RESEARCH/INVESTIGACIÓN

REACTION OF SUNFLOWER GENOTYPES TO *PRATYLENCHUS BRACHYURUS* AND *MELOIDOGYNE JAVANICA*

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ABSTRACT

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Sunflower is commonly grown as a rotation crop with soybean. However, it may be susceptible to some plant-parasitic nematode species. This study aimed to assess the reaction of sunflower genotypes to *Pratylenchus brachyurus* and *Meloidogyne javanica*. Twelve sunflower genotypes (BRS 323, BRS G73, BRS G74, BRS G75, BRS G76, BRS G77, BRS G78, BRS G79, BRS G80, BRS G81, Altis 99, and Helio 250) were evaluated using soybean as a susceptibility reference. Greenhouse experiments were conducted for each nematode species in a completely randomized design with eight replicates; the experiments were conducted twice. Plants were inoculated with 500 *P. brachyurus* or 2,000 *M. javanica* and evaluated at 75 and 60 days after inoculation, respectively. The number of nematodes per gram of root and reproduction factor (RF=final population/initial population) values were determined. Sunflower genotypes were moderately resistant or resistant to *P. brachyurus*, with RF values ranging from 0.3 to 1.8 in Trial 1 and from 1.0 to 2.5 in Trial 2. For soybean, RF values were 7.0 and 25.3 in Trials 1 and 2, respectively. By contrast, sunflower genotypes were susceptible to *M. javanica*, with RF values ranging from 40.8 to 178.2 in Trial 1 and from 5.0 to 20.6 in Trial 2. These values were similar or higher to those recorded for soybean (114.0 and 3.3 in Trials 1 and 2, respectively). The findings indicate that sunflower can be grown in areas infested with *P. brachyurus* but is not recommended for areas infested with *M. javanica*.

Key words: Genetic control, *Helianthus annuus*, lesion nematode, root-knot nematode

RESUMO

Cruz, G. L. S., J. P. Poletine, T. K. Moriyama, F. W. Ferreira, S. M. Santana-Gomes, and C. R. Dias-Arieira. 2025. Reação de genótipos de girassol a *Pratylenchus brachyurus* e *Meloidogyne javanica*. Nematropica 55:10-17.

O girassol tem sido comumente cultivado como cultura de sucessão com a soja. No entanto, ele pode ser suscetível a algumas espécies de nematoides. Assim, objetivou-se avaliar a reação de genótipos de girassol aos nematoides *Pratylenchus brachyurus* e *Meloidogyne javanica*. Foram avaliados doze genótipos de girassol (BRS 323, BRS G73, BRS G74, BRS G75, BRS G76, BRS G77, BRS G78, BRS G79, BRS G80, BRS G81, Altis 99 e Helio 250), usando soja como padrão de suscetibilidade. Foram realizados dois ensaios para cada nematoide, em casa-de-vegetação, em DIC com oito repetições. As plantas foram inoculadas com 500 *P. brachyurus* ou 2.000 *M. javanica* e foram avaliadas aos 75 e 60 dias após a inoculação, respectivamente, quanto as variáveis nematológicas [(número de nematoide/g de raiz e fator de reprodução (FR)]. Os genótipos apresentaram resistência a *P. brachyurus*, com FR variando de 0,3 a 1,8 no Ensaio 1 e de 1,0 a 2,5, no Ensaio 2, enquanto para a soja os FRs foram de 7,0 e 25,3, nos respectivos ensaios. Por outro lado, os genótipos de girassol foram suscetíveis a *M. javanica*, com FR variando de 40,8 a 178,2 (Ensaio 1) e de 5,0 a 20,6 (Ensaio 2), sendo esses valores próximos ou superiores aos observados para a soja 114,0 e 3,3, respectivamente. Conclui-se que o girassol pode ser cultivado em áreas com *P. brachyurus*, mas não é indicado para áreas infestadas com *M. javanica*.

Palavras-chave: Controle genético, *Helianthus annuus*, nematoide das lesões radiculares, nematoide das galhas

INTRODUCTION

Sunflower production is widely distributed throughout the world, with seed production of 54.8 million tons in 2023-2024 and an average annual production of 49.4 million tons over the last decade (USDA, 2024). While most of the production is for oil, this crop is used in many different ways, such as animal feed and ornamentation (Oliveira Filho and Egea, 2021; Pilorgé, 2020;).

