horticultura brasileira

PINHEIRO, JB; SILVA, GO; BISCAIA, D; MAGALHÃES, CC; SOUZA, LR; PEREIRA, WS; MELO, RAC. 2022. Resistance sources to *Meloidogyne enterolobii* in wild *Solanum* species and interspecific hybrids. *Horticultura Brasileira* 40: 275-280. DOI: http://dx.doi.org/10.1590/s0102-0536-20220305

Resistance sources to *Meloidogyne enterolobii* in wild *Solanum* species and interspecific hybrids

Jadir B Pinheiro [1]; Giovani Olegário da Silva [1*]; Danielle Biscaia [1]; Caroline da C Magalhães [2]; Ludmila R de Souza [3]; Wandressa de S Pereira [4]; Raphael Augusto de C e Melo [1]

[1]Embrapa Hortaliças, Brasília-DF, Brasil; jadir.pinheiro@embrapa.br; giovani.olegario@embrapa.br (author for correspondence); danielle.biscaia@embrapa.br; raphael.melo@embrapa.br; [2]Centro Universitário de Desenvolvimento do Centro-Oeste (UNIDESC), Luziania-GO, Brasil; carolinecruzmagalhaes@gmail.com; [3]Universidade de Brasília (UnB), Brasília-DF, Brasil; ludmilaraulino@gmail.com; [4]Centro Universitário ICESP, Brasília-DF, Brasil; wandressasouza6@gmail.com

ABSTRACT

The objective of this work was to prospect sources of resistance to the root-knot nematode *Meloidogyne enterolobii* in wild *Solanum* species and hybrids to be used as potential rootstocks for cultivated Solanaceae. Twenty-three accessions of seven *Solanum* species, as well as 35 interspecific hybrids of two crosses, were characterized for their resistance to *M. enterolobii*. The experiments were conducted in a greenhouse in Brasília-DF, Brazil, in a completely randomized block design with four replications of one plant per pot. Plants were inoculated with *egg masses and* evaluated for the nematological variables egg mass index, galls index, number of eggs per root gram and reproduction factor. *Solanum torvum*, *S. paludosum*, and *S. paniculatum* presented high levels of resistance. Six among seven accessions of *S. crinitum* were resistant, as well as two accessions among five of *S. macrocarpon*, and one among three of *S. sisymbriifolium*. Except one, the 24 interspecific hybrids among *S. stramonifolium* var. inerme and *S. stramonifolium*, as well as five interspecific hybrids of *S. stramonifolium* and *S. aethiopicum* gr. gilo, among eleven were resistant. These results are relevant, since cultivated Solanaceae species of economic importance resistant to *M. enterolobii* are difficult to obtain by conventional breeding. Therefore, the identification of resistance in *Solanum* species compatible for grafting with cultivated species can be important to enable their use as rootstocks for disease control.

Keywords: horticulture, root-knot nematode, solanaceae rootstocks, genetic breeding.

RESUMO

Fontes de resistência a *Meloidogyne enterolobii* de espécies silvestres de *Solanum* e híbridos interespecíficos

O objetivo deste trabalho foi prospectar fontes de resistência ao nematoide-das-galhas *Meloidogyne enterolobii* em espécies silvestres de *Solanum* e híbridos com potencial para serem utilizados como porta-enxertos para solanáceas cultivadas. Vinte e três acessos de sete espécies de *Solanum*, bem como 35 híbridos de dois cruzamentos interespecíficos, foram caracterizados quanto à resistência a *M. enterolobii*. Os experimentos foram conduzidos em casa de vegetação em Brasília-DF, Brasil, em delineamento de blocos inteiramente casualizados, com quatro repetições de uma planta por vaso inoculada com ovos do nematoide, avaliadas quanto **às variáveis** nematológicas: índice de massa de ovos, índice de galhas, número de ovos por grama de raiz e fator de reprodução. Todos os acessos de *Solanum torvum, S. paludosum* e *S. paniculatum* apresentaram alta resistência. No caso de *S. crinitum*, *S. macrocarpon* e *S. sisymbriifolium*, as reações foram variadas, com seis de sete, dois de cinco e um de três acessos resistentes, respectivamente. Vinte e três dos 24 híbridos interespecíficos entre *S. stramonifolium* var. inerme e *S. stramonifolium*, e cinco híbridos interespecíficos de *S. stramonifolium* e *S. aethiopicum* gr. gilo, entre onze, também foram resistentes. Esses resultados são de interesse prático para o controle do nematoide-das-galhas, uma vez que solanáceas cultivadas resistentes a *M. enterolobii* são de difícil obtenção por meio de melhoramento convencional. Por isso, a identificação de resistência em espécies de *Solanum* compatíveis com as espécies cultivadas pode ser importante para permitir o uso como porta-enxertos.

