



## CROP SCIENCE

# Reproduction of *Meloidogyne morocciensis* (Tylenchida: Meloidogynidae) in weeds found in Brazil

TIAGO EDU KASPARY, RODRIGO F. RAMOS, LISIANE SOBUCKI, RICARDO R. BALARDIN, DAIANE DALLA NORA & CRISTIANO BELLÉ

**Abstract:** Weeds can be hosts of root-knot nematodes of the genus *Meloidogyne*. The importance of the species *Meloidogyne morocciensis* parasitizing many crops is recognized, but their reproductive capacity in weeds is not known. The present study hypothesizes the ability of *M. morocciensis* to parasitize and reproduce in different weed species found in Brazil. The objective was to evaluate the reproduction of *M. morocciensis* in 36 weed species. The plants were individually inoculated with 5,000 eggs and second stage juveniles and kept in greenhouse for 60 days. The experimental design was completely randomized with twelve replications. The root system of each plant was evaluated for gall index (GI), final nematode population (PF), number of nematode/g of root (NNGR) and reproduction factor (RF). It was verified that *M. morocciensis* has the capacity to parasitize 36 weed species belonging to 16 different botanical families, confirming the hypothesis proposed. From the 36 species evaluated, 77.8% (28) were susceptible ( $FR \geq 1.0$ ) to *M. morocciensis*. The present study is the first to identify different weeds as hosts of *M. morocciensis*, evidencing its polyphagous habit, indicating species of plants with high capacity to multiply this nematode and that need more attention during the integrated management of these pathogen.

**Key words:** invasive plants; host status; nematode reproduction; root-knot nematodes.

## INTRODUCTION

Weeds are one of the most important biotic factors limiting agricultural crops. The damage caused to crop development and productivity can be generated by direct competition for resources such as water, light and nutrients, or by the action of allelopathic compounds produced by weeds (Fried et al. 2017). In addition, the presence of weeds may compromise the final quality of agricultural products, contamination with their plant remains and seeds, or become alternative hosts of pests and diseases, multiplying them and becoming a source of inoculum for future reinfestation (Anwar et al. 2009, Rich et al. 2009, Singh et al. 2010, Bellé

et al. 2017b). These factors, combining the broad geographic distribution, high capacity of production and propagation of propagules, and the constant evolution of herbicide-resistant genotypes, add to the importance of weeds as a biotic component to be managed in agricultural environments (Ramos et al. 2019).

The knowledge of weeds that act as alternative hosts of pests and diseases has been used as an integrated management tool in several agricultural crop systems. In this context, several weed species have been reported as plant-parasitic nematode hosts, among them root-knot nematodes (*Meloidogyne* spp.). This genus of phytoparasite has the greatest impact

on crops in the world, besides being the most frequently found species parasitizing weed roots (Ferraz et al. 1978, Moens et al. 2009). In Brazil, a growing number of studies on weeds in agricultural areas have been developed as natural hosts of several nematode species of the genus *Meloidogyne* (Bellé et al. 2016, Groth et al. 2017, Kaspary et al. 2017). The ability of several weeds to be susceptible by *M. incognita*, *M. javanica* and *M. paranaensis*, and recently by *M. enterolobii*, are already described in the literature (Roese & Oliveira 2004, Mônico et al. 2008, Bellé et al. 2017b). However, many other nematode species make up the genus *Meloidogyne*, and there is a lack of knowledge about their ability to parasitize weeds, such is the case of *M. morocciensis*.

The first description of parasitism of the species *M. morocciensis* was carried out in the mid-90s on peach (*Prunus persica* L.) plants in Morocco (Rammah and Hirschmann 1990). In Central America *M. morocciensis* has been reported parasitizing coffee plants (*Coffea arabica* L.) in commercial plantations in Guatemala (Villain et al. 2013). Meanwhile, in South America, this species has recently been reported parasitizing grapevine plants (*Vitis vinifera* L.) in the main table grape producing regions of Peru (Huaroto 2018, Pongo 2018). In Brazil, its presence is mainly associated with soybean (*Glycine max* L.) and grapevine cultivation in different regions of the country (Somavilla 2011, Kirsch et al. 2016, Mattos et al. 2016). In addition, it shows reproduction in potato (*Solanum tuberosum* L.) (Lima-Medina et al. 2016). Thus, this plant-parasitic nematode can be considered an emerging species in agriculture, which is little known about the potential range of host species.

