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Effect of Field Crops on Population Densities of *Pratylenchus neglectus* and *P. thornei* in Southeastern Australia; Part 1: *P. neglectus*[1]

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Abstract: Eighty-one cultivars from 12 field crop species were assessed for suitability as hosts to the root lesion nematode, *Pratylenchus neglectus,* in two field trials. Host status was assessed on the basis of either final *P. neglectus* densities in soil or multiplication rate under different crops. Both techniques gave consistent results for crop and cultivar ranking, and it was therefore concluded that, in these trials, final population density could be used for screening cultivars for resistance to *P. neglectus.* Differences were observed among crops and cultivars for host suitability to *P. neglectus.* Chickpea, wheat, and canola were good hosts, while barley, oat, durum wheat, medic, and vetch were moderate hosts. Field pea, faba bean, and triticale were poor hosts. A range in host suitability was observed for wheat, barley, and oat cultivars.
Key words: barley, canola, chickpea, control, faba bean, field pea, host suitability, medic, multiplication, oat, resistance, root lesion nematode, rotation, susceptibility, triticale, vetch, wheat.

The root lesion nematode, *Pratylenchus neglectus* (Rensch) Filipjev Schuurmans Stekhoven, is a migratory endoparasite of many crop and pasture species in temperate regions of the world. This nematode has been implicated in causing yield loss in barley (Ferris et al., 1994; Umesh and Ferris, 1992), potato (Olthof, 1990), alfalfa (Griffin, 1991; Griffin and Gray, 1990), and rangeland grasses (Griffin, 1996).

In the dryland, large-scale cropping areas of southeastern Australia, wheat is a major host of *P. neglectus.* This nematode has been shown to cause yield loss of approximately 20% in nematicide trials and by linear correlation analyses of final nematode populations with grain yield (Taylor et al., 1999; Vanstone et al., 1998). Another species of root lesion nematode, *P. thornei* Sher and Allen, is also common in this region, with yield losses of up to 40% in cereals (Thompson et al., 1995; Vanstone et al., 1998). Both *Pratylenchus* species have similar host ranges and may occur together in southeastern Australia.

Reducing initial nematode densities can minimize damage caused by plant-parasitic nematodes and is best achieved, in low-input cropping systems, by growing resistant crops or cultivars (Brown, 1987). Resistance is defined as ''the capacity of the plant to prevent or decrease nematode multiplication'' (Trudgill et al., 1998). Resistant cultivars are desirable within cropping rotations, as the direct replacement of a susceptible cultivar often requires no specialized equipment and shorter rotations may be implemented (Cook and Evans, 1987). In addition, the need for nematicides is eliminated—a factor critical to the production of low-input crops in southeastern Australia.

Cook and Evans (1987) note that cultivars may be ''completely resistant'' (allowing no nematode multiplication) or ''partially resistant'' (allowing intermediate levels of nematode multiplication). Complete resistance has been shown to occur against nematodes that have a highly specialized relationship with the host, such as *Meloidogyne* or *Heterodera* (e.g., in peanut to *M. arenaria*) (Nelson et al., 1989). For migratory endoparasites with a less specialized host-parasite interaction, partial resistance appears common. Examples of partial resistance have

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been demonstrated for *P. vulnus* in *Prunus* spp. (Alcañiz et al., 1996), *Rotylenchus reniformis* in soybean (Robbins et al., 1994), and *P. penetrans* in alfalfa (Thies et al., 1994).

Resistance is commonly measured by assessing final nematode densities in plants (termed Pf; e.g., Fernández et al., 1994) or multiplication rate (termed Pf/Pi [final population density/initial population density]; e.g., Alcañiz et al., 1996). Non-hosts have also been described as having a multiplication rate (MR) of <0.1, a poor host as having MR < 1, and a good host MR > 1. Assessment of MR enables comparison when unequal initial densities occur and allows comparisons across experiments or even between nematode species.

