Tropical Plant Pathology (2025) 50:51
https://doi.org/10.1007/s40858-025-00732-1

SHORT COMMUNICATION

Host status of selected summer forage grasses to *Meloidogyne javanica* and *M. incognita*

Mayara Rodrigues de Souza[1] · Matheus Martins Pereira[1] · Sabrina de Oliveira Martins[1] · Sergio Elmar Bender[2] · Andrea Mittelmann[2] · Jeronimo Vieira de Araujo Filho[1]

Received: 16 August 2024 / Accepted: 25 March 2025

Abstract

Forage grasses have been included in systems (no-tillage) with crops susceptible to important plant parasitic nematodes (PPNs), but the host status of commercial genotypes is still poorly known. Therefore, the objective of our study was to evaluate the host status of summer forage species to *Meloidogyne javanica* (*Mj*) and *M. incognita* (*Mi*), under greenhouse conditions. For each interaction, the trials were repeated twice. For this, seedlings were inoculated with an initial population (*Ip*) of 1,000 specimens (eggs plus second-stage juveniles). After 60—71 days of inoculation, the specimens were extracted from the roots (*Fp*) to obtain estimates of the reproductive factor ($RF = Fp/Ip$) and nematodes per gram root (*Nema* g^{-1}). The species/cultivars tested were Millet 'ANM 38', *Brachiaria ruziziensis* 'BRS Integra', *B. ruziziensis* x *B. brizantha* 'BRS RB331 Ipyporã', *B. brizantha* 'BRS Piatã', *Panicum maximum* 'BRS Tamani', *P. maximum* 'BRS Quênia' and *P. maximum* 'BRS Zuri'. All species/cultivars tested were rated as resistant to *M. javanica* ($0 \leq RF \leq 0.19$; $0 \leq Nema\ g^{-1} \leq 141.44$) and *M. incognita* ($0.01 \leq RF \leq 0.07$; $2.43 \leq Nema\ g^{-1} \leq 66.74$). Our study opens the possibility of using these forage species/cultivars for rotation/succession schedules in areas with infestation by these PPNs.

Keywords Cultural control · Crop rotation and succession · Root-knot nematodes · Southern Brazil

Brazil has approximately 160 million hectares of pastures, including native and cultivated species (Antonio 2015). In recent years, Brazil showed an increase in pasture cultivation, encompassing about 70% of the cropped area in Brazil (Omote et al. 2021). The use of forages in Brazil has been increasingly advancing due to the benefits related to the production system, such as the no-tillage system (Inomoto et al. 2007). Therefore, the use of forages has become increasingly important in the intensification of agricultural production systems, whether in forage production (crop-livestock system) or the production of dry matter for soil coverage and improving the structural quality of the soil (Silva et al. 2015; Assis et al. 2018). Furthermore, some plant species have historically played an important role (poor host or non-host) in the integrated management of the major plant parasitic nematodes (PPNs), influencing the dynamics of PPN populations (Asmus and Cruz 2020; Gabriel et al. 2018).

Meloidogyne species are undoubtedly the main group of PPNs worldwide, known as root-knot nematodes (RKNs) (Trudgill and Blok 2001). Of the ninety species of RKNs described, *Meloidogyne incognita* (*Mi*) (Kofoid & White) Chitwood and *M. javanica* (*Mj*) (Treub) Chitwood stand out by their high geographical distribution and/or damage intensity (Elling 2013). For these reasons, it is necessary to develop new tools for reducing their populations in infested areas with *Mj* and *Mi*. Within this framework, it is extremely important to evaluate the host status of poaceous forage cultivars to the major *Meloidogyne* species, so that they can be used in areas cultivated with cropping systems affected by these PPNs, such as those with soybean. It should be noted that *Mj* and *Mi* have historically been associated with significant losses in soybeans (Gorny et al. 2021), with estimated reductions of over 80% (Asmus and Ferraz 2001). Therefore, the objective of our study was to determine the host status of selected forager grasses to *Mj* and *Mi* under greenhouse conditions.

