

## EFFECT OF CULTIVAR AND CULTURAL TECHNIQUES ON CARROT RUST FLY AND CARROT PRODUCTION

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In New Zealand, carrots (*Daucus carota* Hoffm) are a commodity crop grown mainly for the local market but a small volume is processed. Carrot rust fly (*Psila rosae*) is the major pest problem facing carrot growers in New Zealand. In commercial practice growers either grow the crop at a time of year when the pest is not present, or present in very low numbers, or use various pesticides (Chapman and Penman 1982; O'Connor 1988).

In organic production systems use of synthetic pesticides is not permissible and pest control must rely on other means such as the use of cultural techniques. Dufault and Coaker (1987) maintained that cultural control of carrot rust fly could only be achieved by varying time of planting. Identification of carrot cultivars resistant to carrot rust fly has been the subject of at least 20 years research at the National Vegetable Research Station at Wellesbourne England, and they have produced some useful data on variation in susceptibility between cultivars, seasons and sites (Ellis *et al* 1978, 1987, 1983; Ellis and Hardman 1981; Wheatley and Freeman 1982; Cole *et al* 1987).

Other vegetable crop pests have been controlled by a range of cultural controls. For example firmly packed soil prevents oviposition by sciarid flies in greenhouses (A.D. Calvert, pers. comm.). Effective cultural control of potato moth is based on careful moulding of soil over the tubers (Fenimore 1978). Oviposition by the onion maggot may be reduced by the use of pino oil (Javer *et al* 1987). Amongst growers of organic produce it is believed that the use of "fly fence" is an effective means of reducing carrot rust fly infestation, although the recommended height of the fence varies. Plant spacing may also affect the number of roots damaged.

The research described here had two aims: to identify growing methods that might reduce or eliminate the need for insecticides for carrot rust fly control and, on a larger scale to investigate methods including plant resistance which may be useful for organically growing carrots on a broad acre basis.

All trials were conducted at the Levin Horticultural Research Centre on a Kiwitea silt loam soil. Seed was planted with a Planet Junior Seed Drill with 20 mm between individual seeds.

### **Cultivar evaluations**

Seed of a range of carrot cultivars was made available by Dr P.R. Ellis of the Institute of Horticulture Research, Wellesbourne, United Kingdom.

Seed of eleven cultivars (Table 1) were planted in November 1988 and the carrots harvested on 22 February 1989. There were two replicated plots of five rows, each 35 cm apart and 5 m long. Yield was taken from 2 rows in each plot, each 1 m long. A sample of 50 carrots from the yield harvest were assessed for carrot rust fly damage. Carrots were sorted as saleable or non-saleable based on the absence or presence of carrot rust fly larval mines. Yield data was analysed by ANOVA, and carrot rust fly infestation levels by analyses of deviances (Wheatley and Freeman 1982).

The eleven cultivars are ranked in ascending order of carrot rust fly infestation (Table 1). Analysis was complicated by overdispersion. Allowing for this in the model of Wheatley and Freeman (1982), there were no significant differences between cultivars in the proportion of carrot rust fly infestation.

'Nandor' and 'Sytan' gave significantly ( $P < 0.05$ ) greater total yield than 'Jaune Obtuse du Daubs', 'Nantacket', 'Touchon Prima' and 'Danvers Harf' (Table 1). The yield of the other cultivars — 'Autumn King', 'Vertou', 'Gelbe Rheinische' and 'Chantenay Elite', did not differ significantly from 'Nandor' and 'Sytan'.

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**TABLE 1: Mean proportion of selected carrot cultivars infested with carrot fly at harvest, February 1989. Approximate standard errors were derived from analysis of deviance and general linear models.**

Variety	Mean proportion infested (approx. s.e.)	Yield/plot (kg)	Saleable yield/plot (kg)
Touchon Prima	0.40 (0.05)	2.9	1.8
Chantenay Elite	0.46 (0.05)	4.0	2.2
Vertou	0.48 (0.05)	4.4	2.3
Nandor	0.50 (0.05)	5.7	2.8
Danvers Harf	0.53 (0.05)	3.3	1.6
Sytan	0.57 (0.05)	5.7	2.4
Nantacket	0.57 (0.05)	3.0	1.3
Chantenay Red Core	0.61 (0.05)	3.9	1.5
Gelbe Rheinische	0.65 (0.05)	4.3	1.5
Autumn King	0.68 (0.05)	4.5	1.4
Jaune Obtuse du Daubs	0.86 (0.03)	3.0	0.4
LSD	N/A	1.8	2.0

Seed of five of the more promising cultivars from the 1988 trial (Table 2) were planted in December 1989 and the carrots harvested on 15 May 1990. Two rows 2 m long were harvested from the centre of each plot and sorted into saleable and unsaleable as above. Clean yield was calculated as the total weight of carrots harvested multiplied by the percentage of clean roots found. Carrot fly infestation levels were analysed with the Tukey multiple comparison test.