In Brazil, the area with sunflower production has grown steadily over the years. Estimates for 2022-2023 indicated a 65.1% rise in production in Goiás, the country's leading sunflower-producing state (CONAB, 2023). Following Goiás, the states of Minas Gerais, Mato Grosso, Rio Grande do Sul, São Paulo, Distrito Federal, and Paraná also produce sunflower (CONAB, 2023). Sunflower has been commonly cultivated in rotation with soybean. However, this practice can potentially increase nematode population densities, which has attracted the attention of researchers. Plant-parasitic nematodes are estimated to cause more than R$27 billion in loss to soybean production (Syngenta, 2022).

Among the plant-parasitic nematodes that infect soybean, some species warrant special mention, such as the lesion nematode, *Pratylenchus brachyurus*, and the root-knot nematodes, *Meloidogyne javanica* and *M. incognita* (Favoreto *et al*., 2019). Research conducted by Syngenta, in conjunction with the Brazilian Society of Nematology and AgroConsult, demonstrated that 57.6% of the samples collected in southern Brazil were positive for *Pratylenchus* spp. and 64.0% for *Meloidogyne* spp. In the same study, the rates in the Cerrado and Northern regions reached 86.9% for *Pratylenchus* spp. and 25.4% for *Meloidogyne* spp. (Syngenta, 2022).

Pratylenchus brachyurus is a migratory endoparasite that can move inside host roots. When moving and feeding, these nematodes release enzymes and toxins that degrade cell walls, resulting in cell disorganization and destruction (Fosu-Nyarko and Jones, 2016; Francilino *et al*., 2017). *Meloidogyne* is a sedentary endoparasitic nematode. It establishes a complex feeding site characterized by the formation of giant cells with hypertrophy and hyperplasia, resulting in root galls, the typical symptom of the disease (Khan *et al*., 2023).

Rotation of nematode-susceptible plants has been identified as the major cause of the increased incidence of these pathogens in Brazil. It is noteworthy that there are no recent studies on the reaction of sunflower genotypes to key plant-parasitic nematodes. Previous studies suggested that sunflower is resistant to *P. brachyurus*, with reproduction factor values below 1.0 (Dias *et al*., 2016), but susceptible to *M. javanica* (Bernard and Keyserling, 1985; Dias-Arieira *et al*., 2009; Rich and Green, 1981). However, the genetic materials analyzed in these studies are no longer cultivated in Brazil, and there is a lack of information about the reaction of new genotypes to plant-parasitic nematodes. This study aimed to examine the reaction of 12 sunflower genotypes to *P.*

brachyurus and *M. javanica* under controlled conditions.

MATERIALS AND METHODS

Two experiments were conducted in a greenhouse at the State University of Maringá, Brazil to evaluate the reaction of sunflower genotypes to *P. brachyurus* and *M. javanica*. For each experiment, two trials were conducted and arranged in a completely randomized design, and each trial had eight replicates. For *P. brachyurus*, Trials 1 and 2 were conducted from September to December 2023 and from November 2023 to January 2024, respectively. The average minimum and maximum temperatures were 19.4 and 31.0°C (Trial 1) and 20.5 and 31.1°C (Trial 2), respectively. For *M. javanica*, Trial 1 was conducted from September to December 2023 (average minimum and maximum temperatures of 19.4 and 31.1°C, respectively) and Trial 2 from March to May 2024 (average minimum and maximum temperatures of 18.4 and 30.9°C, respectively).

The 12 sunflower genotypes analyzed in the study were BRS 323, BRS G73, BRS G74, BRS G75, BRS G76, BRS G77, BRS G78, BRS G79, BRS G80, BRS G81, Altis 99, and Helio 250. Additionally, soybean cv. Brasmax Nexus 64IX66 RSF I2X was included in the experiments as a control of inoculum viability. Each experimental unit consisted of an expanded polystyrene cup containing 950 cm^3 of a 2:1 mixture of soil and sand. The substrate was previously autoclaved at 120°C for 2 hr. The soil was limed to raise the base saturation to 70%. Fertilization followed the recommendations for the crop (60 kg N/ha, 80 kg P_2O_5/ha, and 70 kg K_2O/ha).

Initially, five seeds were planted per cup. Seedlings were thinned to one plant per cup five days after germination. At seven days after thinning, plants were inoculated with 500 *P. brachyurus* (juveniles and adults) or 2,000 eggs and second-stage juveniles (J2) of *M. javanica*. The nematode inoculum was deposited into two, 2-cm deep holes made in the soil near the base of the plant. Nematode inocula were obtained from pure populations multiplied on soybean in a greenhouse. The nematodes were extracted according to the method of Hussey and Barker (1972) and adapted by Boneti and Ferraz (1981). Suspensions were calibrated to the desired concentration in 2 mL by using a Peters chamber under an optical microscope.