Multiplication rate will be affected by many factors. Edaphic factors such as soil moisture (Duncan and el-Morshedy, 1996), texture (Delaville et al., 1996), nutrient status (Lopez et al., 1997), and temperature (Mani and Hinai, 1997) affect both nematode and host. Synergistic (Taheri, 1996; Walker, 1997) and antagonistic (Wenefrida, et al., 1998) soil biota may alter the extent or severity of damage and (or) the MR of nematodes within a host. Initial densities of plant-parasitic nematodes also affect MR, with lower initial densities resulting in higher multiplication (Fisher and Hancock, 1991; Seinhorst, 1966). Multiplication rate is therefore usually estimated in greenhouse experiments where temperature, moisture, and soil and shoot biota are more easily controlled. Validation of greenhouse tests with field experiments is essential to better understand how nematode densities may change under different environmental conditions (Nombela and Romera 1999).

Although resistance to root lesion nematodes is often compared among cultivars of one crop species, few comparative rankings within and among crops in field experiments have been conducted. In this study, field trials were established to enable comparison of *P. neglectus* multiplication for 81 cultivars of 12 crop and pasture species at two sites over two growing seasons. Resistance in field crops was defined using comparison with a suitable wheat host (cv. Machete) or non-suitable triticale host (cv. Abacus) previously identified in field and pot experiments (Farsi, 1995; Taylor et al., 1999; Vanstone, pers. comm.). Both MR and final nematode density were used to determine the resistance or susceptibility of crops and cultivars. Implications for management of both *P. neglectus* and *P. thornei* are further discussed by Hollaway et al. (2000).

Materials and Methods

Field trials: Field trials were located on sites naturally infested with *P. neglectus* at Sandilands, 1996 (calcareous loamy earth) and Paskeville, 1997 (alkaline red duplex soil) Yorke Peninsula, South Australia. Rainfall data are presented in Table 1, and no supplementary irrigation was supplied at either site.

In both trials, a susceptible wheat (cv. Machete) and resistant triticale (cv. Abacus) were included as reference cultivars. At Sandilands, 17 wheat (*Triticum aestivum* L.), 2 durum (*T. turgidum* L. subsp. *durum* (Desf. [Husn]), 7 barley (*Hordeum vulgare* L.), 7 oat (*Avena sativa* L.), 3 triticale [derived from rye (*Secale cereale* L.) x wheat hybridization], 5 chickpea (*Cicer arietinum* L.), 7 field pea (*Pisum sativum* L.), 3 faba bean (*Vicia faba* L.), 3 vetch (*V. sativa* L.), 7 canola (*Brassica napus* L.), and 8 annual medic (*Medicago* spp.) cultivars were sown. At Paskeville, 18 wheat, 2 durum, 9 barley, 7 oat, 2 triticale, 2 cereal rye, 6 chickpea, 3 field pea, 3 faba bean, 2 vetch, 8 canola, and 8 medic cultivars were sown (Table 2). Seeding rates for each crop (seeds/m^2) were: wheat, durum, oat, triticale and rye 180; barley 165; medic 200; vetch 50; desi chickpea 50; kabuli chick-

Table 1. Average, annual, and growing-season rainfall for Sandilands (1996) and Paskeville (1997), South Australia (South Australian Bureau of Meteorology).

	Annual rainfall (mm)	Growing-season rainfall (April to August) (mm)
Sandilands, 1996	486 (504)[a]	302 (300)
Paskeville, 1997	499 (390)	180 (224)

[a] Figures in brackets are average rainfall (1947–1997).

TABLE 2. Comparison of final *Pratylenchus neglectus* density (Pf) and multiplication rate (Pf/Pi) between cultivars of 12 field crop and pasture species grown in field trials in 1996 (Sandilands) and 1997 (Paskeville), South Australia.

