and in 2005 approx. 200 m away from the field site. White/Japanese radish (*Raphanus sativus* var. *niger* “Rex”) was grown to assess damage by cabbage root fly (*Delia radicum*) and carrots (*Daucus carota* ssp. *sativus* “Almaro”) to monitor carrot rust fly (*Psila rosae*) damage. Crops were sown in mid to late April so that the appropriate plant stage was available for host searching rootflies in April/May. The radish was grown for 9 weeks and was harvested by the end of June. The carrots were grown for more than 4 months and harvested by the end of August. In both years, the germinating radish seedlings were heavily attacked by flea beetles, making a pyrethroid treatment necessary to save the experiment. The insecticide was applied approximately 1 week prior to peak cabbage root fly flight activity.

The fenced and unfenced plots were replicated four times. Four blocks, each containing a fenced and an unfenced plot, were set up next to each other with 10 m bare soil and mown grass in between (Fig. 1). The fenced and unfenced plots measured 20 m x 25 m in size and contained one area of carrots and one area of radish. Each area of crop was 10 m x 25 m in size and consisted of four beds with a row spacing of 0.4 m. Radish and carrot plots were alternated so that the fenced radish was never grown adjacent to open radish and the same strategy was adopted for the carrots. Fenced and unfenced plots of one crop variety were loctaed 10 m apart. At this point, we would like to emphasise the importance of locating control plots too close to fenced areas, as flies then have no need to move over the barrier. The fences were 1.70 m high and used commercially available insect netting (Rantai S48, Schachtrupp, Hamburg), with a mesh size of 0,8 mm x 0,8 mm, nailed to wooden posts. In 2004, a wooden overhang was attached. This was held at an angle of 45° and was 18 cm long. In 2005, this was replaced by a white plastic overhang 35 cm long.

Data collection and analysis

The radish and carrots were sampled at the end of the growing period. Samples of five plants were taken from 10-12 locations evenly distributed throughout each plot, providing 200-240 plants per treatment. The roots were inspected visually for damage and classified using a scoring system (I = no damage and marketable, II = very small traces of feeding damage and marketable, III = medium, but obvious damage and not marketable, IV = excessive damage.). The frequency of roots in each category was analysed using a χ^2 Test. If there was a statistically significant difference then the efficacy of the treatment was calculated. A quantitative comparison between treatments was approximated using the degree of efficiency after ABBOTT.

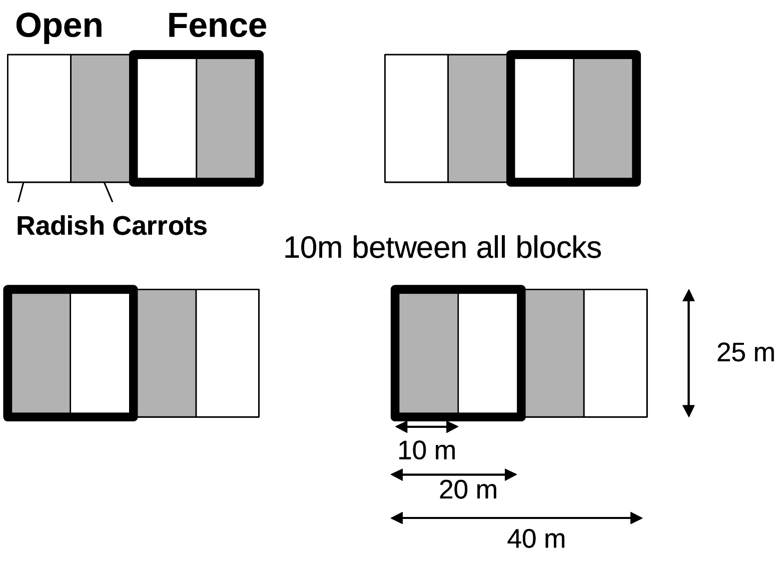

Figure 1. Experimental layout of crop areas, fenced plots and blocks

Results

In 2004, the fence had no effect on root flies ($\chi 2$ test on counts of damaged roots, carrots: n = 240, $\chi 2$ = 0,290, p = 0,865 and radish: n = 200, $\chi 2$ = 5,301, p = 0,151). Marketable yield was 86 %-88 % for the carrots and only 12 % -13 % in radish regardless of the fence. We also observed as many flea beetles and aphids outside the fence netting as inside. Cabbage root fly attack was heavy, rendering almost 90 % of the radish unmarketable. Carrot fly damage was moderate, however, with just over 10 % visibly damaged roots being unacceptable (2-5 % damage threshold). Reason for failure may the length of the overhang structure. Since the overhang was less than 20 cm long on a fence that was 1.70m tall, flies may not have been prevented from moving up and over the fence (see Bomford et al. 2000). In 2005, we increased the overhang to 35 cm and used white polyethylene instead of wood. Although we cannot be certain whether the length of the overhang or the low population size affected the results, the fence excluded a significant number of cabbage root flies and reduced damage to the radish (Tab.1). For comparison, the uncorrected degree of efficiency resulted in 55 % less damaged roots. This result is almost in line with results reported elsewhere Meadow & Johanson 2003).

Table 1. Proportion of damaged radish roots in each damage category in 2005.

	Damage scores				
	I	II	Market (I+II)	III	IV
No Fence	37 %	12 %	50 %	48 %	3 %
With Fence	66 %	10 %	77 %	23 %	0 %

Root counts in the different damage categories are statistically different between the fenced and unfenced treatments; n = 240, $\chi^2 = 22.473$, $p < 0{,}001$

However, as in 2004, the fence did not prevent carrot fly damage (Tab. 2.). The carrot fly differs from the cabbage root fly in size, biology and flight behaviour and these differences seem to play a significant role in for the response of carrot rust flies to fences. Being a rather weak flier, carrot flies may be affected by air turbulence or may just walk over the overhang once they have landed on the fence. Indeed, carrot flies are spending a large proportion of their time in hedges or hedge-like structures and commonly walk over and within barriers (Stan Finch, pers. comm.). Since these flies regularly enter and leave carrot fields, a second overhang, inside the fence, seems to be necessary (Bob Vernon, pers. comm.).

Table 2. Proportion of damaged carrot roots in categories of damage scores in 2005

	Damage scores				
	I	II	Market (I+II)	III	IV
No Fence	48 %	33 %	81 %	19 %	0 %
With Fence	53 %	26 %	79 %	21 %	0 %

Root counts in the different damage categories are not statistically different between the fenced and unfenced treatments; n = 240, $\chi^2 = 3.258$, p = 0.196

The factors that are crucial to the success of insect fences seem to be the structure of the overhang and the pest population density. Although fences improve pest control considerably, the reported damage reductions of 50-70 % (Vernon & Mackenzie 1998; Pats & Vernon 1999; Vernon & McGregor 1999; Bomford et al. 2000; Meadow and Johansson 2003; Wyss et al. 2004) may not be sufficient in a commercial situation . Also, fences that are effective against cabbage root fly may not necessarily work against carrot rust fly. There is a need for more research on the behaviour of this fly as they come into contact with the fences and encounter the overhang. Before this technique can be used in commercial vegetable growing, its efficacy, practicability and cost need further evaluation.

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