The plants were grown in a greenhouse and watered daily. Plants inoculated with *P. brachyurus* were grown for 75 days after inoculation, whereas those inoculated with *M. javanica* were grown for 60 days. After the respective period, plants were collected, and the aerial part was separated from the root system. Shoots were discarded, and the root system was manually washed to remove substrate. The root fresh weight was determined using a semi-analytical scale. Subsequently, nematodes were extracted by the above-mentioned method. The total number of nematodes was determined and divided by the root fresh weight to obtain the population density (nematodes per gram of root). The reproduction factor (RF) was calculated using the equation RF = Final population/Initial population (Oostenbrink, 1966). Finally, mean RF values were used to calculate the relative reduction in RF compared with the control (soybean). Relative RF percentages were adopted as a criterion for resistant plants, defined as those with an RF value less than 10% of the control (Brito *et al*., 2007; Cortada *et al*., 2008; Hussey and Janssen, 2002).

The data were subjected to analysis of variance and, when significant, means were compared by the Scott-Knott means grouping test at the 5% significance level. When necessary, the original data were transformed by $\sqrt{(x + 0.5)}$ to meet normality and homogeneity assumptions. Statistical analyses were performed using SISVAR software (Ferreira, 2011).

RESULTS AND DISCUSSION

Reaction of sunflower genotypes to P. brachyurus

In both trials, *P. brachyurus* multiplication was significantly lower on sunflower genotypes than on soybean (Table 1). In Trial 1, the mean population density in sunflower ranged from 10 to 41 nematodes/g root, without significant differences between genotypes, whereas the mean value in the control was 221 nematodes/g root. In Trial 2, nematode population densities ranged from 26 to 62 nematodes/g root among sunflower genotypes, as compared with 747 nematodes/g root in soybean.

In Trial 1, the mean RF values ranged from 0.3 and 1.7 among sunflower genotypes, whereas that

Table 1. *Pratylenchus brachyurus* per gram of root, reproduction factor, and relative reduction in reproduction factor (final population density/intial population density) on sunflower genotypes at 75 days after nematode inoculation in two trials.

	P. brachyurus/g root[x]		Reproduction factor		Relative reduction[y] (%)	
Genotype	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Soybean	221 a	747 a	7.0 a	25.3 a	-	-
BRS323	41 b	62 b	1.5 b	2.5 b	78.6	90.1
BRS G73	27 b	40 b	1.0 b	1.8 b	85.7	93.6
BRS G74	25 b	32 b	1.3 b	1.0 b	82.1	96.0
BRS G75	15 b	32 b	0.3 b	1.0 b	96.4	96.0
BRS G76	30 b	26 b	1.0 b	1.0 b	85.7	96.0
BRS G77	41 b	28 b	1.8 b	1.3 b	75.0	95.0
BRS G78	17 b	53 b	0.8 b	2.0 b	89.3	92.1
BRS G79	10 b	58 b	0.5 b	2.3 b	92.9	91.1
BRS G80	26 b	28 b	1.3 b	1.0 b	82.1	96.0
Altis	29 b	56 b	1.3 b	2.0 b	82.1	92.1
Helio 250	34 b	61 b	1.3 b	1.8 b	82.1	93.1
BRS G81	19 b	55 b	0.8 b	2.0 b	89.3	92.1
CV[z] (%)	37.7	21.1	47.8	44.8	-	-

[w]Means followed by the same letter are not significantly different from each other by the Scott-Knott test at $p < 0.05$.

[x]Original means of *P. brachyurus*/g root were transformed by $\sqrt{(x + 0.5)}$.

[y]Relative reductions in reproduction factor compared with soybean (control).

[z]CV, coefficient of variation.

of the control was 7.0 (Table 1). In Trial 2, a similar pattern was observed, with mean RF values of 1.0 to 2.5, which differed significantly from that of the control (RF = 25.3). Thus, the reductions in RF values were greater than 78% in Trial 1 and 90% in Trial 2. The sunflower genotypes can be classified as moderately resistant or resistant. According to Hussey and Janssen (2002) and Yan and Baidoo (2018), plants with RF values ranging from 0.7 to 2.1 in Trial 1 and from 2.5 to 7.5 in Trial 2 are moderately resistant. Those with RF values lower than 0.7 and 2.5 in Trials 1 and 2, respectively, are resistant compared with the control (soybean).

Previous studies reported that *P. brachyurus* was unable to efficiently reproduce on sunflower; 14 genotypes were found to have RF values ranging from 0.1 to 0.5, as compared with RF values of 1.9 to 2.9 in the controls (Dias *et al*., 2016). Additionally, Altis 99, Sany 66, and Nusol 606 were found to be resistant to the nematode, with RF values of 0.04 to 0.14 (Dalcin *et al*., 2023). Thus, it is suggested that, while *P. brachyurus* can reproduce to a certain degree on sunflower, these plants can be considered unfavorable hosts.