In the current literature, there are no studies related to weed behavior as possible hosts of *M. morocciensis*. However, studies have shown

that weeds are usually hosts of *Meloidogyne* genus nematodes (Anwar et al. 2009, Mônico et al. 2009, Silva et al. 2013, Bellé et al. 2019). Thus, the hypothesis of the present work is that *M. morocciensis* has the ability to parasitize and reproduce in different species of weeds. Therefore, the objective of this study was to evaluate the reproduction of *M. morocciensis* in 36 weed species commonly found in agricultural areas of Brazil.

## MATERIALS AND METHODS

The determination of *M. morocciensis* reproduction was performed using 36 weed species, commonly found in agricultural areas and belonging to 16 botanical families (Table I). The experiment was conducted from March to September 2018, in a greenhouse with a temperature set at  $25 \pm 3$  °C. The experimental design was completely randomized, with twelve (12) replicates. Seeding of the weeds was started with seeds of lower speed of germination and development and finished with the fast development species. Thus, homogenization of development at inoculation was maintained. The substrate used in the experiment consisted of the mixture of sand and soil (2:1), which was sterilized by autoclaving. The soil used in the experiment is characterized as Latossolo Vermelho aluminoférrico, according to the Brazilian Soil Classification System (SBCS, 2013), with the following physical and chemical properties: clay = 48%; pH water = 6.5; SMP index = 6.5; potential acidity (H + Al) =  $5.5 \text{ cmol}_c.\text{dm}^{-3}$ ; organic matter = 3.1%; sand = 30%; phosphorus =  $10.9 \text{ mg}.\text{dm}^{-3}$ ; potassium =  $88 \text{ mg}.\text{dm}^{-3}$ ; calcium =  $5.3 \text{ cmol}_c.\text{dm}^{-3}$ ; magnesium =  $5.0 \text{ cmol}_c.\text{dm}^{-3}$  and sulfur =  $9 \text{ cmol}_c.\text{dm}^{-3}$ . Ten days after emergence, the seedlings were transplanted into  $2,000 \text{ dm}^3$  pots containing substrate, one plant per pot.

**Table I. Family, scientific name, common name, habit, and distribution of weed species used in the present study.**

Family	Scientific name	Common name <sup>a</sup>	Habit <sup>b</sup>	Distribution regions <sup>a,b</sup>
Amaranthaceae	<i>Amaranthus hybridus</i> L.	Slim amaranth	HA <sup>3</sup>	Southeast and South
	<i>Amaranthus spinosus</i> L.	Spiny amaranth	HA	All regions
	<i>Amaranthus viridis</i> L.	Green amaranth	HA	All regions
	<i>Chenopodium album</i> L.	White goosefoot	HA	Midwest, Southeast and South
Asteraceae	<i>Acanthospermum australe</i> (Loefl.) Kuntze	Paraguay starburr	HA	All regions
	<i>Bidens pilosa</i> (L.) DC.	Hairy beggarticks	HA	All regions
	<i>Conyza bonariensis</i> (L.) Cronquist	Hairy fleabane	HA	All regions
	<i>Galinsoga parviflora</i> Cav.	Gallant soldier	HA	Southeast and South
	<i>Senecio brasiliensis</i> (Spreng.) Less.	Flower-of-souls	SP	Midwest, Southeast and South
	<i>Sonchus oleraceus</i> L.	Common sowthistle	HA/HB	All regions
Brassicaceae	<i>Raphanus raphanistrum</i> L.	Wild radish	HA	Midwest, Southeast and South
Commelinaceae	<i>Commelina benghalensis</i> L.	Benghal dayflower	HP	All regions
Convolvulaceae	<i>Ipomoea grandifolia</i> (Dammer) O'Donell	Morning glory	TA	All regions
	<i>Ipomoea nil</i> (L.) Roth.	Morning glory	HA	All regions
	<i>Ipomoea purpurea</i> (L.) Roth.	Morning glory	HA	All regions
Cyperaceae	<i>Cyperus rotundus</i> L.	Nutgrass	HP	All regions
Euphorbiaceae	<i>Caperonia palustris</i> (L.) A. St.-Hil.	Sacatrapo	HA	North, Northeast, Midwest and Southeast
	<i>Euphorbia heterophylla</i> L.	Fireplant	HA	All regions
Lamiaceae	<i>Leonurus sibiricus</i> L.	Honeyweed	HA/HB	All regions
Malvaceae	<i>Sida rhombifolia</i> L.	Arrowleaf sida	SP	All regions
Oxalidaceae	<i>Oxalis corniculata</i> L.	Creeping woodsorrel	HP	All regions
Poaceae	<i>Cynodon dactylon</i> (L.) Pers.	Bermuda grass	PHP	All regions
	<i>Digitaria horizontalis</i> Willd. (Digho)	Crabgrass; Sourgrass	GAE	All regions
	<i>Digitaria insularis</i> (L.) Fedde	Sourgrass	GAE	All regions
	<i>Echinochloa colonum</i> (L.) Link	Jungle rice	GAE	All regions
	<i>Eleusine indica</i> (L.) Gaertn	Indian goosegrass	GAE	All regions
	<i>Lolium multiflorum</i> Lam.	Ryegrass	GAE/GBA	Southeast and South
	<i>Rhynchelytrum repens</i> (Willd.) C.E.Hubb	Natal grass	GAE	All regions
Polygonaceae	<i>Polygonum hydropiperoides</i> (Michx.) Small	Swamp smartweed	HP	Midwest, Southeast, South and Bahia State
Portulacaceae	<i>Portulaca oleracea</i> L.	Verdolaga; Red root	HA	All regions
Sapindaceae	<i>Cardiospermum halicacabum</i> L.	Balloon vine	TA	All regions
Solanaceae	<i>Nicandra physaloides</i> (L.) Gaertn.	Apple-of-Peru	AS	All regions
	<i>Solanum americanum</i> Mill.	American black nightshade	HA	All regions
	<i>Solanum pseudocapsicum</i> L.	Jerusalem cherry	AP/SP	Midwest, Southeast and South.
	<i>Solanum sisymbriifolium</i> Lam.	Sticky nightshade	HP/SP	Midwest, Southeast, South and Bahia State
Talinaceae	<i>Talinum paniculatum</i> (Jacq.) Gaertn	Fameflower	HA	All regions

