[SHORT COMMUNICATION]

Decrease in *Globodera rostochiensis* (Wollenweber) (Nematode: Heteroderidae) population density on resistant tomato cultivars in greenhouse trials

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The potato cyst nematode (PCN) *Globodera rostochiensis* (Wollenweber) was first found in Japan in 1972 in a potato field of Makkari Village in Hokkaido (Yamada *et al.*, 1972). PCN subsequently spread to other parts of Hokkaido and has become a serious problem in many potato-growing areas, causing substantial yield reductions. All eggs of PCN are produced inside the female body, which becomes a cyst with a hardened protective wall upon death. This structure protects the eggs from rapid desiccation and enhances their ability to remain viable for many years. In a potato field, the main scheme for integrated control is based on crop rotation with non-host crops and potato cultivars resistant to the nematode (Inagaki, 1984; Yamada, 1987; Whitehead and Turner, 1998).

PCN can also multiply on tomato plants and has been reported as a problem plaguing tomatoes in Europe (Graham, 1966; Ellis, 1968; Ellis and Maxon Smith, 1971; Hesling and Ellis, 1972; Trifonova *et al.*, 1995). Some susceptible tomato cultivars were severely stunted by infection with high initial numbers of nematodes (Hesling and Ellis, 1972). In Hokkaido, where areas of tomato cultivation have increased, the susceptible cultivar Momotaro-8 was also found to be stunted by PCN. Therefore, PCN is now regarded as a new tomato pest in Hokkaido (Hokkaido Plant Protection Office, 1997), and it has become necessary to find PCN-resistant cultivars and resistant rootstocks. Recently, we found several tomato cultivars and one tomato rootstock cultivar that show strong resistance to PCN (Uehara *et al.*, 2008).

The usefulness of cyst nematode-resistant potato cultivars for controlling the nematode has been recognized in several studies (Inagaki, 1978; Trudgill *et al.*, 1978; Yamada

and Takakura, 1981; Whitehead, 1991), whereas the usefulness of cyst nematode-resistant tomato cultivars has not been studied in detail. In the present study, we investigated the effectiveness of cyst nematode-resistant tomato cultivars in reducing the population of PCN in greenhouse trials.

MATERIALS AND METHODS

Multiplication of PCN in tomato experiments:

Globodera rostochiensis pathotype Ro1, a population originally isolated from potatoes in Kucchan, Hokkaido, Japan, was propagated on greenhouse-grown potatoes. To isolate cyst nematode eggs, PCN cysts were crushed in a homogenizer (MH-1010, AS ONE, Osaka, Japan), and the eggs were rinsed with water on a 38-µm sieve. The PCN eggs were stimulated to hatch over waste culture media from hydroponically cultured tomatoes that were grown at 22 °C for 6 days. Two resistant tomato cultivars (rootstock cultivar: 'Doctor-K' and cherry tomato cultivar: 'Sugar-Lump'), one susceptible cultivar ('Kyouryoku-Beiju') and two non-tuber-bearing solanaceous plants (*Solanum peruvianum* and *S. sisymbriifolium*) were used in this study. Plants were maintained in pots containing autoclaved soil in a greenhouse. Five biological replications were prepared for each plant. Plants were inoculated at 28 days after germination with 10,000 second-stage PCN juveniles (J2) per plant and then grown for 90 days. Three 50-g soil samples were taken from each pot, and cysts were isolated from the soil by the dry-flotation method. After being counted, the cysts were collected with finely pointed forceps and crushed to count the number of encysted larvae and eggs.

Greenhouse experiments:

Polyethylene pots (1/10,000 a) were filled with nematode-infected soil obtained from a commercial field in Kucchan, Hokkaido, Japan. The resistant tomato cultivar 'Sugar-Lump', the resistant tomato rootstock cultivar 'Doctor-K', and the susceptible cultivar 'Kyouryoku-Beiju' were used in this study. Two solanaceous species (*S. peruvianum* and *S. sisymbriifolium*) grown in pots and pots with soil but no plants were prepared as controls. Five biological replications were prepared for each plant cultivar or species and treatment. The plants were initially maintained in pots containing autoclaved soil in a greenhouse at an average temperature of 22 °C (17–27 °C). Plants were then transplanted to polyethylene pots (1/10,000 a) filled with nematode-infected soil at 30 days after germination and cultivated for 90 days. The nematode population level was measured before transplanting and after 90 days. The numbers of cysts and eggs were estimated as described above.

Statistical analysis:

For statistical analysis of nematode bioassays, the sta-

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Table 1. Numbers of new cysts per 50 g of dried soil and eggs per 1 g of dried soil.