Palavras-chave: horticultura, nematoide-das-galhas, porta enxertos de solanáceas, melhoramento genético.

Received on March 7, 2022; accepted on July 7, 2022

The plant-parasitic root-knot nematodes belonging to the *Meloidogyne* genus are considered the most important in the world due to the significant economic losses caused in a wide range of crop hosts (Bernard *et al*., 2017; Ye *et al*., 2021). Among them, *M. enterolobii* (syn. *Meloidogyne mayaguensis*) is known to break many horticultural species resistances, including some hybrids with known Mi-genes, for instance Mi-1 and N (Shao *et al*., 2021).

In Brazil, *M. enterolobii* was originally reported in 2001, in guava (*Psidium guajava*) orchards situated in the states of Pernambuco and Bahia (Carneiro *et al*., 2001). Since then, it quickly spread in the national territory (Silva *et al.*, 2021), causing significant losses to several other species and threatening the whole horticulture productive chain (Pinheiro *et al.*, 2020).

Meloidogyne enterolobii specifically damages many important solanaceous crops, such as tobacco, potato, tomato, eggplant, scarlet eggplant (gilo), and pepper (Pinheiro *et al.*, 2020; Schwarz *et al.*, 2020; Silva *et al.*, 2021; Ye *et al.*, 2021), making it difficult to find root knot resistance sources amongst them. Thus, the identification of resistance sources in landraces (wild species) may allow the utilization of interspecific crossings and the use of grafting, that is a simpler technology with the potential of reducing the damages of soilborne diseases (Thies, 2021). Mendonça *et al.* (2017) stated that, although grafting is an efficient technique to overcome the appearance of new pathogen species or races, its adoption in Brazil is evolving slowly, due to the high cost of hybrid rootstocks and scions seeds. Alternatively, grafting by using native species that are compatible with other cultivated *Solanum* species, with the possibility of seed production by growers, can reduce costs and improve crop sustainability.

Solanum stramonifolium is the most studied species in Brazil as a rootstock for tomato with resistance to *M. enterolobii*. Pereira *et al.* (2018) evaluated 22 accessions and found that 11 were resistant. For other *Solanum* species evaluated in this study, good compatibility for grafting with tomato was reported in *Solanum paniculatum* (Pereira *et al.*, 2018), *S. crinitum* (Carvalho *et al.*, 2020), and *S. mammosum* (Bletsos & Olympio, 2008), being this first species resistant to *M. enterolobii* according to Mattos *et al.* (2011), and *S. mammosum* resistant to *M. arenaria* (González *et al.*, 2010).

Grafting is also possible with *S. macrocarpon, S. torvum and S. sisymbriifolium,* for being resistant to *M. incognita* (Nyaku & Amissah, 2018). Currently, there is no information about resistance to *M. enterolobii* in *S. crinitum* and in *S. sisymbriifolium.* Bellé *et al.* (2019) classified one accession of *S. sisymbriifolium* as susceptible to *M. enterolobii* and Hajihassani *et al.* (2020) identified four resistant accessions of *S. sisymbriifolium*. *Solanum paludosum* has not been characterized for grafting compatibility or for nematode resistance. *Solanum macrocarpon* is a major vegetable crop in sub-Saharan Africa and constitutes the so-called scarlet and gboma eggplant complexes being able to cross with eggplant (Plazas *et al.*, 2014; Sounou *et al.*, 2021), and to be used as rootstock (Gisbert *et al.*, 2011). *Solanum torvum* is also used worldwide as an eggplant rootstock resistant to many plant parasitic nematode species, like *M. incognita, M. javanica, M. arenaria,* and *M. luci* (Serap *et al.*, 2018).

Considering the possibility of using this wild *Solanum* species as rootstocks, and the scarcity of information regarding resistance to *M. enterolobii*, the objective of this work was to prospect resistance sources to this important pathogen in wild *Solanum* species and hybrids, to be used as potential rootstocks for cultivated Solanaceae.

MATERIAL AND METHODS

Three experiments were conducted under greenhouse conditions from August 2019 to January 2020 at Embrapa Vegetables (15º56'S, and 48º08'W, 996 m altitude), Brasília-DF, Brazil. For inoculation purposes, females of *M. enterolobii*, maintained in tomato plants, were previously identified by perineal cuts (Taylor & Sasser, 1978) and isoenzymes pattern (Carneiro & Almeida, 2001).