Cultivar and crop	Sandilands 1996		Paskeville 1997		Ranking[a]		Resistance designation[c]
	Pf[d]	Pf/Pi	Pf	Pf/Pi	Pf	Pf/Pi	
Desavic (Chickpea)	0.8 (1.3)[b]	1.7 (4.7)	1.1 (2.1)	2.2 (7.6)	0.81	2.00	S
Machete (Wheat)	1.3 (2.6)	1.6 (4.2)	1.3 (2.6)	2.0 (6.0)	1.38	1.71	S
Narendra (Canola)	0.8 (1.2)	1.3 (2.5)	—	—	0.74	1.66	S
Silverstar (Wheat)	1.0 (1.7)	0.7 (1.1)	1.4 (3.0)	2.5 (11.5)	1.03	1.55	S
Hyola 42 (Canola)	0.9 (1.5)	1.2 (1.3)	0.6 (0.9)	1.0 (1.8)	0.66	1.46	S
Beulah (Wheat)	0.8 (1.3)	1.2 (2.2)	0.9 (1.7)	1.3 (2.5)	0.96	1.43	S
Rainbow (Canola)	1.0 (1.7)	1.4 (3.1)	0.4 (0.6)	0.7 (0.9)	0.75	1.43	S
Buckley (Wheat)	1.0 (1.8)	1.2 (2.4)	—	—	1.15	1.38	S
Janz (Wheat)	0.8 (1.1)	1.3 (2.7)	1.1 (1.9)	1.4 (2.9)	0.71	1.37	S
Meering (Wheat)	0.5 (0.6)	0.8 (1.2)	1.2 (2.2)	2.0 (6.6)	0.59	1.35	S
Frame (Wheat)	0.3 (0.4)	0.4 (0.5)	1.1 (1.9)	2.1 (7.2)	0.40	1.35	S
Sloop (Barley)	0.9 (1.6)	1.6 (3.9)	0.9 (1.4)	1.3 (2.6)	0.73	1.34	S
Tyson (Chickpea)	0.5 (0.7)	0.7 (1.0)	1.0 (1.8)	1.6 (4.1)	0.70	1.33	S
Pallinup (Oat)	—	—	1.1 (1.9)	1.8 (4.8)	0.55	1.27	S
Dunkeld (Canola)	1.4 (3.2)	1.5 (3.6)	0.8 (1.3)	1.2 (2.2)	0.80	1.25	S
Ouyen (Wheat)	0.7 (1.0)	0.7 (1.1)	0.8 (1.2)	1.4 (3.0)	0.60	1.22	S
Yanac (Wheat)	0.7 (1.1)	0.8 (1.1)	1.2 (2.3)	1.6 (4.0)	0.86	1.19	S
Trident (Wheat)	0.6 (0.8)	0.6 (0.9)	0.9 (1.4)	1.6 (3.9)	0.53	1.16	S
Barunga (Wheat)	0.6 (0.8)	0.7 (1.1)	0.9 (1.4)	1.4 (2.9)	0.55	1.14	S
Spear (Wheat)	0.7 (0.9)	0.9 (1.3)	0.9 (1.6)	1.5 (3.7)	0.63	1.09	S
Grouse (Canola)	—	—	1.1 (1.8)	1.5 (3.5)	0.56	1.09	S
Kaniva (Chickpea)	0.9 (1.6)	0.8 (1.2)	1.0 (1.6)	1.4 (3.2)	0.69	1.09	S
Karoo (Canola)	0.9 (1.6)	1.0 (1.8)	0.7 (0.9)	0.9 (1.4)	0.59	1.07	S
Carnamah (Wheat)	—	—	0.9 (1.5)	1.5 (3.6)	0.40	1.05	S
Oscar (Canola)	1.0 (1.6)	1.6 (3.7)	0.6 (0.8)	1.0 (1.6)	0.33	1.03	S
Amethyst (Chickpea)	0.6 (0.9)	0.8 (1.1)	0.6 (0.9)	1.1 (2.1)	0.45	1.03	S
Monty (Canola)	0.9 (1.6)	1.0 (1.7)	0.8 (1.4)	1.3 (2.7)	0.55	1.01	S