<sup>a</sup>At Brazil. <sup>b</sup>The authors elaborated on the descriptions of weed species by Moreira & Bragança (2011), Gazziero et al. (2015) and Flora Digital do Rio Grande do Sul and Santa Catarina (FLORARS 2019), where AP = Perennial Shrub; GAE = Entwined Annual Grass; GBE = Entwined Biannual Gramine; HA = Annual Herbaceous; HB = Biannual Herbaceous; HP = Perennial Herbaceous; PHP = Perennial of Prostrate Habit; SA = Annual Underfloor; SP = Perennial Sub-shrub; TA = Annual Climber.

The population of *M. morocciensis* (Est. A3) was isolated from soybean roots, from the Cerrito county, Rio Grande do Sul, Brazil (Kirsch et al. 2016), and multiplied in 'Santa Cruz' tomato. The nematode inoculum was obtained from the root system of plants kept in greenhouse, using the Hussey & Barker (1973) method. The plants were inoculated five days after transplantation, with suspension of 5,000 eggs and second stage juveniles (J2), in three holes approximately 2 cm deep, open around the plant. 'Santa Cruz' tomatoes were used as standard to prove the viability of the inoculum used.

After 60 days of inoculation, the root systems were washed in running water and then the gall index (GI) was determined according to the methodology proposed by Taylor & Sasser (1978), where 0 = no galls, 1 = 1 to 2, 2 = 3 to 10, 3 = 11 to 30, 4 = 31 to 100 and 5 = more than 100 galls per root system. Afterwards, the root systems were processed according to the method of Coolen & D'Herde (1972), using 0.5% sodium hypochlorite solution in substitution of water, for final nematode population (PF) quantification. From the final population of nematodes in the root system, calculations were performed for the number of nematode per root gram (NNGR) and reproduction factor (FR = final population / initial population) of *M. morocciensis* in each replicate. Immune (FR = 0), resistant (FR <1) and susceptible (FR > 1) species were considered (Oostenbrink 1966). The number of nematodes per gram of root was estimated by the ratio of the total number of nematodes to the roots total mass, in grams, of each replicate.

The final nematode population data and the reproduction factor were submitted to analysis of variance, and the means were compared by the Scott-Knott test with a 95% confidence level using the GENES software (Cruz 2006).