In the first experiment three *Solanum paludosum*, five *S. macrocarpon*, seven *S. crinitum*, three *S. sisymbriifolium*, one *S. paniculatum*, three *S. mammosum,* and one *S. torvum* accessions were evaluated. The tomato cultivar Rutgers was used as the susceptible control.

In the second experiment, 24 interspecific hybrids were evaluated. These hybrids, with few thorns, are in the F6 generation of self-pollination, and were generated from crossing of *Solanum stramonifolium* var. inerme, a thornless species, previously evaluated as a source of resistance to *M. enterolobii* (Pinheiro *et al.*, 2021) and graft compatible with tomato (Mendonça *et al.*, 2017) with *Solanum stramonifolium*. This species presents thorns, is well adapted to hot climates from the North of Brazil, being used as a rootstock for tomato and eggplant in areas with high pressure of bacterial wilt caused by *Ralstonia* spp. The tomato cultivar Rutgers and one accession of *S. stramonifolium* var. inerme were used as susceptible and resistant controls, respectively.

In the third experiment, 11 interspecific hybrids among *S. stramonifolium* and scarlet eggplant (*S. aethiopicum* gr. *gilo*) were likewise evaluated. The scarlet eggplant is a species susceptible to *M. enterolobii* (Pinheiro *et al.*, 2021), but graft compatible with tomato and eggplant (Mendonça *et al.*, 2017).

All trials were held in a completely randomized block design with four replications, with one plant representing the experimental plot. Seedlings were produced in plastic trays with 128 plugs (40 cm^3 per plug) using coconut coir and peat moss mix-based commercial substrate (Plantmax®). Thirty days after sowing, plantlets were transplanted in plastic pots containing 1.5 dm^3 of a sterilized mix: soil retrieved from subsurface layers (a clayey Oxisol, typically encountered region in Brazil in the Cerrado Biome), washed sand, cow manure, and carbonized rice husk in the proportion 1:1:1:1. This mixture was fertilized and corrected with 300 g of 4-30-16 N-P-K formulation and 300 g of calcined dolomitic lime per 300 kg. After transplantation, plants were inoculated with 5.000 eggs and eventual second-stage juveniles (J2) of *M. enterolobii* utilizing a 5 mL suspension applied around the plant shoot region. Watering from seedling transplantation to the final evaluation was performed twice daily with enough water to start the run-off at the bottom of the pots. All other cultural practices were performed using technical recommendations for controlled environment tomato cultivation (Schwarz *et al.*, 2020).

At 120 days after inoculation, the gall index (GI), egg mass index (EMI), number of eggs per gram of roots (NE), and reproduction factor (RF) were evaluated according to Dickson & Struble (1965). EMI and GI were obtained according to Taylor & Sasser (1978) using a scoring scale from 0 to 5, where: 0 = roots without galls or egg masses; 1 = presence of 1 to 2 galls or egg masses; 2 = presence of 3 to 10 galls or egg masses; 3 = presence of 11 to 30 galls or egg masses; 4 = presence of 31 to 100 galls or egg masses and 5 = presence of more than 100 galls or egg masses. RF was obtained by dividing the initial and final nematode population (RF= FP/IP), considering the initial population (IP) the one inoculated, and the final population (FP) as the one extracted from the root system using Boneti & Ferraz (1981) recommendations. Plants were considered immune (I) when the RF presented value = 0, resistant (R) with a RF value <1, and susceptible (S) with RF value ≥1 (Oostenbrink, 1966). Data were checked for evidences of a normal distribution and variance homogeneity. Data were subjected to analysis of variance (ANOVA), and the means compared using the Scott-Knott clustering method at a significance level of 0.05. All statistical analyses were performed using Genes software (Cruz, 2013).

RESULTS AND DISCUSSION

Significant differences were observed for all evaluated variables in the first experiment (P<0.05) (data not shown). The coefficients of variation were considered low for most of the evaluated variables, but for the number of eggs per root gram (NE) a value of 41.76% indicates that, for this character, the experimental precision was lower. The rate between the genotypic coefficient of variation and the environmental coefficient of variation (CVg/CV) was superior to the unity value for all the variables, which indicates the preponderance of genetic variability to the environmental variability, as well as a satisfactory degree of accuracy for the obtained results (Table 1).