Lasseter (Chickpea)	—	—	0.9 (1.6)	1.6 (3.8)	0.30	1.00	S
Chebec (Barley)	0.5 (0.6)	0.7 (1.0)	0.9 (1.5)	1.6 (3.7)	0.19	0.98	M
Bettong (Oat)	0.4 (0.6)	0.5 (0.7)	0.8 (1.3)	1.4 (2.9)	0.38	0.98	M
Schooner (Barley)	0.8 (1.2)	0.8 (1.3)	0.5 (0.7)	0.9 (1.6)	0.35	0.97	M
Dooen (Chickpea)	0.6 (0.8)	0.6 (0.8)	1.0 (1.8)	1.4 (3.1)	0.60	0.97	M
Bandicoot (Oat)	0.4 (0.5)	0.6 (0.8)	—	—	0.21	0.97	M
Languedoc (Vetch)	0.4 (0.5)	0.3 (0.4)	1.1 (1.9)	1.6 (3.9)	0.65	0.96	M
Echidna (Oat)	0.4 (0.5)	0.4 (0.5)	1.1 (2.1)	1.5 (3.6)	0.35	0.90	M
Marloo (Oat)	—	—	0.7 (1.0)	1.0 (1.7)	0.46	0.88	M
Barque (Barley)	0.4 (0.6)	0.4 (0.5)	0.9 (1.5)	1.6 (4.1)	0.28	0.88	M
Franklin (Barley)	0.5 (0.7)	0.5 (0.6)	0.9 (1.5)	1.9 (5.6)	0.30	0.87	M
Goldmark (Wheat)	—	—	0.9 (1.4)	1.2 (2.4)	0.42	0.84	M
Carrolup (Oat)	0.5 (0.6)	0.9 (1.5)	0.8 (1.2)	1.0 (1.6)	0.31	0.79	M
Pinnacle (Canola)	—	—	0.8 (1.2)	1.4 (2.9)	0.24	0.76	M
Arapiles (Barley)	0.2 (0.2)	0.3 (0.4)	0.7 (1.1)	1.4 (2.9)	−0.31	0.76	M
Skiff (Barley)	—	—	0.7 (0.9)	1.1 (2.1)	0.07	0.68	M
Popany (Vetch)	0.4 (0.5)	0.4 (0.5)	—	—	−0.17	0.63	M
Herald (Medic)	0.4 (0.6)	0.5 (0.7)	0.5 (0.6)	0.9 (1.4)	−0.04	0.60	M
Bowie (Wheat)	0.4 (0.5)	0.6 (0.8)	0.7 (1.1)	0.8 (1.2)	−0.03	0.60	M
Mundah (Barley)	—	—	0.9 (1.6)	1.2 (2.4)	0.26	0.60	M
Mogul (Medic)	0.4 (0.5)	0.4 (0.5)	0.6 (1.9)	1.2 (2.5)	−0.03	0.59	M
Cascades (Wheat)	—	—	0.5 (0.6)	1.1 (2.1)	−0.26	0.58	M
Potoroo (Oat)	0.3 (0.3)	0.4 (0.4)	0.8 (1.3)	1.3 (2.7)	−0.17	0.58	M
Parabinga (Medic)	0.3 (0.4)	0.3 (0.4)	0.6 (0.9)	1.0 (1.6)	−0.04	0.47	M
Galleon (Barley)	0.2 (0.2)	0.3 (0.3)	0.8 (1.2)	1.1 (2.1)	−0.08	0.46	M
Sava (Medic)	0.2 (0.2)	0.4 (0.5)	0.4 (0.5)	0.9 (1.4)	−0.48	0.45	M
Wallaroo (Oat)	0.4 (0.5)	0.3 (0.4)	—	—	0.08	0.44	M
Tamaroi (Durum)	0.2 (0.3)	0.4 (0.5)	0.5 (0.7)	1.1 (2.0)	−0.37	0.38	M
Blanchefleur (Vetch)	0.3 (0.3)	0.2 (0.3)	0.8 (1.2)	1.1 (2.1)	0.07	0.36	M