## RESULTS AND DISCUSSION

The differences in the living conditions indicates significant ( $p \leq 0.05\%$ ) in relation to *M. morocciensis* parasitism, based on the final population (PF), gall index (GI), number of nematodes per root gram (NNGR) and reproduction factor (RF), control (*L. esculentus*) (Table II). The viability of the nematode inoculum can be confirmed by the reproduction factor (FR =  $51.6 \pm 3.27$ ) for the total control (Table II).

The data obtained in this work show that 77.8% (28) of the 36 weed species were susceptible (FR  $\geq 1.0$ ) to *M. morocciensis*, being: *Acanthospermum australe* (Loef) Kuntze, *Amaranthus hybridus* L., *Amaranthus spinosus* L., *Amaranthus viridis* L., *Bidens pilosa* L., *Caperonia palustres* (L.) A. St.-Hil., *Cardiospermum halicacabum* L., *Chenopodium album* L., *Commelina benghalensis* L., *Cyperus rotundus* L., *Echinochloa colonum* (L.) Link, *Eleusine indica* (L.) Gaertn., *Euphorbia heterophylla* L., *Galinsoga parviflora* Cav., *Ipomoea grandifolia* (Dammer) O'Donell, *Ipomoea nil* (L.) Roth., *Ipomoea purpurea* (L.) Roth., *Leonurus sibiricus* L., *Nicandra physaloides* (L.) Gaertn., *Oxalis corniculata* L., *Polygonum hydropiperoides* (Michx.) Small, *Portulaca oleracea* L., *Sida rhombifolia* L., *Solanum americanum* Mill., *Solanum pseudocapsicum* L., *Solanum sisymbriifolium* L., *Sonchus oleraceus* L. e *Talinum paniculatum* (Jacq.) Gaertn (Tabela 2). It was observed that 27.8% (10) of the weed species evaluated presented average GI values equal to the control (GI = 5 for *L. esculentus*). In this group, all species of the family Solanaceae (*N. physaloides*, *S. americanum*, *S. pseudocapsicum* and *S. sisymbriifolium*), in addition to the species *A. viridis* (Amaranthaceae), *G. parviflora* (Asteraceae), *L. sibiricus* (Lamiaceae), *O. corniculata* (Oxalidaceae) *P. oleracea* (Portulacaceae) and *S. rhombifolia* (Malvaceae).

**Table II. Galls index (GI), final population (FP), nematodes per root gram (NNGR) and reproduction factors (RF) of *Meloidogyne morocciensis* on different weeds.**