Despite the low RF of *P. brachyurus* on sunflower observed here and in previous studies, it has been shown that soybean grown in rotation with sunflower had similar population density for this nematode species in soybean grown after susceptible crops, such as maize and rice (Santana-Gomes *et al*., 2014). This finding suggests that *P. brachyurus* can survive in the soil and maintain densities over successive crop rotations. Therefore, it is necessary to adopt integrated management, protecting sunflower and succeeding crops via nematicide treatments.

This study did not analyze vegetative variables of aerial parts, as these properties are intrinsic to each genetic material. Only the fresh root weight was determined, as it is important in estimating nematode population density (nematodes per gram of root). This variable indicates a plant's potential for suppressing nematode reproduction (Miamoto *et al*., 2016). However, no significant differences in root fresh weight were observed between genotypes (Table 2).

Reaction of sunflower genotypes to M. javanica

All sunflower genotypes were susceptible to *M. javanica* with nematode reproduction greater in some genotypes than in soybean (Table 3). In Trial 1, four statistical groups for population densities were identified. The first group including BRS G76, BRS G77, BRS G80, Altis 99, Helio 250, and

Table 2. Root fresh weight (g) of soybean and sunflower genotypes at 75 days after inoculation with 500 *Pratylenchus brachyurus* in two trials.

	Root fresh weight[y] (g)	
Genotype	Trial 1	Trial 2
Soybean	18.0 a	17.4 a
BRS 323	19.5 a	22.7 a
BRS G73	19.6 a	21.8 a
BRS G74	24.1 a	15.7 a
BRS G75	19.2 a	16.1 a
BRS G76	18.1 a	19.1 a
BRS G77	21.9 a	22.5 a
BRS G78	18.9 a	20.8 a
BRS G79	23.0 a	22.7 a
BRS G80	23.6 a	17.8 a
Altis 99	22.1 a	17.9 a
Helio 250	17.9 a	14.7 a
BRS G81	20.7 a	19.4 a
CV[z] (%)	27.6	27.3

[y]Means followed by the same letter are not significantly different from each other by the Scott-Knott test at $p < 0.05$.
[z]CV, coefficient of variation.

Table 3. *Meloidogyne javanica* per gram of root, reproduction factor, and relative reduction in reproduction factor (final population density/initial population density) on sunflower genotypes at 60 days after nematode inoculation in two trials.

	M. javanica/g root[w]		Reproduction factor		Relative reduction[x] (%)	
Genotype[y]	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Soybean	27,052 a	1,966 b	114.0 b	3.3 c	-	-
BRS323	8,975 c	2,083 b	84.2 c	16.3 a	26.4	-
BRS G73	7,500 c	1,709 b	120.2 b	10.6 b	-	-
BRS G74	7,739 c	3,938 a	81.7 c	20.2 a	28.4	-
BRS G75	16,888 b	1,638 b	178.2 a	9.3 b	-	-
BRS G76	6,197 d	3,085 a	61.7 d	20.6 a	45.9	-
BRS G77	4,065 d	1,420 b	42.5 d	12.8 b	62.8	-
BRS G78	10,638 c	1,923 b	102.8 b	19.0 a	9.9	-
BRS G79	7,298 c	1,811 b	77.4 c	11.9 b	32.1	-
BRS G80	6,570 d	4,056 a	66.4 c	16.1 a	41.8	-
Altis 99	5,373 d	1,008 b	57.5 d	5.0 c	49.6	-
Helio 250	4,295 d	2,225 b	56.3 d	9.5 b	50.6	-
BRS G81	4,948 d	1,974 b	40.8 d	10.1 b	64.3	-
CV[z] (%)	18.6	24.1	24.6	29.7	-	-

[w]Original means of *M. javanica* g^{-1} root were transformed by $\sqrt{(x + 0.5)}$.
[x]Relative reductions in reproduction factor compared with soybean (control).
[y]Means followed by the same letter are not significantly different from each other by the Scott-Knott test at $p < 0.05$.
[z]CV, coefficient of variation.

BRS G81 had the lowest *M. javanica* population densities, not differing from each other. The next group was comprised of BRS 323, BRS G73, BRS G74, and BRS G78, which did not differ from each other. The third group included BRS G75, and the last group was the control (soybean), which supported the highest *M. javanica* population density (Table 3). In Trial 2, there were two groups of genotypes, namely BRS G74, BRS G76, and BRS G80, which supported the highest nematode population densities, differing from the other genotypes and the control.