TABLE 2. *Continued*

Cultivar and crop	Sandilands 1996		Paskeville 1997		Ranking[a]		Resistance designation[c]
	Pf[d]	Pf/Pi	Pf	Pf/Pi	Pf	Pf/Pi	
Tatiara (Wheat)	0.3 (0.3)	0.3 (0.4)	—	—	−0.17	0.31	M
Glenroy (Field pea)	0.2 (0.2)	0.3 (0.3)	—	—	−0.59	0.30	M
Excalibur (Wheat)	0.4 (0.5)	0.5 (0.7)	0.7 (1.0)	1.2 (2.2)	−0.19	0.29	M
Worrakatta (Wheat)	0.2 (0.3)	0.2 (0.2)	0.5 (0.7)	1.0 (1.8)	−0.38	0.29	M
Laura (Field pea)	0.2 (0.2)	0.3 (0.3)	—	—	−0.71	0.29	M
Bluey (Field pea)	0.2 (0.2)	0.5 (0.7)	0.2 (0.2)	0.4 (0.4)	−1.01	0.28	R
Santiago (Medic)	0.2 (0.3)	0.3 (0.3)	0.5 (0.6)	0.7 (2.1)	−0.49	0.24	R
Paraggio (Medic)	0.2 (0.2)	0.2 (0.2)	0.5 (0.7)	0.9 (1.4)	−0.42	0.15	R
Yallaroi (Durum)	0.1 (0.1)	0.3 (0.4)	0.4 (0.5)	0.7 (1.0)	−0.75	0.14	R
Harbinger (Medic)	0.4 (0.5)	0.3 (0.3)	0.3 (0.3)	0.7 (1.0)	−0.57	0.06	R
Caliph (Medic)	0.1 (0.1)	0.3 (0.3)	0.4 (0.4)	0.7 (1.1)	−0.81	0.03	R
Ascot (Faba bean)	0.1 (0.1)	0.2 (0.2)	0.5 (0.6)	0.7 (1.1)	−0.81	0.02	R
Bevy (Rye)	—	—	0.2 (0.2)	0.5 (0.7)	−0.98	−0.01	R
Dundale (Field pea)	0.1 (0.2)	0.6 (0.9)	0.2 (0.2)	0.3 (0.3)	−1.28	−0.06	R
Icarus (Faba bean)	0.1 (0.2)	0.2 (0.2)	0.4 (0.5)	0.6 (0.9)	−0.92	−0.06	R
Tahara (Triticale)	0.1 (0.1)	0.2 (0.2)	0.2 (0.3)	0.5 (0.7)	−1.00	−0.06	R
Fiord (Faba bean)	0.1 (0.1)	0.1 (0.1)	0.4 (0.4)	0.6 (0.8)	−0.84	−0.16	R
Euro (Oat)	0.3 (0.4)	0.3 (0.3)	0.5 (0.6)	0.6 (0.9)	−0.78	−0.20	R
Krichauff (Wheat)	0.1 (0.1)	0.1 (0.1)	0.5 (0.7)	1.0 (1.7)	−0.93	−0.24	R
Muir (Triticale)	0.1 (0.1)	0.1 (0.1)	—	—	−0.73	−0.30	R
SA Rye (Rye)	—	—	0.2 (0.2)	0.5 (0.7)	−1.27	−0.33	R
Bonzer (Field pea)	0.2 (0.2)	0.2 (0.2)	—	—	−0.87	−0.35	R
Alma (Field pea)	0.1 (0.1)	0.2 (0.2)	0.2 (0.2)	0.4 (0.4)	−1.28	−0.50	R
Early dun (Field pea)	0.2 (0.2)	0.2 (0.2)	—	—	−0.93	−0.53	R
Abacus (Triticale)	0.1 (0.1)	0.2 (0.2)	0.3 (0.3)	0.5 (0.7)	−1.3	−0.76	R
LSD (0.05)	0.4	0.6	0.5	0.6	na	na	

[a] Combined data from 1996 and 1997 ranked on multiplication rate (Pf/Pi).
[b] Figures in parentheses are back-transformed means (*P. neglectus*/g dry soil).
[c] S = susceptible (mean significantly > Abacus), M = moderate (mean not significantly different from Machete or Abacus), R = resistant (mean significantly < Machete).
[d] Final density of *P. neglectus* [$\log_e$ (*P. neglectus*)].

pea 35; field pea 35; faba bean 22; and canola 190.

At each site, all crops were sown within the same trial area but separated into blocks for herbicide management. The separate blocks were: wheat, barley and triticale; oat; faba bean and vetch; canola; medic; field pea; chickpea. Cereal, faba bean, chickpea, vetch, and field pea cultivars were sown at a depth of 50–60 mm. Medic and canola cultivars were sown at a depth of 10 mm.

The Sandilands site was sown on 20 June 1996, and all plots were harvested on 16 December 1996. The Paskeville site was sown on 4 June 1977, and field pea, vetch, oat, and early canola varieties were harvested on 15 November 1997. Wheat, barley, triticale, chickpea, and late canola varieties were harvested on 20 November 1997.

All plots were 5 m long by 0.8 m wide with 6 rows per plot (120-mm row spacing). Fertilizer was applied at seeding (N:P:K 17:19:0, Zn 5%) at 80 kg/ha (70 g/plot). Weeds and insects were controlled using recommended district practice (Code and Chambers, 1997). Medic buffers (cv. Caliph) were sown between blocks to allow separation for herbicide management. Each field trial was set up as completely randomized blocks of four replications.