Regarding the reproduction factor (RF), *S. torvum* CNPH 610 was the only immune accession among all *Solanum* species evaluated. The three accessions of *S. paludosum* and the accession of *S. paniculatum* were resistant (Table 1). CNPH 610 also presented lower values of egg mass index (EMI), gall index (GI), and NE, being the most resistant *Solanum* species of this experiment. This result is very important since the two aforementioned species were not so far evaluated for their *M. enterolobii* resistance. *Solanum crinitum* has also presented six among seven accessions with resistant response. This species is used in Brazil as a tomato rootstock to control bacterial wilt (Carvalho *et al.*, 2020), but there was no information available about its resistance to *M. enterolobii*.

There are also two accessions of *S. macrocarpon* (CNPH 47 and CNPH 444), from the five evaluated ones, and one *S. sisymbriifolium* (CNPH 118), from three evaluated ones that were resistant (Table 1). All accessions of *S. mammosum* were susceptible. Bellé *et al.* (2019) classified one accession of *S. sisymbriifolium* as susceptible to this nematode. Hajihassani *et al.* (2020) evaluated four *S. sisymbriifolium*

Table 1. Evaluation of wild *Solanum* accessions for the reaction to *Meloidogyne enterolobii*. Embrapa, Brasília, 2020.

***Solanum* species**	**Accessions**	**EMI**	**GI**	**NE**	**RF/Reaction**
S. paludosum	CNPH 45	1.25 f	1.25 f	11.79 d	0.11 c / R
S. paludosum	CNPH 200	2.50 d	2.50 d	39.12 d	0.12 c / R
S. paludosum	CNPH 205	2.75 d	2.75 d	32.24 d	0.15 c / R
S. macrocarpon	CNPH 38	3.50 c	3.50 c	68.13 c	1.13 b / S
S. macrocarpon	CNPH 47	5.00 a	5.00 a	33.89 d	0.41 c / R
S. macrocarpon	CNPH 444	4.75 a	4.75 a	57.02 c	0.56 b / R
S. macrocarpon	CNPH 445	4.75 a	4.75 a	243.86 b	3.83 a / S
S. macrocarpon	CNPH 503	5.00 a	5.00 a	354.86 b	3.95 a / S
S. crinitum	CNPH 189	3.75 c	3.75 c	89.46 c	0.38 c / R
S. crinitum	CNPH 190	4.00 b	4.00 b	104.38 c	1.47 b / S
S. crinitum	CNPH 191	4.75 a	4.75 a	65.45 c	0.68 b / R
S. crinitum	CNPH 193	3.75 c	3.75 c	104.30 c	0.92 b / R
S. crinitum	CNPH 194	4.00 b	4.00 b	53.31 c	0.59 b / R
S. crinitum	CNPH 195	4.75 a	4.75 a	162.97 c	0.99 b / R
S. crinitum	CNPH 225	2.00 e	2.00 e	4.88 d	0.09 c / R
S. sissymbriifolium	CNPH 34	3.75 c	3.75 c	68.60 c	1.21 b / S
S. sissymbriifolium	CNPH 118	3.50 c	3.50 c	14.71 d	0.20 c / R
S. sissymbriifolium	CNPH 368	3.75 c	3.75 c	113.29 c	2.18 a / S
S. paniculatum	CNPH 27	3.25 c	3.25 c	18.17 d	0.27 c / R
S. mammosum	CNPH 35	5.00 a	5.00 a	201.29 b	3.33 a / S
S. mammosum	CNPH 36	5.00 a	5.00 a	197.96 b	2.61 a / S
S. mammosum	CNPH 334	5.00 a	5.00 a	300.45 b	4.49 a / S
S. torvum	CNPH 610	3.00 c	3.00 c	0.00 d	0.00 c / I
Tomato	Rutgers	4.25 b	4.25 b	538.95 a	2.39 a / S
Means	-	3.88	3.88	119.96	1.34
CV (%)	-	10.30	10.30	41.76	20.72
CVg/CV	-	2.43	2.43	1.56	1.77

EMI= Egg mass index; GI= Galls index (Taylor & Sasser, 1978); NE= number of eggs per root gram; RF= Reproduction factor = final population / initial population (RF= FP/IP) (5000 eggs and eventual J2). Reaction of resistance according to Oostenbrink (1966): Immune (I) RF= 0, resistant (R) RF<1 and susceptible (S) RF≥1. Means followed by same lowercase letters in the columns do not differ by Scott-Knott clustering test at 5% probability; CV: coefficient of variation; CVg/CV: rate between the genotypic and environmental coefficient of variation.

accessions also using tomato 'Rutgers' as susceptible control, obtaining one as resistant to *M. arenaria*, three to *M. incognita*, all resistant to *M. haplanaria* and *M. enterolobii,* and susceptible to *M. javanica*. González *et al.* (2010) classified one accession of *S. mammosum* as resistant to *M. incognita* race 2 and *M. arenaria*. These results reinforce the need to evaluate a diverse source of accession in order to establish the reaction of the species (interspecific variability).

