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Response of *Capsicum annuum* L. var. *annuum* genotypes to root-knot nematode infection

Renato Silva Soares[1*], Edgard Henrique Costa Silva[1], Roberta Luiza Vidal[1], Willame dos Santos Candido[2], Carolina Andrade Franco[1], Francisco José Becker Reifschneider[3], and Leila Trevisan Braz[1]

[1]Universidade Estadual Paulista (UNESP), Via de Acesso Prof. Paulo Donato Castellane, Jaboticabal, São Paulo, 14884-900, Brasil. [*]Corresponding author (renato_2366@hotmail.com).
[2]Universidade Federal de Goiás, Jataí, Goiás, 75804-020, Brasil.
[3]Empresa Brasileira de Pesquisa Agropecuária (Embrapa), Secretaria de Relações Internacionais, Brasília-DF, 70770-901, Brasil.

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ABSTRACT

Root-knot nematodes are among the main agents that negatively affect the pepper and sweet pepper crop (*Capsicum annuum* L.), especially *Meloidogyne incognita*, *M. javanica,* and *M. enterolobii*. The objective of this study was to evaluate genotypes of *C. annuum* L. var. *annuum* in their response to infection by *M. incognita* race 3, *M. javanica,* and *M. enterolobii*. The experiment was conducted using a completely randomized design arranged in a 27 × 3 factorial scheme with six replicates and each plot consisted of one plant. The experiment was carried out at the UNESP-FCAV in Jaboticabal, São Paulo, Brazil. The genotypes were in plastic pots containing an autoclaved mixture of soil, sand, and bovine manure under greenhouse conditions, and they were evaluated for the reproduction index and reproduction factor at 90 d after inoculation. Thirteen genotypes were classified as resistant, based on the reproductive factor, and highly resistant, based on the reproduction index, to *M. javanica,* while six were resistant and highly resistant materials to *M. incognita* race 3. No materials resistant to *M. enterolobii* were identified. The genotypes CNPH 698, CNPH 701, CNPH 702, CNPH 717, and CNPH 718 were simultaneously classified as resistant to *M. incognita* race 3 and *M. javanica* based on the reproduction factor.

Key words: *Meloidogyne* spp., hot and sweet peppers, reaction, resistance.

INTRODUCTION

Sweet pepper (*Capsicum annuum* L. var. *annuum*) is among the main vegetable crops in Brazil and is mostly cultivated in a protected environment (Araújo et al., 2009; Oliveira et al., 2009). This type of crop system has allowed the farmer, in addition to better fruit quality, to market the product throughout the year, providing better remuneration (Pinheiro et al., 2014). However, its intensified use has led to an increase in the incidence and severity of soil-borne pathogens, especially root-knot nematodes (*Meloidogyne* spp.)

Nematodes belonging to the genus *Meloidogyne* are considered as the most economically important species worldwide (Jones et al., 2013). Symptoms include reduced growth, wilting, and leaf discoloration, which are similar to the symptoms of mineral deficiency. According to Mota et al. (2013), nematodes can also form complexes with other pathogens, such as *Fusarium oxysporum*, *Rhizoctonia solani,* and *Thielaviopsis basicola*.

Farmers use resistant rootstocks to manage the nematodes of the genus *Meloidogyne* in pepper cropping. Currently, materials that are resistant to *Meloidogyne incognita* (Kofoid & White) and *Meloidogyne javanica* (Treub) are species cited by Pinheiro et al. (2014) as the most important for vegetable crops. However, a third species, *Meloidogyne enterolobii* Yang & Eisenback (sin. *Meloidogyne mayaguensis* Rammah & Hirschmann) has been gaining importance; it has been found to infect materials resistant to the abovementioned species (Pinheiro et al., 2014).

Due to its great harmful potential, wide range of hosts, and absence of resistant commercial material, *M. enterolobii* poses a great threat to sweet pepper production (Pinheiro et al., 2013a).