✉ Jeronimo Vieira de Araujo Filho
jeronimo.vieira@ufpel.edu.br

[1] Departamento de Fitossanidade, Faculdade de Agronomia Eliseu Maciel (FAEM), Universidade Federal de Pelotas, Pelotas, RS, Brasil 96050-500

[2] Embrapa Clima Temperado, Rod. BR 392, Km 78, 6010-971 Pelotas, RS, Brasil

The *Mj* and *Mi* nematode isolates (one egg-masses) were previously identified from esterase (Est) phenotypes (Carneiro and Almeida 2001) and maintained on tomato [*Solanum licopersicum* (L)] 'Santa Clara'. The isolate of *Mj* (Est J3) came from Tupanciretã (RS) while *Mi* (Est I1) of Urussanga (SC). All trials were performed twice under greenhouse conditions at the Universidade Federal de Pelotas, Capão do Leão, Rio Grande do Sul state. The trials were conducted between March 05, 2022, and May 14, 2022 [trial 1(*Mj*)], March 09, 2022, and May 7, 2022 [trial 2 (*Mi*)], and their repetitions were conducted between February 24, 2024, and April 26, 2024 [trial 1 (*Mj*) and trial 2 (*Mi*)].

Initially, seeds of *Panicum maximum* (Jacq.) 'BRS Quênia', *P. maximum* 'BRS Tamani', *P. maximum* 'BRS Zuri', millet [*Pennisetum glaucum* (L.) R] 'ANM 38', *B. ruziziensis* x *B. brizantha* 'BRS RB331 Ipyporã', *B. brizantha* (Stapf) 'BRS Piatã' and *B. ruziziensis* (Germ & Evrard) 'BRS Integra' were germinated in boxes with filter paper soaked in distilled water. After five days, three seedlings were transplanted into each pot (1000 ml). Subsequently, we leave only one plant per pot. Tomato 'Santa Cruz Kada' was included as control of susceptibility. The composition of the substrate used consisted of a mixture (1:1) of commercial substrate and previously autoclaved soil (120ºC for 2 h). Unfortunately, millet was not included in the second evaluation because of unavailability of seeds.

The initial populations (*Ip*) were of 1000 specimens [eggs plus juveniles of second stage (J2s)] and introduced into two (2 cm-deep) holes around seedlings. The final population (*Fp*) was obtained at 71 (trial 1—2022), 60 (trial 2 −2022) and 62 (trials 1 and 2—2024) *dai*, according to Coolen and D'Herde (1972) using sodium hypochlorite 0.5%. Nematode resistance was measured by the reproductive factor ($RF = Fp/Ip$) and number of nematodes per gram of root (*Nema* g^{-1}) and defined according to statistical analysis. We consider plants/cultivars to be resistant if the RF is less than 1 and to be susceptible if the RF is greater than 1 (Oostenbrink 1966). All the trials were carried out in a completely randomized design and five replicates. Each experimental unit was composed of one plant per pot.

Data were analyzed by one-way analysis of variance (ANOVA) and means of the treatments compared by Tukey's HSD test ($P \leq 0.01$) using software R 4.2.1 (R Development Core Team 2022). The data set was transformed into ln(x + 1) before ANOVA (Noe 1985).

The high RF values observed for tomatoes prove the viability of the inoculum used and the adequacy of the experimental conditions adopted for both PPNs (Tables 1 and 2). All tested species/cultivars were resistant to *Mj* (RF < 1.0) (Table 1) ($P < 0.01$). Similarly, the same trend was found for trials with *Mi*, in which the RF values were lower than 1, being rated as resistant (poor host) (Table 2) ($P < 0.01$). The results of *Nema* g^{-1} strongly corroborate the results obtained for RF (similar trend), whether for *Mj* ($0 \leq Nema\ g^{-1} \leq 141.44$) or *Mi* ($2.43 \leq Nema\ g^{-1} \leq 66.74$). The results presented here highlight the strong response of the tested species/cultivars, strengthening the reliability of the data obtained and signaling the promising use. Galls were not observed for any grasses, regardless of the year.