Some accessions classified as resistant or immune according to RF (Oostenbrink, 1966), i.e., showing lower number of nematodes compared to the initial inoculated population, presented some amount of egg masses (EMI) and galls (GI). Although these indexes provide support for the interpretation of RF results, there is not always a positive correlation among them. Generally, this varies depending on the evaluated species and its accessions. Thus, there are genotypes that the plant responds with some number of galls; there is the formation of egg mass, but the fact that they are resistant means that fewer nematodes are produced and there is a low value of the reproduction factor (RF) (Hussey & Janssen, 2002). For example, tomato plants carrying the *Mi* gene that confers resistance, or even in certain cases immunity to the main species of root-knot nematode (*M. incognita*, *M. javanica* and *M. arenaria*), not always show total absence of galls or egg mass (Hussey & Janssen, 2002).

About the second experiment, differences among the genotypes (P<0.05) were observed for all evaluated variables. The resistant and susceptible controls presented the expected responses (Table 2). Except for the accession L29 all hybrids were resistant. These hybrids were obtained from the cross of *S. stramonifolium* var. inerme, a thornless species with a good source of resistance to *M. enterolobii* (Pinheiro *et al.*, 2021), and *S. stramonifolium,* that is well adapted to hot climates as in the North of Brazil, but with the limitation of having many thorns (Mendonça *et al.*, 2017). These are important information, indicating that there are accessions with few thorns, so with better manipulation when used for grafting, and resistance to *M. enterolobii*. Pereira *et al.* (2018) evaluated 22 accessions of *S. stramonifolium* to *M. enterolobii* and found that 11 were resistant.

In the third experiment, following the trend observed in the two experiments, there were significant differences among accessions for all the evaluated variables, showing a higher CV value for NE. All genotypes had a RF value lower than the susceptible control, except the accessions L1 and L6.

Table 2. Evaluation of interspecific hybrids among *Solanum* species, *Solanum stramonifolium* var. inerme and *Solanum stramonifolium*, F6 generation of self-pollination, for the resistance to *Meloidogyne enterolobii*. Embrapa, Brasília, 2020.

Hybrids	EMI	GI	NE	RF/Reaction
L1	2.00 c	2.00 c	2.44 d	0.03 d / R
L2	2.00 c	2.00 c	2.56 d	0.03 d / R
L3	3.00 b	3.00 b	16.95 d	0.15 d / R
L4	3.00 b	3.00 b	12.87 d	0.14 d / R
L5	2.50 c	2.50 c	7.34 d	0.03 d / R
L6	3.50 a	3.50 a	130.21 b	0.45 c / R
L9	3.00 b	3.00 b	18.35 d	0.14 d / R
L12	3.75 a	3.75 a	29.70 c	0.21 d / R
L15	2.50 c	2.50 c	54.62 c	0.36 d / R
L16	3.25 b	3.25 b	61.22 c	0.53 c / R
L18	3.00 b	3.00 b	34.03 c	0.30 d / R
L19	3.75 a	3.75 a	43.85 c	0.57 c / R
L21	3.50 a	3.50 a	54.33 c	0.24 d / R
L24	3.50 a	3.50 a	60.37 c	0.65 c / R
L25	3.50 a	3.50 a	16.56 d	0.21 d / R
L26	2.00 c	2.00 c	14.79 d	0.17 d / R
L29	3.25 b	3.25 b	150.56 b	1.07 b / S
L31	3.50 a	3.50 a	103.10 c	0.44 c / R
L32	3.00 b	3.00 b	39.20 c	0.29 d / R
L34	3.25 b	3.25 b	5.80 d	0.08 d / R
L35	3.25 b	3.25 b	8.21 d	0.08 d / R
L42	2.00 c	2.00 c	1.00 d	0.02 d / R
L43	3.75 a	3.75 a	47.02 c	0.50 c / R
L61	3.25 b	3.25 b	28.22 c	0.20 d / R
S. stramonifolium var. inerme	3.50 a	3.50 a	19.57 d	0.14 d / R
Tomato 'Rutgers'	4.25 a	4.25 a	538.95 a	2.93 a / S
Means	3.11	3.09	57.76	0.38
CV (%)	13.66	14.15	43.66	12.42
CVg/CV	1.35	1.28	1.63	1.96

EMI= Egg mass index and GI= Galls index (Taylor & Sasser, 1978); NE= number of eggs per root gram; RF= Reproduction factor = final population / initial population (RF= FP/IP) (5000 eggs and eventual J2); Reaction of resistance according to Oostenbrink (1966): Immune (I) RF= 0, resistant (R) RF<1 and susceptible (S) RF≥1. Means followed by same lowercase letters in the columns do not differ by Scott-Knott clustering test at 5% probability; CV= coefficient of variation; CVg/CV= rate between the genotypic and environmental coefficient of variation.