In Trial 1, the lowest RF values were observed in BRS G76, BRS G77, Altis 99, Helio 250, and

BRS G81, followed by BRS 323, BRS G74, BRS G79, and BRS G80. The third group was formed by BRS G73 and BRS G78, which did not differ from each other or the control. Finally, BRS G75 had the highest RF. In Trial 2, the control had the lowest RF value, followed by Altis 99.

In Trial 1, BRS G77, Helio 250, and BRS G81 were moderately resistant to *M. javanica*. However, in Trial 2, all genotypes were susceptible, according to the scale proposed by Taylor (1967), exhibiting RF values higher than that of the control. The fact that sunflower genotypes increased *M. javanica* population densities in at least one of the trials underscores the importance of repeating susceptibility tests. It should be noted that the aggressiveness of a nematode population on a host may vary (Chidichima *et al*., 2021; Rammah and Hirschmann, 1990; Tihohod *et al*., 1998). Therefore, there is the potential for other populations of *M. javanica* to reproduce on the evaluated sunflower genotypes, reinforcing the need to treat plants with nematicides, duly registered for the crop or biological target. In the case of sunflower, it is recommended to avoid planting in fields with *M. javanica* infestations.

The susceptibility of sunflower to *Meloidogyne* spp. has been observed over the years, with a report of efficient *M. javanica* reproduction (Dias-Arieira *et al*., 2009). The hybrids France Lever, Peredovicks, Sigco445, PwkE5, and Insanka were found to be moderately or severely affected by *Meloidogyne* spp. (Fabiyi, 2014). BRS 321 and BRS 323 had an RF of 0.2 and 1.1, respectively, for *M. javanica* (Dias *et al*., 2016). Altis 99, Sany 66, and Nusol 606 were considered resistant, with RF values ranging from 0.01 to 0.04 (Dalcin *et al*., 2023). These findings differ from those observed in the current study. Here, BRS 323 had RF values of 84.2 and 16.3 in Trials 1 and 2, respectively, and Altis 99, 57.5 and 5.0.

There were three statistical groups for root fresh weight in Trial 1 (Table 4). The control had the lowest root weight, followed by BRS 323, BRS G74, BRS G75, BRS G76, BRS G77, BRS G78, BRS G79, BRS G80, Altis 99, Helio 250, and BRS G81. The highest root fresh weight was observed in BRS G73, differing from the others. BRS G73 also had the highest root weight in Trial 2, together with BRS 323, BRS G75, BRS G76, BRS G77, BRS G78, BRS G79, and BRS G81. These genotypes differed significantly from Helio 250, Altis 99, BRS G80, BRS G74, and the control.

Although vegetative development was not the focus of this research, Korayem *et al.* (2009) demonstrated that initial nematode population densities negatively affected shoot height and weight. Initial densities of 10,000 and 20,000 nematodes/kg soil caused reductions of 6.5% and

Table 4. Root fresh weight (g) of soybean and sunflower genotypes at 60 days after inoculation with 2,000 *Meloidogyne javanica* in two trials.

	Root fresh weight[y] (g)	
Genotype	Trial 1	Trial 2
Soybean	9.1 c	3.5 b
BRS 323	21.5 b	18.2 a
BRS G73	35.5 a	16.5 a
BRS G74	22.3 b	11.8 b
BRS G75	25.1 b	14.4 a
BRS G76	20.3 b	14.4 a
BRS G77	21.7 b	19.0 a
BRS G78	19.7 b	20.0 a
BRS G79	21.4 b	14.1 a
BRS G80	22.5 b	8.4 b
Altis 99	21.8 b	10.4 b
Helio 250	27.5 a	9.9 b
BRS G81	16.6 b	13.1 a
CV[z] (%)	31.3	41.8

[y]Means followed by the same letter are not significantly different from each other by the Scott-Knott test at $p < 0.05$.

[z]CV, coefficient of variation.

9.2% in height, respectively. Thus, it can be said that *Meloidogyne* spp. can cause direct damage to sunflower promoting the maintenance of high initial densities in succeeding crops, which is commonly observed in soybean.

This research provides information about the reaction of new sunflower genotypes to two important plant-parasitic nematodes. *Pratylenchus brachyurus* did not reproduce efficiently on sunflower genotypes, with RF reductions of up to 90% in relation to soybean in different trials. By contrast, *M. javanica* densities increased on the sunflower genotypes, with RF values ranging from 40.8 to 178.2 in Trial 1 and from 5.0 to 20.6 in Trial 2. Thus, this crop is not recommended for rotation with soybean in areas infested with *M. javanica.*

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