Genetic resistance is considered as the best alternative to control phytonematodes because of the low efficiency of chemical control and the search for sources of vital resistance to breeding programs (Hussain et al., 2014; Liu et al., 2015). However, there are currently no pepper materials, or even rootstocks, that have multiple resistance to the three major species of root-knot nematodes.

Therefore, the objective of the present study was to evaluate genotypes of *Capsicum annuum* L. var. *annuum* with respect to their response to infection by *M. incognita* race 3, *M. javanica,* and *M. enterolobii*.

MATERIALS AND METHODS

The experiment was carried out in a protected environment in the Sector of Vegetable Crops and Aromatic Medicinal Plants and Plant Pathology Laboratory, Department of Plant Protection, Universidade Estadual Paulista (UNESP), Agricultural and Veterinary Sciences Faculty (FCAV) in Jaboticabal (21°14'05" S, 48°17'09" W; 614 m a.s.l.), São Paulo, Brazil.

We evaluated 24 *Capsicum annuum* L. var. *annuum* accessions from the Embrapa Hortaliças germplasm bank (CNPH 146, CNPH 694, CNPH 696, CNPH 697, CNPH 698, CNPH 701, CNPH 702, CNPH 703, CNPH 705, CNPH 707, CNPH 708, CNPH 709, CNPH 712, CNPH 714, CNPH 717, CNPH 718, CNPH 719, CNPH 723, CNPH 726, CNPH 727, CNPH 728, CNPH 729, CNPH 730, and CNPH 731), hot pepper 'BRS Moema' (*C. chinense* Jacq.), and sweet pepper 'Ikeda' (*C. annuum* L.) Tomato (*Solanum lycopersicum* L.) 'Santa Cruz Kada' was used as a standard of susceptibility and to verify the viability of the inoculum.

The experiment was conducted with a completely randomized design, arranged in a 27 × 3 factorial scheme, and included 26 genotypes of *Capsicum* spp., tomato and three species of root-knot nematodes. Each plot consisted of one plant and six replicates per treatment were performed.

The initial inocula were obtained from subpopulations of *M. incognita* race 3, *M. javanica,* and *M. enterolobii* from the Laboratory of Nematology of the UNESP-FCAV, Campus of Jaboticabal. The morphological characteristics of the perineal pattern (Taylor and Netscher, 1974) and the morphology of the male labial region (Eisenback, 1985) were used to identify the species *M. incognita* race 3 and *M. javanica*. For *M. enterolobii*, the original description of the species was used according to Yang and Eisenback (1983).

The subpopulations were inoculated separately in 'Santa Cruz Kada' tomato and kept in the greenhouse for multiplication and maintenance of the inoculum. Approximately 120 d after inoculation, eggs and second-stage juveniles (J_2) of the nematode species were extracted separately using the methodology described by Hussey and Barker (1973). The egg population and J_2 present in the suspension were estimated with a Peters counting chamber under a photonic microscope. Subsequently, the concentration of this suspension was adjusted to 1000 eggs and second-stage juveniles mL^{-1}.

Seedlings were produced in 128-cell expanded polystyrene trays with commercial substrate (Bioplant, Bioplant Agricola Ltda., Nova Ponte, Minas Gerais, Brazil) and kept in a greenhouse with a sprinkler irrigation system. After 40 d, seedlings were transplanted into 2-L plastic pots containing previously autoclaved (120 °C, 1 atm, 1 h) 1:3:1 soil, sand, and bovine manure mixture. Concomitantly, a 5-mL suspension containing 1000 eggs and second-stage juveniles mL^{-1} in each pot were inoculated with an automatic pipette; the initial population (P_i) was 5000 eggs and J_2.

After 90 d of inoculation, plants were evaluated for nematode response. For this, roots were separated from shoots, washed with water to remove excess adhered mixture, and then weighed on a digital analytical balance. The extraction of *Meloidogyne* species was performed according to Hussey and Barker (1973). The total number of eggs and J_2 (TNEJ) were then quantified by extrapolating the 1 mL count of the suspension into a Peters chamber under a photonic microscope. The TNEJ also corresponded to the final nematode population (P_f). The number of eggs and J_2 per gram of root (NEJGR) was calculated by dividing TNEJ by total root weight.