Table 3. Evaluation of interspecific hybrids among *Solanum stramonifolium* and *Solanum aethiopicum* gr. *gilo* for the resistance to *Meloidogyne enterolobii*. Embrapa, Brasília, 2020

Hybrids	EMI	GI	NE	RF/Reaction
L1	5.00 a	5.00 a	349.57 a	3.93 a / S
L2	5.00 a	5.00 a	56.44 c	0.87 c / R
L3	5.00 a	5.00 a	48.60 c	0.83 c / R
L4	5.00 a	4.75 a	35.07 c	0.51 c / R
L5	5.00 a	5.00 a	113.24 b	1.74 b / S
L6	5.00 a	5.00 a	150.06 b	2.69 a / S
L7	5.00 a	5.00 a	79.88 b	1.23 c / S
L8	5.00 a	5.00 a	39.92 c	0.68 c / R
L9	5.00 a	5.00 a	93.66 b	1.37 c / S
L10	5.00 a	5.00 a	23.65 c	0.41 c / R
L11	5.00 a	5.00 a	85.95 b	1.95 b / S
Tomato Rutgers	4.25 b	4.25 b	538.95 a	2.93 a / S
Means	4.94	4.92	134.58	1.59
CV (%)	2.92	4.34	30.23	17.92
CVg/CV	1.41	0.91	1.69	1.38

EMI= Egg mass index and GI= Galls index (Taylor & Sasser, 1978); NE= number of eggs per root gram; RF= Reproduction factor = final population / initial population (RF= FP/IP) (5000 eggs and eventual J2); Reaction of resistance according to Oostenbrink (1966): Immune (I) RF= 0, resistant (R) RF<1 and susceptible (S) RF≥1. Means followed by same lowercase letters in the columns do not differ by Scott-Knott clustering test at 5% probability; CV= coefficient of variation; CVg/CV= rate between the genotypic and environmental coefficient of variation.

These two accessions, together with L5, L7, L9, and L11 were classified as susceptible according to Oostenbrink (1966), presenting an RF value higher than 1. The accessions L2, L3, L4, L8, and L10 were classified as resistant, presenting an RF value lower than 1 (Table 3).

Pinheiro *et al.* (2021) stated that the resistance of eggplant and scarlet eggplant to root-knot nematodes is difficult to obtain by conventional breeding, and that crossing these species with wild Solanaceae accessions presenting a higher degree of resistance, such as *S. stramonifolium*, is feasible. This is a strategy that could be employed to develop hybrid rootstocks compatible to important crop vegetable solanaceous species, maintaining the parent's resistance, and having complementary traits such as a lower amount or absence of thorns.

In conclusion, we verified that S*olanum torvum*, *S. paludosum*, and *S. paniculatum* are species resistant to *M. enterolobii* with all the evaluated accessions classified as resistant or immune. *Solanum crinitum* also has six among seven accessions being resistant (CNPH 189, CNPH 191, CNPH 193, CNPH 194, CNPH 195 and CNPH 225) whereas, for *S. macrocarpon,* two accessions from five evaluated (CNPH 47 and CNPH 444), and one *S. sisymbriifolium* from three evaluated (CNPH 118), also are resistant. All accessions of *S. mammosum* were susceptible. Almost all interspecific hybrids, presenting few thorns, between *S. stramonifolium* var. inerme and *S. stramonifolium*, except one (L29), are similarly resistant to this plant parasitic nematode. Five interspecific hybrids of *S. stramonifolium* and eggplant (L2, L3, L4, L8, and L10), among eleven, are also resistant. These results are significant, since the resistance of the root-knot nematode *M. enterolobii* in cultivated solanaceous species of economic importance, such as tomato and eggplant, is difficult to obtain by conventional breeding; consequently, the identification of resistant and graft compatible species can enable their use as rootstocks for disease control.

ACKNOWLEDGEMENTS

To the Fundação de Apoio à Pesquisa no Distrito Federal (FAP-DF), for the support of this study carried out within the project entitled "Ações de Pesquisa, Transferência de Tecnologias e Inovação no manejo do nematoide-das-galhas no DF".