Species	GI <sup>a</sup>		PF <sup>b</sup>		NNGR <sup>c</sup>		FR <sup>d</sup>		Reaction <sup>e</sup>
<i>Acanthospermum australe</i>	2.0 ± 0.21 <sup>f</sup>	F	5417 ± 368	H	1316 ± 102	F	1.1 ± 0.07	H	S
<i>Amaranthus hybridus</i>	4.7 ± 0.14	B	18375 ± 1360	G	4412 ± 321	E	3.7 ± 0.27	G	S
<i>Amaranthus spinosus</i>	3.7 ± 0.14	C	36750 ± 3182	E	8430 ± 943	D	7.4 ± 0.64	E	S
<i>Amaranthus viridis</i>	5.0 ± 0.00	A	24792 ± 2831	F	5792 ± 637	E	5.0 ± 0.57	F	S
<i>Bidens pilosa</i>	4.1 ± 0.15	C	11667 ± 1236	H	3045 ± 336	F	2.3 ± 0.25	H	S
<i>Caperonia palustres</i>	4.5 ± 0.15	B	36375 ± 4128	E	8253 ± 940	D	7.3 ± 0.83	E	S
<i>Cardiospermum halicacabum</i>	3.9 ± 0.23	C	22667 ± 2882	F	5600 ± 867	E	4.5 ± 0.58	F	S
<i>Chenopodium album</i>	3.6 ± 0.15	C	62750 ± 3528	C	14815 ± 624	B	12.6 ± 0.71	C	S
<i>Commelina benghalensis</i>	3.3 ± 0.13	D	10042 ± 1072	H	2247 ± 278	F	2.0 ± 0.21	H	S
<i>Conyza bonariensis</i>	0.4 ± 0.15	I	796 ± 171	I	201 ± 55	G	0.2 ± 0.03	I	R
<i>Cynodon dactylon</i>	1.0 ± 0.17	H	1625 ± 247	I	415 ± 68	G	0.3 ± 0.05	I	R
<i>Cyperus rotundus</i>	3.0 ± 0.21	D	9083 ± 931	H	2322 ± 253	F	1.8 ± 0.19	H	S
<i>Digitaria horizontalis</i>	1.5 ± 0.26	G	479 ± 102	I	109 ± 25	G	0.1 ± 0.02	I	R
<i>Digitaria insularis</i>	1.6 ± 0.15	G	621 ± 119	I	160 ± 37	G	0.1 ± 0.02	I	R
<i>Echinochloa colonum</i>	2.5 ± 0.26	E	21708 ± 1498	F	5461 ± 416	E	4.3 ± 0.30	F	S
<i>Eleusine indica</i>	2.7 ± 0.22	E	6542 ± 675	H	1702 ± 169	F	1.3 ± 0.14	H	S
<i>Euphorbia heterophylla</i>	3.8 ± 0.21	C	19917 ± 2023	G	4420 ± 469	E	4.0 ± 0.40	G	S
<i>Galinsoga parviflora</i>	5.0 ± 0.00	A	46042 ± 2216	D	11023 ± 695	C	9.2 ± 0.44	D	S
<i>Ipomoea grandifolia</i>	4.3 ± 0.14	B	26833 ± 2397	F	6684 ± 581	D	5.4 ± 0.48	F	S
<i>Ipomoea nil</i>	4.0 ± 0.17	C	23458 ± 3976	F	5719 ± 954	E	4.7 ± 0.80	F	S
<i>Ipomoea purpurea</i>	4.3 ± 0.19	B	24458 ± 3700	F	5663 ± 835	E	4.9 ± 0.74	F	S
<i>Leonurus sibiricus</i>	5.0 ± 0.00	A	19667 ± 2735	G	4773 ± 697	E	3.9 ± 0.55	G	S
<i>Lolium multiflorum</i>	0.3 ± 0.19	I	946 ± 167	I	237 ± 33	G	0.2 ± 0.03	I	R
<i>Nicandra physaloides</i>	5.0 ± 0.00	A	15250 ± 1572	G	3841 ± 387	E	3.1 ± 0.31	G	S
<i>Oxalis corniculata</i>	5.0 ± 0.00	A	91208 ± 3289	A	21324 ± 924	A	18.2 ± 0.66	A	S
<i>Polygonum hydropiperoides</i>	1.1 ± 0.23	H	7813 ± 685	H	1909 ± 207	F	1.6 ± 0.14	H	S
<i>Portulaca oleracea</i>	5.0 ± 0.00	A	76833 ± 3584	B	19856 ± 1329	A	15.4 ± 0.72	B	S
<i>Raphanus raphanistrum</i>	2.1 ± 0.19	F	1792 ± 226	I	464 ± 74	G	0.4 ± 0.05	I	R
<i>Rhynchelytrum repens</i>	1.3 ± 0.14	G	1229 ± 155	I	299 ± 42	G	0.2 ± 0.03	I	R
<i>Senecio brasiliensis</i>	1.4 ± 0.15	G	942 ± 182	I	251 ± 56	G	0.2 ± 0.04	I	R
<i>Sida rhombifolia</i>	5.0 ± 0.00	A	50292 ± 5508	D	13706 ± 1730	B	10.1 ± 1.10	D	S
<i>Solanum americanum</i>	5.0 ± 0.00	A	19042 ± 1701	G	4580 ± 548	E	3.8 ± 0.34	G	S
<i>Solanum pseudocapsicum</i>	5.0 ± 0.00	A	24417 ± 2193	F	5666 ± 647	E	4.9 ± 0.44	F	S
<i>Solanum sisymbriifolium</i>	5.0 ± 0.00	A	32542 ± 3420	E	8274 ± 964	D	6.5 ± 0.68	E	S
<i>Sonchus oleraceus</i>	0.9 ± 0.19	H	5167 ± 4671	H	1229 ± 1094	F	1.0 ± 0.93	H	S
<i>Talinum paniculatum</i>	4.8 ± 0.11	A	30583 ± 3027	E	8339 ± 878	D	6.1 ± 0.61	E	S
<i>Lycopersicon esculentum</i>	5.0 ± 0.00	-	258083 ± 16334	-	6000 ± 442	-	51.6 ± 3.27	-	-
CV (%)	16.09		39.42		43.81		39.42		

<sup>a</sup>Galls Index based on Taylor and Sasser (1978): 0 = no galls; 1 = 1-2; 2 = 3-10; 3 = 11-30; 4 = 31-100 and 5 = more than 100 galls per root system. <sup>b</sup>Final population of nematodes. <sup>c</sup>Number of nematodes per gram of root: ratio between total nematodes and total root mass. <sup>d</sup>RF = Final population/Initial population <sup>e</sup>Reaction based on Oostenbrink (1966): resistant (R; RF < 1.0) and susceptible (S; RF ≥ 1.0). <sup>f</sup>Means followed by the same letter in each column do not differ significantly by the Scott-Knott test at 5 % probability.