In a study carried out by Carneiro et al. (2006), the obtained RF values for all *Brachiaria* species/cultivars were less than 1.0, which means a considerable reduction in the population of these PPNs. For instance, *B. brizantha* 'MG5', *B. brizantha* 'Marandu', *B. decumbens* x *B. brizantha* 'MG4' showed resistance to *Mj* and *Mi*. In this same study, *P. maximum* 'Tanzânia' and *P. maximum* 'Mombaça'

Table 1 Reproductive factor (RF), number of nematodes per gram of roots (Nema g^{-1}) and host status for forage species/cultivars inoculated (1000 specimens) with *Meloidogyne javanica* under greenhouse conditions

Treatments	Trial 1 (2022)		Trial 2 (2024)		Host status[3]
	RF	Nema g^{-1}	RF	Nema g^{-1}	
Tomato[1]	13.51 ± 6.41 a[2]	3,637.11 ± 1,821.75 c	44.13 ± 3.35 a	20,328.1 ± 2,722.1 a	S
Panicum maximum 'BRS Tamani'	0 ± 0 b	0 ± 0 a	0.06 ± 0.02 b	18.85 ± 12.24 b	R
Millet 'ANM 38'	0.19 ± 0.21 b	105.53 ± 115.24 b	-	-	R
B. ruziziensis x *B. brizantha* 'BRS RB331 Ipyporã'	0 ± 0 b	0 ± 0 a	0.04 ± 0.02 b	20.06 ± 6.85 b	R
Brachiaria brizantha 'BRS Piatã'	0 ± 0 b	0 ± 0 a	0.03 ± 0.02 b	9.79 ± 4.23 b	R
Panicum maximum 'BRS Quênia'	0 ± 0 b	0 ± 0 a	0.07 ± 0.02 b	14.7 ± 5.39 b	R
Brachiaria ruziziensis 'BRS Integra'	0.11 ± 0.02 b	141.44 ± 101.26 b	0.06 ± 0.03 b	42.18 ± 33.01 b	R
Panicum maximum 'BRS Zuri'	0 ± 0 b	0 ± 0 a	0.03 ± 0.02 b	66.74 ± 55.96 b	R

[1] Control of susceptibility

[2] Means (± standard deviation) followed by the same letter in each column did not differ significantly ($P = 0.01$) by Tukey's HSD test

[3] S = susceptible (RF > 1.0); R = resistant (RF < 1.0);—= not tested

n = 5 replicates for each trial

Table 2 Reproductive factor (RF), number of nematodes per gram of roots (Nema g^{-1}) and host status of forage species/cultivars inoculated (1000 specimens) with *Meloidogyne incognita* under greenhouse conditions

	Trial 1 (2022)		Trial 2 (2024)		
Treatments	RF	Nema g^{-1}	RF	Nema g^{-1}	Host status
Tomato[1]	26.23 ± 7.82 a	5,232.06 ± 2,363.81 a	18.80 ± 6.13 a	5,996.73 ± 2,622.52 a	S
Panicum maximum 'BRS Tamani'	0.12 ± 0.20 b	29.99 ± 44.26 b	0.01 ± 0.02 b	3.52 ± 3.76 bc	R
Millet 'ANM 38'	0.09 ± 0.13 b	45.56 ± 60.02 b	-	-	R
B. ruziziensis x *B. brizantha* 'BRS RB331 Ipyporã'	0 ± 0 b	0 ± 0 b	0.06 ± 0.03 b	31.26 ± 23.04 c	R
Brachiaria brizantha 'BRS Piatã'	0.06 ± 0.06 b	37.31 ± 50.54 b	0.02 ± 0.02 b	15.38 ± 13.73 bc	R
Panicum maximum 'BRS Quênia'	0.01 ± 0.01 b	1.10 ± 1.58 b	0.05 ± 0.03 b	18.16 ± 15.80 bc	R
Brachiaria ruziziensis 'BRS Integra'	0 ± 0 b	0 ± 0 b	0.01 ± 0.02 b	2.43 ± 3.75 b	R
Panicum maximum 'BRS Zuri'	0 ± 0 b	0 ± 0 b	0.01 ± 0.01 b	6.04 ± 6.03 bc	R