REFERENCES

BELLÉ, C; RAMOS, RF; BALARDIN, RR; KASPARY, TE; ANTONIOLLI, ZI. 2019. Reproduction of *Meloidogyne enterolobii* on weeds found in Brazil. *Tropical Plant Pathology* 44: 380-384. Available https://doi.org/10.1007/s40858-019-00278-z

BERNARD, GC; EGNIN, M; BONSI, C. 2017. *The impact of plant-parasitic nematodes on agriculture and methods of control*. In: SHAH, MM; MAHAMOOD, M (eds). Nematology: concepts, diagnosis, and control (ed). Rijeka: *InTech*. p.121-151. Available at https://doi.org/10.5772/intechopen.68958.

BLETSOS, FA; OLYMPIO, CM. 2008. Rootstocks, and grafting of tomatoes, peppers, and eggplants for soil-borne disease resistance, improved yield, and quality. *The European Journal of Plant Science and Biotechnology* 2: 62-73.

BONETI, JIS; FERRAZ, S. 1981. Modificação do método de Hussey e Barker para extração de ovos de *Meloidogyne exigua* de raízes de cafeeiro. *Fitopatologia Brasileira* 6: 53.

CARNEIRO, RMDG; ALMEIDA, MRA. 2001. Técnica de eletroforese usada no estudo de enzimas de nematoides de galhas para identificação de espécies. *Nematologia Brasileira* 25: 35-44.

CARNEIRO, RMDG; MOREIRA, WA; ALMEIDA, MRA; GOMES, ACMM. 2001. Primeiro registro de *Meloidogyne mayaguensis* em goiabeira no Brasil. *Nematologia Brasileira* 25: 223-228.

CARVALHO, LTD; MELO, DM; VARGAS, PF; SANTOS, HCA; FERREIRA, JV. 2020. Tomato grafting onto Solanaceae genotypes to control bacterial wilt (*Ralstonia solanacearum* Smith 1896). *Pesquisa Agropecuária Tropical* 50: e63476. Available at https://doi.org/10.1590/1983-40632020v5063476.

CRUZ, CD. 2013. Genes: a software package for analysis in experimental statistics and quantitative genetics. *Acta Scientiarum*

Agronomy 35: 271-276. https://doi.org/10.4025/actasciagron.v35i3.21251.

DICKSON, DW; STRUBLE, FB. 1965. A sieving-staining technique for extraction of egg mass of *Meloidogyne incognita* from the soil. *Phytopathology* 55: 497.

GISBERT, C; PROHENS, J; RAIGÓN, MD; STOMMEL, JR; NUEZ, F. 2011. Eggplant relatives as sources of variation for developing new rootstocks: effects of grafting on eggplant yield and fruit apparent quality and composition. *Scientia Horticulturae* 128: 14-22. Available at https://doi.org/10.1016/j.scienta.2010.12.007.

GONZÁLEZ, FM; GÓMEZ, L; RODRÍGUEZ, MG; PIÑÓN, M; CASANOVA, A; GÓMEZ, O; RODRÍGUEZ, Y. 2010. Respuesta de genotipos de solanáceas frente a *Meloidogyne incognita* (Kofoid y White) Chitwood raza 2 y *M. arenaria* (Neal) Chitwood. *Revista de Proteção Vegetal* 25: 51-57.

HAJIHASSANI, A; RUTTER, WB; SCHWARZ, T; WOLDEMESKEL, M; ALI, ME; HAMIDI, N. 2020. Characterization of resistance to major tropical root-knot nematodes (*Meloidogyne* spp.) in *Solanum sisymbriifolium*. *Phytopathology* 110: 666-673. Available at https://doi.org/10.1094/PHYTO-10-19-0393-R.

HUSSEY, RS; JANSSEN, GJW. 2002. *Root-knot nematodes: Meloidogyne species*. In: STARR, JLR; COOK, R; BRIDGE, J (eds). Plant resistance to parasitic nematodes. p. 43-70. Wallingford, UK: CABI. Available at http://dx.doi.org/10.1079/9780851994666.0000

MATTOS, LM; PINHEIRO, JB; MENDONÇA, JL; SANTANA, JP. 2011. Wild Solanaceae: potential for the use as rootstocks resistant to root-knot nematode (*Meloidogyne* spp.). *Acta Horticulturae* 917: 243-247.

MENDONÇA, JL; LOPES, CA; MOITA, AW. 2017. Compatibilidade de enxertia de híbridos interespecíficos de *Solanum* com tomateiro visando controle de patógenos de solo. *Savannah Journal of Research and Development* 1: 34-38.