Nematode sampling and extraction: At Sandilands, all plots were sampled on 2 July 1996 (to obtain Pi) and on 19 November 1996 (to obtain Pf). At Paskeville, all plots were sampled on 11 June 1997 and on 3 December 1997. Fifteen to 20 soil samples (containing root material) were collected from each plot using an Arborline corer (25-mm diam. × 100-mm depth) and sealed in plastic bags. Soil samples were stored at 4 °C prior to

TABLE 2. Comparison of multiplication rate (Pf/Pi) and final density of *Pratylenchus neglectus* following field crop and pasture species grown in field trials in South Australia (1996 and 1997). Figures are scaled: site mean = 0.

	Sandilands 1996			Paskeville 1997	
Crop type	Multiplication rate	Final *P. neglectus*/g	Crop type	Multiplication rate	Final *P. neglectus*/g
Canola	1.53	1.23	Chickpea	0.86	0.85
Chickpea	0.81	0.87	Wheat	0.71	0.75
Wheat	0.48	0.63	Barley	0.61	0.60
Barley	0.37	0.32	Oat	0.43	0.63
Oat	0.15	0.20	Canola	0.38	0.61
Medic	–0.10	–0.05	Vetch	0.35	0.37
Durum	–0.16	–0.33	Medic	–0.20	–0.17
Vetch	–0.17	0.15	Durum	–0.21	–0.27
Field pea	–0.71	–0.88	Triticale	–0.43	–0.78
Faba bean	–0.77	–0.95	Faba bean	–0.57	–0.36
Triticale	–1.42	–1.18	Rye	–0.76	–0.95
Rye	not tested	not tested	Field pea	–1.16	–1.29
LSD (0.05)	0.51	0.42	l.s.d	0.29	0.30

nematode extraction. Soil water content for each plot was assessed by drying a 50-g soil subsample at 60 °C for 72 hours.

Nematodes were extracted over 72 hours at 22 °C from a 200-g subsample using modified Whitehead trays (Whitehead and Hemming, 1965) and concentrated using a 20-µm sieve. The resulting nematode suspensions were stored at 4 °C until counted. Nematode densities for each sample were determined by counting two, 1-ml subsamples under a dissection microscope (40×) and expressed as nematodes per gram of dry soil. In each plot, *P. neglectus* was identified on the basis of the vulval position in adult females (V = 73–80%; Loof, 1991) and confirmed for each site by allozyme electrophoresis (unpubl. data).

Statistical analysis: For each cultivar, the means of four replicates were log transformed [log, (*P. neglectus*/g soil)] to normalize data sets before analysis of variance was conducted and means separated ($P \leq 0.05$). Multiplication rates were determined by dividing final *P. neglectus*/g soil by initial *P. neglectus*/g soil. Differences among cultivars were compared with either susceptible wheat (cv. Machete) or resistant triticale (cv. Abacus), using Fisher's protected least significant difference (l.s.d). Cultivars were rated as susceptible (mean not significantly different from Machete and significantly > Abacus), moderate (mean not significantly different from Machete or Abacus), and resistant (mean not significantly different from Abacus and significantly < Machete). In addition, to assess comparative differences among cultivars in both trials, data were analyzed using the spatial techniques of Cullis and Gleeson (1991) and Gilmour et al. (1997). This analysis allows for edaphic differences between sites. Using this analysis, the following models were compared:

$$Log_e\ (multiplication\ rate) = block + mean + cultivar$$

$$Log_e\ (final\ \mathrm{P.\ neglectus}\ density/g\ of\ soil) = block + mean + cultivar.$$

The block factor was used to extract field variation due to trends within each trial and was a combination of row and (or) column effects. The cultivar factor was fitted as a random effect to generate a genetic variance for each trial. In addition, correlation between study sites determined similarity of cultivars using the following model:

$$Log_e\ (Final\ \mathrm{P.\ neglectus}/g\ soil\ or\ multiplication\ rate) = block + site + site{:}cultivar.$$

Analysis between crop species was determined using the model:

$$Log_e\ (Final\ \text{P. neglectus}/g\ soil\ or\ multiplication\ rate) = block + mean + crop\ type.$$

Cultivars were ranked against the site mean for each trial and an overall ''common'' ranking for each cultivar calculated from the between site correlations (Table 2).