We used the reproduction factor (RF) and the reproduction index (RI) to verify the resistance of *C. annuum* genotypes to the root-knot nematodes. The RF was determined by dividing the final (P_f) and initial (P_i) population densities: $RF = P_f/P_i$. According to Oostenbrink (1966), plants that exhibited RF < 1 were considered resistant to the nematode and were classified as susceptible when RF ≥ 1.

The value of the reproduction index (RI) was calculated by considering the tomato 'Santa Cruz Kada' as a pattern of susceptibility in relation to nematode reproduction obtained in *Capsicum* genotypes. The formula [100 × (NEJGR mean of each genotype/NEJGR mean of the 'Santa Cruz Kada' tomato cultivar)] was used. According to the criterion established by Taylor (1967), the degree of resistance was classified as susceptible (S) if RI > 50% of the value obtained for the 'Santa Cruz Kada' tomato, slightly resistant (SLR) when RI was between 26% and 50%, moderately resistant (MR) when RI was between 11% and 25%, very resistant (VR) when RI was between 1% and 10% and highly resistant/immune (HR/I) when RI < 1%.

To meet the normality assumptions and error distribution, data were transformed to log (x+5) and then subjected to ANOVA. When significant differences were detected by the F test, these were grouped by the Scott-Knott test at 5% probability. The analyses were performed with the statistical AgroEstat software (Barbosa and Maldonado Júnior, 2015).

RESULTS AND DISCUSSION

The ANOVA detected a significant effect between TNEJ and NEJGR for genotypes of *C. annuum* and the nematode species *M. incognita* race 3, *M. javanica,* and *M. enterolobii*. There was also a significant difference for the interaction between genotypes of *C. annuum* and the species of root-knot nematodes (Table 1).

The 'Santa Cruz Kada' tomato showed high values of TNEJ and NEJGR, differing significantly by the Scott-Knott test ($p < 0.05$) to *C. annuum* genotypes, hot pepper 'BRS Moema', and sweet pepper 'Ikeda' (Tables 2 and 3). The reactions represented by the RF were also considered high for the three species of *Meloidogyne*; they exhibited values > 119.64 (Table 2) and ensured that the environmental conditions made it possible to multiply the inoculum.

The RF classified sweet pepper 'Ikeda' as susceptible to *M. incognita* race 3 and *M. enterolobii* and resistant to *M. javanica* (Table 2). Regarding RI, this cultivar showed a susceptible reaction to *M. incognita* race 3 and *M. enterolobii* and was highly resistant to *M. javanica* (Table 3). Peixoto et al. (1999) also observed a susceptible reaction to *M. incognita* race 3 and resistance to *M. javanica* for 'Ikeda' when evaluating different genotypes of sweet pepper. Bitencourt and Silva (2010), Melo et al. (2011), and Goncalves et al. (2014) also observed susceptibility of 'Ikeda' to *M. enterolobii*.

In studies carried out by Pinheiro et al. (2013a; 2013b), hot pepper 'BRS Moema' was resistant to *M. javanica* and susceptible to *M. incognita* and *M. enterolobii*. The same behavior was detected in the present study.

Except for *M. enterolobii*, the *C. annuum* genotypes differed for TNEJ and NEJGR, indicating the existence of genetic variability among them for resistance to *M. incognita* and *M. javanica* (Tables 2 and 3). For *M. enterolobii*, all genotypes were considered susceptible by the RF and RI. It was also observed that the RF and RI values for *M. enterolobii* were generally higher when compared to the other two species, indicating a greater aggressiveness of this species in the pepper crop. The high reproduction rate of *M. enterolobii* and the wide host range in vegetable crops is reported by Cantu et al. (2009) and Rosa et al. (2015). According to the authors, these factors are evidence of the aggressiveness of the species, which is able to overcome sources of resistance to other root-knot nematodes, such as *M. incognita*, *M. javanica,* and *M. arenaria*.