NYAKU, ST.; AMISSAH, N. 2018. *Grafting: an effective strategy for nematode management in tomato genotypes*. In: NYAKU, ST; DANQUAH, A (eds). Recent advances in tomato breeding and production. London: *IntechOpen*, p.3-16. Available at https://doi.org/10.5772/intechopen.82774.

OOSTENBRINK, M. 1966. Major characteristics of the relation between nematodes and plants. *Mededelingen Landbouw* 66: 1-46.

PEREIRA, RB; PINHEIRO, JB; TORRES, TB; MENDONÇA JL; LUCAS, GC; GUIMARÃES, JA. 2018. Potential of wild *Solanum stramonifolium* accesses as rootstock resistant to soilborne pathogens in tomato crops. *Horticultura Brasileira* 36: 235-239. Available at https://doi.org/10.1590/S0102-053620180215.

PINHEIRO, JB; SILVA, GO; JESUS, JG; BISCAIA, D; CASTRO, RA. 2021. Evaluation of eggplant and gilo genotypes and interspecific hybrids as to root-knot nematode resistance. *Colloquium Agrariae*, 17: 30-38. Available at https://doi.org/10.5747/ca.2021.v17.n2.a427.

PINHEIRO, JB; SILVA, GO; MACÊDO, AG; BISCAIA, D; RAGASSI, CF; RIBEIRO, CSC; CARVALHO, SIC; REIFSCHNEIDER, FJB. 2020. New resistance sources to root-knot nematode in *Capsicum* pepper. *Horticultura Brasileira* 38: 33-40. Available at https://doi.org/10.1590/S0102-053620200105.

PLAZAS, M; ANDÚJAR, I; VILANOVA, S; GRAMAZIO, P; HERRAIZ, FJ; PROHENS, J; SCHWARZ, D; THOMPSON, AJ; KLÄRING, HP. 2014. Conventional and phenomics characterization provides insight into the diversity and relationships of hypervariable scarlet (*Solanum aethiopicum* L.) and gboma (*S. macrocarpon* L.) eggplant complexes. Guidelines to use tomato in experiments with a controlled environment. *Frontiers of Plant Science* 5: 1-16. Available at https://doi.org/10.3389/fpls.2014.00318.

SCHWARZ, T; LI, C; YE, W; DAVIS, E. 2020. Distribution of *Meloidogyne enterolobii* in eastern North Carolina and comparison of four isolates. *Plant Health Progress* 21: 91-96. Available at https://doi.org/10.1094/PHP-12-19-0093-RS.

SERAP, Ö; ÖZALP, T; DEVRAN. Z. 2018. Reaction of wild eggplant *Solanum torvum* to different species of root-knot nematodes from Turkey. *Journal of Plant Diseases and Protection* 125: 577-580. Available at https://doi.org/10.1007/s41348-018-0167-3.

SHAO, H; FU, Y; ZHANG, P; YOU, C; LI, C; PENG, H. 2021. Transcriptome analysis of resistant and susceptible mulberry responses to *Meloidogyne enterolobii* infection. *BMC Plant Biology* 21: 1-16. Available at https://doi.org/10.1186/s12870-021-03128-w.

SILVA, RVD; OLIVEIRA, JOD; ÁVILA, JHD; LIMA, BVD; MOREIRA, NF. 2021. Occurrence of *Meloidogyne enterolobii* in common bean in southern Goiás State, Brazil. *Ciência Rural* 51: e20200403. Available at https://doi.org/10.1590/0103-8478cr20200403.

SOUNOU, EEGYE; MENSAH, ACEG; MONTCHO, KDH; GOUVEITCHA, MBG; KOMLAN, FA; GANDONOU, CB. 2021. Response of seven African eggplant (*Solanum macrocarpon* L.) cultivars produced in Benin to salinity stress at seedling stage. *African Journal of Agricultural Research* 17: 292-301. https://doi.org/10.5897/AJAR2020.15345.

TAYLOR, AL; SASSER, JN. 1978. *Biology, identification and control of root-knot nematodes* (*Meloidogyne species)*. Raleigh: Department of plant pathology. North Carolina State University Graphics, 111p.

THIES, JA. 2021. Grafting for managing vegetable crop pests. *Pest management Science*, p.1-11. Available at https://doi.org/10.1002/ps.6512.

YE, W; KOENNING, SR; ZENG, Y; ZHUO, K; LIAO, J. 2021. Molecular characterization of an emerging root-knot nematode *Meloidogyne enterolobii* in North Carolina, USA. *Plant Disease* 105: 819-831. Available at https://doi.org/10.1094/PDIS-04-20-0816-RE