Results

Site conditions: The mean initial *P. neglectus* densities were 1.1 nematodes/g of dry soil (range = 0.1–6.5/g) at Sandilands and 0.5 nematodes/g of soil (range = 0.1–1.6/g) at Paskeville. Total annual rainfall at both sites was similar. At Paskeville, however, rainfall in the April-to-August growing period was below average, with 40% less than that recorded for the same period at Sandilands in 1996 (Table 1).

Comparison of cultivar rankings using MR or final nematode density: The final densities and MRs of *P. neglectus* following a range of field crops and pasture species tested in the field at Sandilands and Paskeville are shown in Table 2. In 1996 at Sandilands, cultivars were generally less susceptible, with 13 of the 69 cultivars rated as susceptible compared with 44 of 71 cultivars in 1997 at Paskeville. In 1996, there were differences between rankings obtained using MR or final density. For example, final nematode densities for Narendra canola and Beulah and Janz wheat were lower than for Machete, while MRs for these cultivars were not different from Machete.

In 1997, fewer differences between rankings were observed using MR and final density. Higher final nematode densities and MRs were observed for most cultivars than in 1996, and selected cultivars rated as resistant in 1996 were moderate or susceptible in 1997 (e.g., Barunga and Goldmark wheat, Amethyst chickpea, Schooner barley, and Bandicoot oat).

The overall site means for both multiplication and final *P. neglectus*/g of dry soil was higher at Paskeville compared with Sandilands (Table 2). Triticale and field pea cultivars were the least susceptible to *P. neglectus* at both sites. In general, canola and chickpea cultivars were the most susceptible. A range in susceptibility was observed among wheat cultivars, with Machete, Silverstar, and Frame wheat being the most susceptible and Krichauff, Worrakatta (sister lines), and Excalibur most resistant. Barley, medic, vetch, and oat cultivars were generally ranked as moderate for susceptibility against the site mean. The barley cv. Sloop was the most susceptible barley tested, with a ranking comparable to the more susceptible wheat and canola cultivars.

Comparison by crop species: Ranking for crop species are presented in Table 3. Ranking using either MR or final *P. neglectus*/g of dry soil produced consistent results. Although vetch was more susceptible in 1996 using final numbers compared with MR, there was no significant difference between susceptibility of vetch, medic, or durum wheat in either analysis. In 1997 there was no significant difference in crop ranking using either final *P. neglectus* density or MR.

Ranking of crops was similar for both trials. Chickpea and wheat produced consistently high final nematode densities, while field pea, faba bean, and triticale had the lowest final densities. Canola was the only crop where the ranking was significantly different between trials—it was the most susceptible at Sandilands in 1996 but only fifth most susceptible at Paskeville in 1997 (Table 3).

Discussion

These trials demonstrate that while many crop and pasture species are hosts to *P. neglectus* in southeastern Australia, variation in host suitability occurs among cultivars within plant species. Using findings of this study for management of *P. neglectus,* growers can now select crops such as field pea and faba bean to lower nematode soil densities and therefore minimize the risk of yield loss to subsequent intolerant crops.

In this study, comparison of host suitability was made among crop cultivars using final *P. neglectus* numbers from soil samples. This method was considered a relevant assessment of host status because each sample also contained root material, and comparison was made with reference to suitable (cv. Machete wheat) and non-suitable (cv. Abacus triticale) hosts, previously identified in glasshouse studies (Farsi, 1995). Because *Pratylenchus* spp. feed both endoparasitically and ectoparasitically (Zunke, 1990), determination of *P. neglectus* from soil containing roots should recover nematodes both within and surrounding plant roots, giving an accurate indication of nematode densities in each field plot. Trudgill (1986) defined a resistant host as one that resists or hinders nematode development or multiplication. In this study, it was assumed that a reduction in final nematode numbers/g of soil (plus root material) in comparison both with the initial nematode density/g of soil and (or) with suitable and non-suitable host plants constituted a reduction in multiplication and was therefore a measure of resistance.

