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Reaction of strawberry cultivars to root-knot and root-lesion nematodes

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ABSTRACT

Considering the economic importance of strawberry in Brazil, with a clear migration trend from the soil to innovative systems on substrates, it is fundamental to evaluate the available cultivars in the market regarding tolerance to pathogens with potential for infestation. The reaction of eight commercial strawberry cultivars (Festival, Camino Real, Camarosa, Oso Grande, Monterey, San Andreas, Aromas, and Albion) to *Meloidogyne* and *Pratylenchus* species was evaluated. Strawberry cultivars were maintained in individual pots with sterilized soil and inoculated with 5,000 eggs + second stage juveniles of *Meloidogyne arenaria, M. incognita, M. javanica* or *M. hapla* or 1,000 specimens of *Pratylenchus zea or P. brachyurus* per plant. The experiment was carried out in a completely randomized design with six replications using tomato 'Rutgers' and sorghum '506' plants as control to root-knot and lesion nematodes, respectively. Ninety days after inoculation, the nematode reproduction factor (RF= final population/initial population) was evaluated to determine the resistance of the strawberry genotypes to each nematode species. All cultivars behaved as resistant (FR<1.00) or immune (FR= 0.00) to *M. javanica, M. incognita, P. zeae* and *P. brachyurus*. The cultivar 'Camarosa' was susceptible (FR>1.00) to *M. arenaria* and *M. hapla* and 'Oso Grande' behaved as a good host to *M. hapla;* however, the other cultivars were resistant to these two *Meloidogyne* species. The assessed cultivars are poor hosts, being an alternative to be used in infested areas with these pests.

Keywords: *Fragaria x ananassa*, *Meloidogyne* spp., *Pratylenchus* spp., resistance.

RESUMO

Reação de cultivares de morangueiro ao nematoide das galhas e das lesões

Considerando a importância econômica da cultura do morangueiro no Brasil, com tendência clara de migração da produção no solo para sistemas inovadores de produção em substratos, é fundamental a avaliação das cultivares disponíveis no mercado quanto a tolerância a patógenos com potencial de infestação. Avaliou-se a resistência de oito cultivares comerciais (Festival, Camino Real, Camarosa, Oso Grande, Monterey, San Andreas, Aromas e Albion) a espécies de *Meloidogyne* e *Pratylenchus*. Cultivares de morango, mantidas em vasos individuais com solo esterilizado, foram inoculadas com 5.000 ovos + juvenis de segundo estágio de *Meloidogyne arenaria*, *M. incognita*, *M. javanica* ou *M. hapla* ou 1.000 espécimes de *Pratylenchus zea* ou *P. brachyurus* por planta. O experimento foi conduzido sob condições de casa de vegetação em delineamento inteiramente casualizado com seis repetições, utilizando-se plantas de sorgo '506' e tomate 'Rutgers' como controles para o nematoides das galhas e das lesões radiculares, respectivamente. Noventa dias após a inoculação, foi avaliado o fator de reprodução dos nematoides (RF = população final / população inicial) para determinar a resistência dos genótipos de morango a cada espécie de fitonematoide. Todas as cultivares se comportaram como resistentes (FR<1,00) ou imunes (FR= 0,00) a *M. javanica, M. incognita, P. zeae e P. brachyurus*. Apenas 'Camarosa' foi suscetível (FR> 1,00) a *M. arenaria* e *M. hapla* e 'Oso Grande' comportou-se como suscetível a *M. hapla*; porém, as demais cultivares foram resistentes a estas duas espécies do nematoide das galhas. As cultivares de morango avaliadas neste trabalho comportaram-se como más hospedeiras dos nematoides estudados e, podem ser consideradas alternativa de cultivo em áreas infestadas com os patógenos.

Palavras-chave: *Fragaria x ananassa*, *Meloidogyne* spp., *Pratylenchus* spp., resistência.

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The strawberry (*Fragaria x ananassa*) has great economic and social importance in the United States, Mexico, Turkey, Poland, Italy, Germany, Russia, including Latin American countries as Chile and Brazil (Coelho Júnior, 2016; OMAIAA, 2017). There are around 4,200 ha of strawberry cultivated areas in Brazil, and the principal producing states are Minas Gerais, Paraná and Rio Grande do Sul (Fagherazzi *et al*., 2017).

New information on the health benefits of strawberries, such as antioxidant levels, folate, potassium, vitamin C and fiber content, stimulated consumption rates (Garcia *et al*., 2017). Despite the high added value of the product, broad acceptance by consumers and diversity in the marketing (Fachinello *et al*., 2011), this crop has a relevant social role in the family farming (Antunes *et al*., 2007; Lemiska *et al*., 2014).