According to the TNEJ and NEJGR variables for *M. incognita* race 3, the *C. annuum* genotypes CNPH 146, CNPH 698, CNPH 701, CNPH 702, CNPH 717, and CNPH 718 showed the lowest values, and these differed from the other materials (Tables 2 and 3). When the reaction of these genotypes based on the RF and RI was considered, they were classified as resistant and highly resistant, respectively, because their values were < 1. The genotypes CNPH 694, CNPH 703, CNPH 719, CNPH 726, CNPH 728, CNPH 729, and CNPH 730 were considered as very resistant and their RI ranged from 1% to 10%. For the moderately resistant reaction, only CNPH 705, CNPH 727, and CNPH 731 were classified in this group. The other genotypes were slightly resistant or susceptible to *M. incognita* race 3.

Table 1. ANOVA and test of comparison of means of the total number of eggs and second-stage juveniles (TNEJ), reproduction factor (RF), number of eggs and second-stage juveniles per gram of root (NEJGR), reproduction index (RI), and reaction (R) of 25 genotypes of *Capsicum annuum*, one hot pepper cultivar (BRS Moema) and tomato 'Santa Cruz Kada'.

Genotypes (G)	TNEJ	RF	Reaction	NEJGR	RI	Reaction
CNPH 146	91300e	18.26	S	2866.86f	46.32	SLR
CNPH 694	55300d	11.06	S	1658.77d	25.92	SLR
CNPH 696	197900b	39.58	S	4866.36c	65.72	S
CNPH 697	209500c	41.90	S	5733.31c	65.58	S
CNPH 698	147700e	29.54	S	5296.33f	85.90	S
CNPH 701	217700e	43.54	S	3738.21f	60.56	S
CNPH 702	156000e	31.20	S	4218.41f	68.46	S
CNPH 703	201200c	40.24	S	4398.06c	69.85	S
CNPH 705	109900d	21.98	S	2755.69d	36.20	SLR
CNPH 707	219400d	43.88	S	10750.53c	100.43	S
CNPH 708	176900b	35.38	S	6728.64b	70.78	S
CNPH 709	228400b	45.68	S	6922.00b	83.68	S
CNPH 712	180400d	36.08	S	6345.91c	63.73	S
CNPH 714	272900b	54.58	S	9472.37a	104.83	S
CNPH 717	160000e	32.00	S	3113.34f	50.47	S
CNPH 718	72900e	14.58	S	1945.82f	31.38	SLR
CNPH 719	93600b	18.72	S	3054.70b	43.61	S
CNPH 723	207500b	41.50	S	6458.70b	87.33	S
CNPH 726	140000c	28.00	S	4148.70c	65.21	S
CNPH 727	152900d	30.58	S	3239.37d	45.92	SLR
CNPH 728	83800d	16.76	S	2792.32d	42.58	SLR
CNPH 729	108900d	21.78	S	1798.04e	28.30	SLR
CNPH 730	115200c	23.04	S	2639.98c	39.72	SLR
CNPH 731	95600c	19.12	S	2506.96c	34.13	LR
Ikeda	371900c	74.38	S	10830.33c	114.17	S
BRS Moema	268300c	53.66	S	6561.16c	75.18	S
'Santa Cruz Kada'	540900a	108.18	S	9340.61a	100.00	S
F test	19.58**			36.87**		
Nematodes (N)						
Meloidogyne incognita	160544.44b	32.10		5353.66b	35.67	
M. javanica	30477.77c	6.09		771.66c	11.25	
M. enterolobii	350755.56a	70.15		8783.73a	142.63	
F test	370.48**			860.99**		
Interaction (G × N)	11.34**			23.31**		
CV%	17.53			13.32		

Means followed by the same letter in a column do not differ by the Scott-Knott test at 5% probability; means observed with statistics based on transformed data for log (x+5).
S: Susceptible, RI > 51%; SLR: slightly resistant, 26% < RI < 50%; MR: moderately resistant, 11% < RI < 25%; VR: very resistant, 1% < RI < 10%; HR/I: highly resistant or immune, RI < 1; CV%: coefficient of variance.
*, **Significant at the 0.05 and 0.01 probability levels, respectively.