The use of final nematode densities compared with MR for comparison of cultivars in the field indicates, for practical purposes, the nematode density remaining to infect the following crop. The use of final nematode density is preferred, as use of MR to determine resistance may be confusing in field trials where it is not independent of initial nematode density (Seinhorst, 1970). In addition, if final density is used to determine resistance, it is not necessary to determine initial levels for individual plots. This reduces the time and effort required to determine host suitability, as assessment is required only at harvest. However, the calculation of an overall site mean for initial nematode densities is useful to gain an understanding of nematode density.

There were clear effects of crop species on *P. neglectus* multiplication, with crop host suitability ranked overall as chickpea > wheat > canola > barley > oat > vetch > medic > durum > faba bean > triticale > rye > field pea. Wheat was one of the most susceptible crops, and this crop has also been shown to host *P. neglectus* in North America (Mojtahedi and Santo, 1992). It is important to note, however, that there was a range in resistance among cereal cultivars. Within wheat, the cultivars Excalibur, Worrakatta, and Krichauff had superior resistance, and final nematode densities following these cultivars were comparable to that of field pea and triticale cultivars. Barley cultivars were generally poorer hosts, with the exception of Sloop and Schooner, in contrast with a report by Umesh and Ferris (1992), where barley was highly susceptible to *P. neglectus.*

Canola was the only crop where ranking changed significantly between seasons, being rated as most susceptible in 1996 and only fifth most susceptible in 1997. This may have been due to a possible biofumigation effect, as this was the only crop where *P. neglectus* levels were lower in 1997 compared with 1996 (Potter et al., 1998).

An overall ranking of the cultivars grown at the two sites (with seasonal and site effects removed) is shown in Table 2. Differentiation was made between susceptible, moderate, and resistant categories based on comparison between a known susceptible wheat (cv. Machete) and a resistant triticale (cv. Abacus). Use of the ''moderate'' category was considered more appropriate than designation of a moderately susceptible or moderately resistant rating as final nematode densities (and MRs) differed between seasons. In 1996, many cultivars with the moderate rating were more resistant; in 1997, they were more susceptible.

Both trial sites were selected with low initial *P. neglectus* levels to minimize an intolerant response (i.e., plant damage caused by high nematode densities) limiting nematode multiplication. In this study, the overall ranking of cultivars, determined by either MR or final *P. neglectus* densities/g of soil, was generally consistent between the two experiments, especially for cultivars rated as either susceptible or resistant. However, higher final densities and rates of multiplication were observed in 1997 compared with 1996. These differences may reflect seasonal conditions as, in 1996 (Sandilands), the rainfall was average to above average for the period of crop establishment (April to August) as compared with conditions in 1997 (Paskeville), when rainfall was below average during this period.

In the southern Australian cropping regions, dry conditions have been observed to increase *P. neglectus* multiplication (Taylor, unpubl.; Vanstone, pers. comm.). Drought also increases densities of the citrus nematode *Tylenchulus semipenetrans* (Duncan and el-Morshedy, 1996), possibly because hydraulic lift in the root xylem resulting from decreased soil moisture prolongs the activity of this nematode. This may also promote other migratory endoparasites in the root system and rhizosphere. In addition, it is possible that low soil moisture may decrease ecto-parasitic feeding by *P. neglectus* as movement between soil pores is restricted in dry conditions, therefore encouraging feeding and multiplication within root systems.

In addition to seasonal conditions, the lower initial nematode densities observed at Paskeville may have resulted in higher MRs. However, the final nematode densities at Paskeville were also higher and a larger number of cultivars were ranked as susceptible. An average of 2 *P. neglectus*/g of dry soil (maximum of 3 *P. neglectus*/g) remained after susceptible cultivars at this site compared with 1.4 *P. neglectus*/g of dry soil (maximum of 3.2 *P. neglectus*/g) at Sandilands. Resistant cultivars resulted in average final densities of 0.4 *P. neglectus*/g at Paskeville and 0.2 *P. neglectus*/g at Sandilands. An initial soil density of 3 *P. neglectus*/g dry soil has been demonstrated to cause yield loss (Vanstone et al., 1998); therefore, final levels recorded at these sites have implications for crop loss in southern Australia.

Difficulties occur in defining resistance or susceptibility using field trials, but awareness of the field performance of cultivars will assist both with recommendations for growers and in understanding the dynamics of nematode populations. Cultivar resistance categories will assist with an integrated approach to managing root disease in cropping rotations and will be useful only if seasonal effects on nematode reproduction are also understood.

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