The species *O. corniculata* and *P. oleracea*, in addition to presenting mean GI values equal to the control, resulted in the highest values for PF (> 76,000), NNGR (> 19,000) and RF (> 15) (Table II). From these results, these species can be considered excellent hosts of *M. morocciensis*, being options of parasitism of this nematode in orchard areas and in areas of annual crops, during the crop cycle or in off-season periods. In this sense, the host of *M. morocciensis* weeds represents the possibility of maintaining and increasing the nematode population in areas where these weeds are present, even in the absence of susceptible agricultural crops.

The weeds used in the present study may be hosts of other species of *Meloidogyne*. In Brazil, weeds *O. corniculata*, a perennial herbaceous plant that develops throughout Brazil, is reported as a susceptible of *M. javanica* and *M. paranaensis* (Mônaco et al. 2009), and has recently been reported as a host of *M. ethiopica* Whitehead and *M. arenaria* (Neal) Chitwood in southern Brazil (Bellé et al. 2016). The species *P. oleracea*, which is also found in all regions of Brazil, is considered susceptible to *M. paranaensis* (Monaco et al. 2008), and to *M. enterolobii*, for which it showed high susceptibility based on the presence of large numbers of nematodes per root gram (> 5084), IG (= 5) and FR (> 13) (Bellé et al. 2019).

Considering the other weeds that have been shown susceptible to *M. morocciensis* in the present work, several of these species are also reported as susceptible to other plant-parasitic nematode species. In this sense, different weeds of the family *Amaranthaceae* are described as hosts to the root-knot nematodes in Brazil. Thus, the weed *A. viridis*, which in the present study had GI equal to the control (GI = 5), has been reported as a host of *M. arenaria*, *M. incognita* and *M. enterolobii* (Bellé et al. 2017b, 2019, Kaspary et al. 2017), as well as host of the

lesion nematode *Pratylenchus zae* Graham (Bellé et al. 2017a). While *A. hybridus*, considered one of the main invasive plant in agricultural crops in southern and southeastern Brazil, has been reported as susceptible of *M. enterolobii*, *M. incognita*, *M. javanica*, *M. paranaensis*, *P. zae* and *Pratylenchus brachyurus* (Godfrey) (Souza et al. 2006, Mônaco et al. 2009, Bellé et al. 2015, 2017a).

Weeds of the *Solanaceae* family, which behaved as susceptible to *M. morocciensis*, are widely distributed in Brazil, being recognized as important invasive plants in agricultural crops, besides being host of the plant-parasitic nematode genus *Meloidogyne*. In this context, *S. sisymbriifolium* and *S. americanum* are reported as susceptible of *M. incognita*, *M. javanica* and *M. paranaensis* (Mônaco et al. 2009); *N. physaloides* susceptible of *M. incognita* (Bellé et al. 2017b), while *S. pseudocapsicum* was recently reported as susceptible of *M. enterolobii* (Groth et al. 2017). Thus, the presence of weeds of this genus should be severely repressed in cultivated areas with crops susceptible to nematodes of the genus *Meloidogyne*, in order to avoid the multiplication and perpetuation of these pathogens and to reduce the negative impact on the crops.

The evaluation of 36 weed species revealed that only eight (22.2%) were classified as resistant (FR < 1.0) to *M. morocciensis* and none as immune (FR = 0). The nematode resistant species were: *Conyza bonariensis* (L.), *Cynodon dactylon* (L.), *Digitaria horizontalis* Willd. (D), *Digitaria insularis* (L.), *Lolium multiflorum* (L), *Raphanus raphanistrum* L., *Rhynchelytrum repens* L. and *Senecio brasiliensis* (Spreng.) (Table II). In this group, five species belong to the botanical family *Poaceae* (*C. dactylon*, *D. horizontalis*, *D. insularis*, *L. multiflorum* and *Rhynchelytrum repens*), which presented low values for FR, ranging from

0.1 to 0.3 for the *Digitaria* spp. and *C. dactylon*, respectively.