[1] Control of susceptibility

[2] Means (± standard deviation) followed by the same letter in each column did not differ significantly ($P = 0.01$) by Tukey's HSD test

[3] S = susceptible (RF > 1.0); R = resistant (RF < 1.0);— = not tested

$n = 5$ replicates for each trial

showed RF values less than 1.0. Similar results were observed by Dias-Arieira et al. (2003) for *P. maximum, B. brizantha* 'MG4' and *B. decumbens*. Still, these results are aligned with the work of Brito and Ferraz (1987), in which *B. decumbens* and *P. maximum* 'Guiné' reduced the population of *Mj.* Brito and Ferraz (1987) verified also that this antagonism was due to the lower rate of hatching and development of J2s.

In relation to millet, according to research conducted by Nascimento et al. (2020), the results revealed that the exclusive use of millet 'ADR 300' provided a significant reduction of 61% and 72% in the population levels of both PPNs. On the other hand, Chidichima et al. (2021) evaluated the host status of millet cultivars ('ADR300', 'ADR500' and 'BRS 1501') to four *Mj* isolates and the authors verified that all studied cultivars were susceptible to *Mj*. This variability was verified also as Inomoto et al. (2008), in which millet 'ADR300' was rated as susceptible while millet 'BN2' was resistant to *Mj*. Notwithstanding, it is necessary to mention discrepant results, for which variable reactions were identified depending on the race of *Mi* inoculated (Carneiro et al. 2007).

Taken together, our findings will help the appropriate selection of poaceous forage species/cultivars to be used in crop rotation and succession, contributing to the efficient management of PPNs the southern Brazil. Indeed, according to surveys conducted by Kirsch et al. (2016) and Marquez et al. (2021), *M. javanica* was the major *Meloidgyne* species in soybean-producing regions in the state of Rio Grande do Sul. In relation to *Mi,* it is known that it is widely distributed in other states in Brazil (Inomoto et al. 2008). In this sense, all the tested species/cultivars may be introduced in these areas, resulting in considerable populational reduction. Furthermore, resistance to these PPNs should be considered in future breeding programs.

Acknowledgements This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001. J.V. Araujo Filho (grant number 317495/2021-6) is supported by fellowships from the Brazilian National Council for Scientific and Technological Development (CNPq).

Authors' contribution All authors contributed to the contextualization of the study. MMP and MRS wrote the manuscript; JVAF and AM contributed to reviewing; MMP, SOM and MRS were responsible for obtaining data and analysis.

Funding This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001.

Data availability The dataset was obtained from trials carried out by the authors and is available from the corresponding author.

Declarations

Conflicts of interests The authors declare no conflict of interest.

Research involving humans and/or animals Not applicable.

References

Antonio RP (2015) Espécies forrageiras: principais contribuições, estado atual e perspectivas para a pesquisa na Embrapa Semiárido. Documentos (Embrapa Semiárido) 269:27

Asmus GL, Cruz TT (2020) Cultivo de *Brachiaria* spp. no manejo de nematoides edáficos fitoparasitos. 2020. Documentos (Embrapa Agropecuária Oeste) 144:20

Asmus GL, Ferraz LCCB (2001) Relações entre densidade populacional de *Meloidogyne javanica* e a área foliar, a fotossíntese e os danos causados a variedades de soja. Nematol Bras 25:1–13

Assis RL, Freitas RS, Mason SC (2018) Peral millet production practices in Brazil: A review. Experimental Agricultural 54:699–718

Brito JA, Ferraz S (1987) Antagonismo de *Brachiaria decumbens* e *Panicum maximum* cv Guiné a Meloidogyne Javanica. Nematol Bras 11:270–285

Carneiro RG, Monaco APA, Lima ACC, Nakamura KC, Moritz MP, Scherer A, Santiago DC (2006) Reação de gramíneas a *Meloidogyne incognita M. paranaensis* e *M. javanica*. Nematol Bras 30:287–291