The five cultivars fell into two groups. 'Royal Chantenay Elite' and 'Danvers Harf' had large roots, low plant density and about 50% of the roots were infested with carrot rust fly (Table 2). These factors combined gave an estimated clean yield of 7.6 and 8.2 kg respectively. 'Vertou', 'Sytan', and 'Nandor' had smaller roots, higher root densities and lower carrot rust fly infestation. 'Vertou' had significantly lower carrot rust fly damaged roots than any other cultivar. The clean yield estimates of 13.8 kg for 'Vertou', 16.4 kg for 'Nandor' and 17.2 kg for Sytan, demonstrated the importance of the interaction between yield, plant density and carrot rust fly infestation. It is not clear why the final density should have varied between cultivars as the original plantings were all at the same seeding rate.

**TABLE 2: Carrot yield and carrot rust fly incidence 1989/90 season. Treatments with different letters are significantly different at the 5% level.**

Cultivar	% infested roots*	Average weight of carrots (gm)	No. of carrots/plot	Estimated clean yield (kgs)**
Vertou	21.04 a	48.5 a	79.6 a	13.8
Nandor	32.93 b	63.1 a	89.6 a	16.4
Sytan	36.23 b	65.9 a	80.6 a	17.2
Royal Chantenay Elite	50.88 c	103.2 b	36.4 b	7.6
Danvers Harf	51.74 c	123.4 b	34.6 b	8.2
LSD =	N/A	30	19.9	

\* Tukey multiple comparison test

\*\* Estimated clear yield = total weight x % clean roots.

'Sytan' is one of the most reliably resistant cultivars available and is used as a standard against which new cultivars are compared (Ellis and Hardman 1981). In some years and at some sites 'Vertou' has been as, or more, resistant than 'Sytan' (Ellis and Hardman 1981) and this cultivar was the least damaged in our trials. 'Nandor' is a newer cultivar and there is no published information on its resistance to carrot rust fly.

It appears promising, however, comparing well with 'Sytan'. In Europe trials with 'Chantenay Elite' and 'Danvers Harf' have given less consistent results than 'Sytan' (Ellis and Hardman 1981).

#### Cultural methods

The trial plots were blocks of five rows, 1 m long of 'Chantenay Red Core'. The treatments (Table 3) were replicated ten times. Seed was planted in November 1988 and the carrots harvested on 22 February 1989. Three rows 0.8 m long were harvested from the centre of each plot and the carrots were separated into saleable and unsaleable lines.

Despite some range in the levels of carrot rust fly infestation between the various treatments (Table 3), the differences were not significant when compared with untreated. The highest yield, both total and saleable, was from the treatment where the soil was pressed down along the rows of carrots ( $P < 0.05$ ). No other yield differed significantly except that the total yield from the plots thinned to 9 cm spacing was significantly lower than the pressed soil treatment and the fenced treatment. The yield response of the carrots to having soil pressed down along the rows is most likely an agronomic effect as it was not related to any decrease in the level of carrot rust fly attack. From the information derived from this trial the development of an effective cultural control for carrot rust fly depends on a more detailed understanding of the biology, ecology and behaviour of the pest in New Zealand.

**TABLE 3: Mean proportion of carrots infested with carrot rust fly when subjected to a range of cultural practices.**

Treatment	Mean proportion infested (approx. s.e.)	Yield/plot (kg)	Saleable yield/plot (kg)
Untreated	0.38 (0.02)	3.2	1.9
Pine oil 1 ppm (4 weekly)	0.25 (0.02)	2.8	1.9
Pine oil 10 ppm (4 weekly)	0.27 (0.02)	3.2	2.2
Pine oil 100 ppm (4 weekly)	0.34 (0.02)	2.8	1.8
Moulding soil along rows	0.23 (0.02)	2.8	2.2
Pressing soil down along rows	0.26 (0.02)	3.9	2.9
Shade cloth fence 300 mm high	0.30 (0.02)	3.3	2.1
Plants spaced 3 cm	0.22 (0.02)	2.6	2.1
Plants spaced 6 cm	0.36 (0.03)	2.6	1.9
Plants spaced 9 cm	0.23 (0.03)	2.4	1.8
LSD	N/A	0.7	0.6

The results from these trials indicated that 'Sytan', 'Nandor' and 'Vertou' were amongst the most resistant cultivars in both seasons, but the level of carrot rust fly infestation was still unacceptably high. None of the cultural controls used in this work were effective.

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