The main strawberry production

system in Brazil is based on growing under low tunnel (Fagherazzi *et al*., 2017). Therefore, this crop may be affected by many soil pathogens such as the plant parasitic nematodes *Meloidogyne* spp. and *Pratylenchus* spp. (Maas, 1998; Gomes & Cofcewics, 2003). Root-knot nematodes (*Meloidogyne* spp.) are polyphagous pests and cause great damage in several annual and perennial crops associated to yield losses (Sharma & Fonseca, 2000; Franzener *et al.*, 2005; Lima-Medina *et al*., 2014). Similarly, root-lesion nematodes (*Pratylenchu*s spp.), the second most important plant-parasitic nematode group for Brazilian agriculture, parasites various crops such as soybeans, oats, corn, millet, sunflower, sugarcane, fruit trees besides other common cultivated plant species (Severino *et al*., 2010; Ribeiro *et al.*, 2010; Lima-Medina *et al*., 2014).

Among the control practices for these two plant-parasitic nematode genera, the use of resistant cultivars is one of the most suitable. However, for strawberry, few studies have been performed for Brazilian conditions. Curi *et al*. (2016) studied the reaction of some strawberry commercial cultivars to *Meloidogyne hapla*. The authors verified the genetic resistance of Oso Grande and Albion. Similarly, 'Camarosa' is resistant to *M. enterolobii* and *M. ethiopica* (Somavilla *et al*., 2006; Freitas *et al*., 2016) but the reaction of these cultivars to other *Meloidgyne* species and to *Pratylenchus* spp. in not known. Considering the pathogenicity of these pests and the scarcity of studies reported on the strawberry, the objective of this work was to evaluate the resistance of eight strawberry cultivars to *Meloidogyne* and *Pratylenchus* species related to tropical and subtropical conditions.

MATERIAL AND METHODS

The reaction of eight strawberry cultivars to four root-knot *Meloidogyne* species and two lesion *Pratylenchus* species was evaluated at greenhouse conditions. Strawberry seedlings of Festival, Monterrey, Camino Real, San Andreas, Camarosa, Oso Grande, Aromas and Albion cultivars obtained from tissue culture were used to establish this assay. The inoculum of the *Meloidogyne* and *Pratylenchus* species was obtained according to the methodology of Hussey & Barker (1973) and Coolen & D'Here (1972), respectively.

One pure population of *M. javanica* Est J3, *M. arenaria* Est A2*, M. incognita* Est I2 and *M. hapla* Est H2 were maintained on tomato plants (*Solanum lycopersicum*) cv. Rutgers at greenhouse conditions in order to use as root-knot nematode inoculum. Similarly, pure populations of *Pratylenchus zeae* and *P. brachyurus* were maintained on *Sorghum bicolor* '506' plants to use nematode inoculum.

Strawberry seedlings 30-day old, grown in pots with sterilized soil, were inoculated with 5,000 eggs + second stage juveniles of *Meloidogyne arenaria, M. incognita, M. javanica or M. hapla* or 1,000 *Pratylenchus zeae or P. brachyurus* per plant. The experiment was carried out under greenhouse conditions in a completely randomized design with six replications using tomato 'Rutgers' and sorghum '506' plants as controls to root-knot and root-lesion nematodes, respectively. A randomized design experiment with six replications of one plant per plot was used.

Ninety days after inoculation, each strawberry plant inoculated with root-knot nematode was evaluated for number of galls in the roots. Subsequently, each root system was processed (Hussey & Barker,1973) to determine the final nematode populations (number of eggs and second stage juveniles) in the different strawberry cultivars. However, to calculate the final population of *Pratylenchus* species, the roots of different plants were processed by Coolen & D'Herde (1972) method. The reproduction factor (RF= final population / initial population) of each nematode species obtained in each genotype was estimated. Averages of the different variables were compared by Scott-Knott's clustering test at 5% using the software SASM-Agri (Canteri *et al*., 2001). The strawberry reaction was determined by the nematode reproduction factor (RF), considering resistant genotypes with RF<1.00, immune with RF= 0.00 and susceptible with RF>1.00 (Oostenbrik, 1966).

RESULTS AND DISCUSSION

Most cultivars were resistant or immune to various nematode species (Table 1). Only 'Camarosa' and 'Oso Grande' were susceptible to *M. arenaria*, and the first was susceptible to *M. hapla* as compared to the susceptible control. Furthermore, the presence of galls on the roots of plants inoculated with *Meloidogyne* spp. was detected principally of susceptible cultivars (Figure 1). All strawberry cultivars were resistant or immune to *P. zeae* and *P. brachyurus* (Table 1). This information is important, because Camarosa is the second most cultivated cultivar in Brazil mainly in soil system production.