Carneiro RG, Moritz MP, Mônaco APA, Nakamura KC, Scherer A (2007) Reação de milho, sorgo e milheto a *Meloidogyne incognita, M. javanica e M. paranaensis*. Nematol Bras 31:9–13

Carneiro RMDG, Almeida MRA (2001) Técnica de eletroforese usada no estudo de enzimas dos nematoides das galhas para identificação de espécies. Nematol Bras 25:223–228

Chidichima L, Miamoto A, Rinaldi L, Corrêia A, Dias-Arieira C (2021) Response of green manure species and millet cultivars to different populations of *Meloidogyne javanica*. Chilean J Agric Res 81:310–316

Coolen WA, D'Herde CJ (1972) A Method for the Quantitative Extraction of Nematodes from Plant Tissue. Ghent, Bélgica. State Nematology and Entomology Research Station

Dias-Arieira CR, Ferraz S, Freitas LG, Mizobutsi EH (2003) Avaliação de gramíneas forrageiras para controle de *Meloidogyne incognita e M. javanica* (Nematoda). Acta Sci 25:473–477

Elling AA (2013) Major emerging problems with minor *Meloidogyne* species. Phytopathology 103:1092–1102

Gabriel M, Kulczynski SM, Belle C, Kirsch VG, Calderan-Bisognin A (2018) Reação de gramíneas forrageiras a *Meloidogyne* spp e *Pratylenchus brachyurus*. Nematropica 48:155–163

Gorny AM, Ye W, Cude S, Thiessen L (2021) Soybean root knot nematode: a diagnostic guide. Plant Health Prog 22:164–175

Inomoto MM, Machado ACZ, Antedomênico SR (2007) Reação de *Brachiaria* spp. e Panicum maximum a *Pratylenchus brachyurus*. Fitopatol Bras 32:341–344

Inomoto MM, Antedomênico SR, Santos VP, Silva RA, Almeida GC (2008) Avaliação em casa de vegetação do uso de sorgo, milheto e crotalária no manejo de *Meloidogyne javanica*. Trop Plant Pathol 33:125–129

Kirsch VG, Kulczynski SM, Gomes CB, Bisognin AC, Gabriel M, Bellé C, Lima-Medina I (2016) Caracterização de espécies de *Meloidogyne* e de *Helicotylenchus* associadas à soja no Rio Grande do Sul. Nematropica 46:197–208

Marquez LAY, Gomes CB, Bellé C, Dallagnol LJ, Araujo Filho JV (2021) Unveiling the structure and distribution of plant-parasitic nematode communities in soybean fields in southern of the Brazil. Eur J Plant Pathol 160:457–468

Nascimento DD, Vidal RL, Pimenta AA, Castro MGC, Soares PLM (2020) Crotalaria and Millet as alternative controls of root-knot nematodes infecting okra. Biosci J 36:713–719

Noe JP (1985) Analysis and interpretation of data from nematological experiments. In: Barker KR, Carter CC, Sasser JN (eds) An advanced treatise on Meloidogyne, vol II. Methodology. Raleigh, NC, USA, North Carolina State University Graphics, pp 187–196

Omote H, Castro LM, Graciano VA, Santos RC, Souza JDF, Vaz APA, Araujo AF, Salman AKD, Bueno LG, Köpp MM, Antonio RP, Euclides VPB, Guarda VDA, Santos PM (2021) Monitoramento tecnológico de cultivares de forrageiras no Brasil. Documentos 139:33p

Oostenbrink M (1966) Major characteristics of the relation between nematodes and plants. Mededelingen and Bouwhogeschool 66:1–46

R Development Core Team (2022) R: a language and environment for statistical computing. R Foundation for Statistical Computing, version 4.2.1, Vienna, Austria. Available online at http://www.R-project.org.

Silva SA, Z P, Amaro PM, Machado ACZ (2015) Host reaction of forage grasses to root-knot and lesion nematodes. Nematoda 2:e01215

Trudgill DL, Blok VC (2001) Apomitic, polyphagous root knot nematodes: Exceptionally successful and damaging biotrophic root pathogens. Annual Rev Phytopathol 39:53–77