For the reaction to *M. javanica*, 13 (54.16%) of the 24 analyzed *C. annuum* genotypes were considered as resistant and highly resistant based on the RF and RI, respectively (Tables 2 and 3).

Regarding the multiple resistance response to the root-knot nematode species, genotypes CNPH 698, CNPH 701, CNPH 702, CNPH 717, and CNPH 718 were simultaneously classified as resistant and highly resistant to *M. incognita* race 3 and *M. javanica*. However, these genotypes were susceptible to *M. enterolobii* (Tables 2 and 3).

The differences in the responses of the same genotype to *M. incognita*, *M. javanica,* and *M. enterolobii* can be derived from the different specificity of some *Me* pepper genes that confer resistance to the *Meloidogyne* species (Pinheiro et al., 2015). Djian-Caporalino et al. (2006) note that resistance to root-knot nematodes in *C. annuum* is associated with several dominant genes, some of which are specific to certain species or populations (*Me4*, *Mech1,* and *Mech2*) and others are efficient against several *Meloidogyne* species (*Me1*, *Me3,* and *Me7*).

Table 2. Post analysis of the interactions between genotypes and species of root-knot nematodes for total number of eggs and second-stage juveniles (TNEJ).

	Meloidogyne incognita race 3			*M. javanica*			*M. enterolobii*			
Genotypes	TNEJ	RF	Reaction	TNEJ	RF	Reaction	TNEJ	RF	Reaction	F test
CNPH 146	2100dB	0.42	R	900dB	0.18	R	270900aA	54.18	S	45.35^{**}
CNPH 694	5400cC	1.08	S	14700bB	2.94	S	145800aA	29.16	S	14.22^{**}
CNPH 696	127800aA	25.56	S	10200bB	2.04	S	455700aA	91.14	S	8.70^{**}
CNPH 697	303600aA	60.72	S	1800cB	0.36	R	323100aA	64.62	S	23.80^{**}
CNPH 698	600dB	0.12	R	900dB	0.18	R	441600aA	88.32	S	52.65^{**}
CNPH 701	1200dB	0.24	R	1200cB	0.24	R	650700aA	130.14	S	56.44^{**}
CNPH 702	300dB	0.06	R	600dB	0.12	R	467100aA	93.42	S	66.88^{**}
CNPH 703	15000bB	3.00	S	20100bB	4.02	S	568500aA	113.70	S	8.58^{**}
CNPH 705	108300aA	21.66	S	2100cB	0.42	R	219300aA	43.86	S	24.55^{**}
CNPH 707	389700aA	77.94	S	900dB	0.18	R	267600aA	53.52	S	53.37^{**}
CNPH 708	318600aA	63.72	S	29700aB	5.94	S	182400aA	36.48	S	2.92^{ns}
CNPH 709	246600aA	49.32	S	47700aA	9.54	S	390900aA	78.18	S	2.54^{ns}
CNPH 712	317700aA	63.54	S	1200cB	0.24	R	222300aA	44.46	S	39.87^{**}
CNPH 714	367500aA	73.50	S	42000aB	8.40	S	409200aA	81.84	S	3.54*
CNPH 717	600dB	0.12	R	1200cB	0.24	R	478200aA	95.64	S	50.08^{**}
CNPH 718	1800dB	0.36	R	900dB	0.18	R	216000aA	43.20	S	43.21^{**}
CNPH 719	29700bA	5.94	S	66000aA	13.20	S	185100aA	37.02	S	1.71^{ns}
CNPH 723	166200aA	33.24	S	36300aA	7.26	S	420000aA	84.00	S	3.00^{ns}
CNPH 726	5700cB	1.14	S	73200aA	14.64	S	341100aA	68.22	S	14.35^{**}
CNPH 727	77700bA	15.54	S	900dB	0.18	R	380100aA	76.02	S	37.94^{**}
CNPH 728	19800bB	3.96	S	4800bB	0.96	R	226800aA	45.36	S	8.02^{**}
CNPH 729	9300bB	1.86	S	2100cC	0.42	R	315300aA	63.06	S	22.53^{**}
CNPH 730	22800bB	4.56	S	12900bB	2.58	S	309900aA	61.98	S	5.60^{**}
CNPH 731	58200bA	11.64	S	10200bB	2.04	S	218400aA	43.68	S	5.69^{**}
Ikeda	677700aA	135.54	S	1200cB	0.24	R	436800aA	87.36	S	47.56^{**}
BRS Moema	472500aA	94.50	S	3000cB	0.60	R	329400aA	65.88	S	22.07^{**}
'Santa Cruz Kada'	588300aA	117.66	S	436200aA	87.24	S	598200aA	119.64	S	0.09^{ns}
F test	25.07^{**}			16.85^{**}			0.34^{ns}			