In other studies, regarding strawberry genetic resistance to *Meloidogyne* spp., 'Camarosa', 'Oso Grande', 'Aromas', 'Camino Real', 'Santa Clara' and 'Ventana' were immune to *M. enterolobii* (Freitas *et al*., 2016) and the first three cultivars were resistant to *M. ethiopica* (Somavilla *et al*., 2006). Pinkerton & Finn (2005), evaluating the reaction of more than 30 strawberry genotypes to *M. hapla,* observed that most cultivars were resistant to nematode including 'Camarosa', which in this study behaved as susceptible.

The reaction of strawberry to root-lesion nematodes observed in this assay was similar to those obtained in other studies with *P. penetrans* in the USA (Pinkerton & Finn, 2005; Villanueva *et al*., 2010). The authors observed resistance and tolerance in more than 30 cultivars, including three genotypes evaluated in this experiment as Camarosa, Diamante and Festival. Once there is little information available on the genetic resistance of strawberry to tropical and subtropical *Pratyenchus* species (*P. zeae* and *P. brachyurus)* our results support the need to carry out additional studies on genetic resistance and aggressiveness, using different populations of phytoparasitic nematodes as noted by Loubser & Meyer (1987) and Lima-Medina *et al*. (2017) in other pathosystems.

Table 1. Reaction of strawberry cultivars to different root-knot (*Meloidogyne* spp.) and root-lesion (*Pratylenchus* spp.) species of nematodes. Pelotas, Embrapa Clima Temperado, 2018.

Cultivars	*Meloidogyne incognita*			*Meloidogyne arenaria*			*Meloidogyne javanica*		
	galls (nº)	RF	R	galls (nº)	RF	R	galls (nº)	RF	R
Control	199.16	7.11	S[1]	352.66	16.33	S[1]	345	24.13	S[1]
Camarosa	0.00[ns]	0.00a*	I	123.00b	2.82c	S	0.00[ns]	0.08b	R
Oso Grande	0.00	0.00a	I	105.00b	2.01c	S	0.00	0.12b	R
Monterrey	0.00	0.00a	I	0.00a	0.01b	R	0.00	0.04b	R
Festival	0.00	0.00a	I	0.00a	0.02b	R	0.00	0.12b	R
San Andres	0.00	0.21b	R	0.00a	0.18b	R	0.00	0.12b	R
Aromas	0.00	0.03a	R	0.00a	0.14b	R	0.00	0.12b	R
Camino Real	0.00	0.00a	I	7.00c	0.11b	R	0.00	0.09b	R
Albion	0.00	0.00a	I	0.00a	0.00a	I	0.00	0.00a	I
CV (%)	-	15.45		21.55	16.23		-	15.13	

	Meloidogyne hapla			*Pratylenchus zeae*		*Pratylenchus brachyurus*	
	galls (nº)	RF	R	RF	R	RF	R
Control	1150	24.39	S[1]	9.41	S[2]	7.51	S[2]
Camarosa	15.00b	1.40b	S	0.88a	R	0.07b	R
Oso Grande	0.00a	0.10a	R	0.60b	R	0.15a	R
Monterrey	0.00a	0.01a	R	0.00c	I	0.00b	I
Festival	0.00a	0.01a	R	0.61b	R	0.00b	I
San Andres	0.40a	0.01a	R	0.00c	I	0.00b	I
Aromas	0.00a	0.17a	R	0.64b	R	0.81a	R
Camino Real	0.00a	0.01a	R	0.00c	I	0.00b	I
Albion	7.40b	0.25a	R	0.18b	R	0.07	R
CV (%)	9.7	11.22		9.91		11.12	

Means followed by same letters in the column belong to the same group by Scott-Knott test, 5% probability. 1= tomato Rutgers control; 2= sorghum BRS 506 control; R= reaction; RF= reproduction factor; (immune with RF= 0.00 and susceptible with RF>1.00) S= susceptible; I= immune; R= resistant.

Figure 1. Root-systems of strawberry plants exhibiting galls caused by *Meloidogyne arenaria* (a) and *M. hapla* (b) at 'Camarosa' and *M. arenaria* at root-system of Oso Grande cultivar (c). Pelotas, Embrapa Clima Temperado, 2017. Foto: Cesar Bauer Gomes.

Considering the most strawberry cultivars were poor hosts to different *Meloidogyne* and *Pratylenchus* species, these results are extremely important for establishing control strategies of these pests, suppressing their populations in the soil. Therefore, the use of resistant strawberry cultivars represents a viable alternative in the implementation of crop rotation systems to the management of these pests, becoming thus an efficient and economic way to reduce nematode populations in infested areas (Carneiro *et al*., 2000; Ferraz & Freitas, 2004; Lima *et al*., 2009; Freitas *et al*., 2016).

Most of the evaluated strawberry cultivars (Festival, Monterrey, Camino Real, San Andreas, Aromas and Albion) are resistant or immune to *Meloidogyne* spp. and *Pratylenchus* spp. which confers their status as poor host. In this way these cultivars are an alternative to use in infested areas with these pests.

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