Plant species		New cysts ¹ /50 g dried soil	Eggs ¹ /g dried soil
<i>Solanum lycopersicum</i>	Kyouryoku-Beiju	130.7 ± 16.3 a ²	175.1 ± 12.1 a ²
	Sugar-Lump	3.4 ± 0.4 b	5.2 ± 1.1 b
	Doctor-K	3.7 ± 0.8 b	4.8 ± 1.8 b
<i>S. sisymbriifolium</i>		0 ± 0 b	0 ± 0 b
<i>S. peruvianum</i>	B6001	15.7 ± 9.2 b	15.1 ± 10.3 b

¹ Mean ± S.D.² Different letters denote significant difference at $P < 0.01$.

tistical package JMP 8 (for Windows; SAS Institute Inc., Cary, NC) was used.

RESULTS AND DISCUSSION

PCN reproduced well on the susceptible tomato 'Kyouryoku-Beiju', but much less on the resistant tomato 'Sugar-Lump' and resistant rootstock 'Doctor-K'. The control *S. sisymbriifolium* showed full resistance, but *S. peruvianum* allowed a small amount of new cysts to form (Table 1).

The values of the final and initial PCN population density ratios (P_f/P_i) after resistant tomato 'Sugar-Lump' and resistant rootstock 'Doctor-K' had been grown for 90 days were about 0.030 and 0.035, respectively (Fig. 1). Thus, cultivation of resistant tomato 'Sugar-Lump' and resistant rootstock 'Doctor-K' reduced the density of nematode eggs in soil by more than 96%. The value of P_f/P_i after *S. peruvianum* and *S. sisymbriifolium* were grown for 90 days was about 0.070 and 0.330, respectively (Fig. 1). The nematode population in pots in which *S. peruvianum* had been planted was smaller than the population in pots in which *S. sisymbriifolium* had been planted ($P < 0.01$). The value of P_f/P_i after the susceptible tomato 'Kyouryoku-Beiju' had been grown for 90 days was about 1.15 (Fig. 1). The susceptible tomato cultivar maintained a high density of PCN (784.2 eggs/g dried soil).

A number of studies have shown commercial tomatoes to be susceptible to PCN (Mai, 1952; Hesling and Ellis, 1972; Yamada, 1987; Uehara *et al.*, 2008). PCN has recently been found in tomato-growing areas in Hokkaido in Japan (Hokkaido Plant Protection Office, 1997). As in other studies, the susceptible tomato cultivar used here either allowed a high level of nematode reproduction or maintained a high nematode population density. Tomatoes can be cultivated repeatedly in the same soil, which allows nematodes to multiply freely. Moreover, commercial tomatoes can be grown for up to 40 weeks, permitting several nematode generations per year, and consequently even greater rates of increase (Hesling and Ellis, 1972). Very high nematode population densities (about 450 eggs/g of dried soil) have also been found in commercial tomato greenhouses in Hokkaido.

Fig. 1. Reduction in the population of potato cyst nematodes the resistant tomato 'Sugar-Lump' and resistant rootstock 'Doctor-K' were grown in pots. Vertical bars represent means ± S.E. ($n = 5$). Mean values with the same letters were not significantly different ($P < 0.01$, Tukey's test). P_f/P_i is the ratio of egg density (P_f) at 90 days after planting to the initial egg density (P_i). Initial egg density was 684.0 eggs per 1 g of dry soil, and the numbers on bars show final egg densities (per g of dried soil) after each treatment.

In general, resistant cultivars provide the most economical means for managing cyst nematodes (Trudgill, 1991). Many H_1 -resistant potato cultivars that are fully resistant to the pathotype Ro1 of *G. rostochiensis* have been bred and can decrease soil infestation by 80–90% (Inagaki, 1978; Yamada and Takakura, 1981; Whitehead and Turner, 1998). In this study we demonstrated the usefulness of a

resistant tomato cultivar and a resistant rootstock cultivar for controlling nematodes. We think that the resistant tomato cultivar is as effective as the resistant potato cultivars for the suppression of PCN populations. Moreover, the resistant tomato and resistant tomato rootstock cultivars are equally or more effective than *S. peruvianum* and *S. sisymbriifolium*, two non-tuber-bearing solanaceous plants that have been studied for use as trap crops for PCN (Scholte, 2000; Scholte and Vos, 2000; Yamada *et al.*, 2007).

The use of resistant tomato or tomato rootstock cultivars is a simple and effective means for reducing populations of PCN. We believe that the choice of tomato cultivars and rootstock cultivars is thus quite important for the management of PCN populations. Further research is needed to clarify the effectiveness of resistant tomato cultivars for reduction of PCN population levels in the field.

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