The same lower-case letters in a column and uppercase letters in a row do not differ by the Scott-Knott test ($p < 0.05$).
RF: Reproduction factor; R: resistant; S: susceptible.
*, **Significant at the 0.05 and 0.01 probability levels, respectively. ^{ns} :Nonsignificant by F test.

Pinheiro et al. (2013a) report that resistance to *M. enterolobii* is apparently mediated by genes other than those conferring resistance to *M. incognita* and *M. javanica*. Goncalves et al. (2014) verified the inefficiency of the *Me* 7 resistance gene against the action of *M. enterolobii*, which confers resistance to *M. incognita*, *M. arenaria,* and *M. javanica* and is present in the genotype of *C. annuum* CM 334.

Resistance to *M. enterolobii* has been reported in *Capsicum* genotypes by Oliveira et al. (2009). According to the authors, a line of *C. frutescens* was identified with simultaneous resistance to *M. incognita* race 3, *M. javanica,* and *M. enterolobii*; however, it is not yet known which genes are related to the resistance to the three nematode species and it is very important to conduct studies on this subject. Goncalves et al. (2014), evaluating accessions of *Capsicum* spp., identified a *C. chinense* genotype resistant to *M. enterolobii*. The authors also affirm that this genotype is also resistant to *Pepper yellow mosaic virus* (PepYMV), a major pepper virus. However, there are no reports of these genotypes with respect to resistance to *M. incognita* and *M. javanica*.

As for the methodologies used, although both the classifications are based on the RI proposed by Taylor (1967) and the classification based on the RF proposed by Oostenbrink (1966), they efficiently discriminate resistant genotypes. The classification based on the RF is best suited for the selection of resistant individuals because it only takes into account the final and initial nematode populations in each studied genotype and selects them in only two classes of reaction (resistant or susceptible). On the other hand, the classification based on the RI considers the proportion of NEJGR, which involves the highly susceptible control. In the present study, tomato 'Santa Cruz Kada' was used, which is a genus and species different from the species of *Capsicum*. Although they belong to the same family, they provide a wider distribution of classes (HR/I, VR, MR, SLR, and S), allowing greater flexibility and low accuracy in the classification (Gomes et al., 2015; Andrade Júnior et al., 2016).

Table 3. Post analysis of interactions between genotypes and root-knot nematode species for number of eggs and second-stage juveniles per gram of root (NEJGR).