The other species evaluated in the Poaceae family, although parasitized by *M. morocciensis*, also presented low values for the reproduction factor, with mean values of 1.3 and 4.3 for *E. indica* and *E. colonum*, respectively (Table II). These results indicate that this botanical family may present mechanisms of resistance to *M. morocciensis*, which may serve as a source of variability for breeding programs that seek genes of resistance to the *Meloidogyne* genus. The results of the present study corroborate those obtained by different studies that evaluated the susceptibility of weeds to other species of the genus *Meloidogyne* and which report *D. insularis* and *R. repens* as resistant to *M. incognita*, *M. javanica* and *M. paranaensis* (Mônaco et al. 2009). While *D. horizontalis* is described as resistant to *M. incognita* and *M. javanica* (Silva et al. 2013). In addition, *E. indica* and *L. multiflorum* were resistant to *M. incognita*, whereas *D. horizontalis*, *D. insularis* and *E. indica* were resistant to *M. enterolobii* (Bellé et al. 2017b, 2019). These authors describe the resistance of *Cyperus rotundus* to *M. enterolobii*, while in the present work this species of the Cyperaceae family presents as susceptible to *M. morocciensis* (Table II)

The results obtained in the present work confirm the hypothesis that *M. morocciensis* is capable of parasitizing and reproducing in different weed species, from the reproduction observed in 36 different weeds belonging to 16 different botanical families. These results show that this pathogen species presents a polyphagous habit that, together with the broad geographic distribution of most weed species in several crops, can facilitate its dissemination in Brazilian agricultural areas.

The abundance (synonymous of population density) of a weed species and the reproduction

factor of the nematodes in this species determines the magnitude of the effect that the weed has on the population densities of the nematodes (Anwar et al. 2009). Thus, the weed species that commonly present high population density in the growing areas and are excellent hosts of *Meloidogyne* sp., are those with the greatest potential to maintain and raise the populations of these plant-parasitic nematodes in cultivated areas. In this sense, weeds with greater potential for multiplication and all those with a hostability of these pathogens increase their capacity to cause damage to crop and should be considered priorities in integrated management programs in areas of occurrence of root-knot nematode.

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#### TIAGO EDU KASPARY<sup>1</sup>

<https://orcid.org/0000-0003-3084-1938>

#### RODRIGO F. RAMOS<sup>2</sup>

<https://orcid.org/0000-0002-6414-376X>

#### LISIANE SOBUCKI<sup>3</sup>

<https://orcid.org/0000-0002-1786-1048>

#### RICARDO R. BALARDIN<sup>3</sup>

<https://orcid.org/0000-0001-8487-7624>

#### DAIANE DALLA NORA<sup>3</sup>

<https://orcid.org/0000-0003-4973-3582>

#### CRISTIANO BELLÉ<sup>4</sup>

<https://orcid.org/0000-0003-2247-3207>

<sup>1</sup> Instituto Nacional de Investigación Agropecuaria – INIA La Estanzuela, Ruta 50, KM 11, 70000, Colonia del Sacramento, Uruguay

<sup>2</sup> SLC Agrícola, Av. Dr. Nilo Peçanha, 2900, 91330-001 Porto Alegre, RS, Brazil

<sup>3</sup> Universidade Federal de Santa Maria, Av. Roraima, 1000, 97105-900 Santa Maria, RS, Brazil

<sup>4</sup> Staphyt, Alameda Antofagasta, 77, 97050-660 Santa Maria, RS, Brazil

Correspondence to: **Rodrigo Ferraz Ramos**

E-mail: [rodrigoferrazramos@gmail.com](mailto:rodrigoferrazramos@gmail.com)

#### Author contributions

Tiago E. Kaspary: Have been involved in drafting the manuscript and agree to be accountable for all aspects of the work. Rodrigo F. Ramos: Have made contributions to data acquisition and have been involved in writing and revising manuscript critically. Lisiane Sobucki: Have been involved in revising the manuscript critically. Ricardo R. Balardin: Have made several contributions to data acquisition and translation of the manuscript into English. Daiane Dalla Nora: Have made substantial contributions to data acquisition. Cristiano Bellé: Have made substantial contributions to conception and design, acquisition of data, data analysis and interpretation, have been involved in revising the manuscript critically, and have given final approval of the version to be published.