	Meloidogyne incognita race 3			*M. javanica*			*M. enterolobii*			
Genotypes	NEJGR	RI	Reaction	NEJGR	RI	Reaction	NEJGR	RI	Reaction	F test
CNPH 146	67.14fB	0.44	HR	28.84eB	0.42	HR	8504.60aA	138.10	S	89.43**
CNPH 694	194.60eC	1.29	VR	716.19cB	10.44	VR	4065.52aA	66.02	S	27.99**
CNPH 696	4126.26bB	27.49	SLR	228.06cC	3.32	VR	10244.77aA	166.36	S	31.77**
CNPH 697	8612.22aA	57.39	S	56.23dB	0.82	HR	8531.49aA	138.54	S	66.17**
CNPH 698	25.84fB	0.17	HR	34.91eB	0.50	HR	15828.25aA	257.03	S	108.89**
CNPH 701	38.97fB	0.26	HR	22.62eB	0.33	HR	11153.03aA	181.11	S	108.61**
CNPH 702	8.39fB	0.05	HR	19.83eB	0.28	HR	12627.02aA	205.05	S	126.77**
CNPH 703	396.02dB	2.63	VR	549.16cB	8.01	VR	12249.00aA	198.91	S	27.92**
CNPH 705	2666.36bA	17.76	MR	59.94dB	0.87	HR	5540.78aA	89.97	S	54.56**
CNPH 707	23224.18aA	154.76	S	32.08eB	0.46	HR	8995.32aA	146.07	S	112.24**
CNPH 708	11837.91aA	78.88	S	1264.75bB	18.44	MR	7083.25aA	115.02	S	8.89**
CNPH 709	8741.36aA	58.25	S	1486.38bB	21.67	MR	10538.26aA	171.13	S	8.66**
CNPH 712	12311.45aA	82.04	S	34.92eB	0.51	HR	6691.36aA	108.66	S	91.00**
CNPH 714	14982.75aA	99.84	S	2106.43bB	30.71	SLR	11327.92aA	183.95	S	9.51**
CNPH 717	20.32fB	0.13	HR	31.04eB	0.45	HR	9288.67aA	150.83	S	98.83**
CNPH 718	62.72fB	0.41	HR	27.62eB	0.40	HR	5747.11aA	93.32	S	81.45**
CNPH 719	1431.03cB	9.53	VR	2583.04bB	37.66	SLR	5150.02aA	83.63	S	3.41*
CNPH 723	5302.08aA	35.33	SLR	1124.01bB	16.39	MR	12950.01aA	210.29	S	11.21**
CNPH 726	226.45eC	1.51	VR	2587.5bB	37.72	SLR	9632.10aA	156.41	S	36.03**
CNPH 727	2088.14bB	13.91	MR	22.29eC	0.32	HR	7607.69aA	123.54	S	74.98**
CNPH 728	841.71cB	5.61	VR	45.10dC	0.67	HR	7409.13aA	120.31	S	31.04**
CNPH 729	272.14dB	1.81	VR	36.78eC	0.53	HR	5085.20aA	82.57	S	51.70**
CNPH 730	918.45cB	6.12	VR	385.28cB	5.61	VR	6616.20aA	107.43	S	15.90**
CNPH 731	2006.36bA	13.37	MR	308.44cB	4.49	VR	5206.08aA	84.54	S	15.90**
Ikeda	19322.76aA	128.76	S	46.61eB	0.68	HR	13121.62aA	213.08	S	104.26**
BRS Moema	9817.49aA	65.42	S	57.72dB	0.84	HR	9808.28aA	159.27	S	66.47**
'Santa Cruz Kada'	15005.71aA	100.00	S	6858.09aA	100.00	S	6158.04aA	100.00	S	1.58ns
Test F	51.53**			31.10**			0.86ns			

The same lower-case letters in a column and uppercase letters in a row do not differ by the Scott-Knott test ($p < 0.05$).
RI: Reproduction index; S: susceptible, RI > 51%; SLR: slightly resistant, 26% < RI < 50%; MR: moderately resistant, 11% < RI < 25%; VR: very resistant, 1% < RI < 10%; HR/I: highly resistant or immune, RI < 1.
*, **Significant at the 0.05 and 0.01 probability levels, respectively. ns: Nonsignificant by F test.

The characterization of available materials in breeding programs in response to the main pathogens that affect the crop is of extreme importance. However, the use of only genetic resistance to control phytonematodes is not recommended because resistance breakdown has already been reported by high selection pressure (Djian-Caporalino et al., 2011). In this way, management must be integrated and include practices that aim to reduce the nematode population levels (Collange et al., 2011).

CONCLUSIONS

The genotypes of *Capsicum annuum* L. var. *annuum* CNPH 146, CNPH 697, CNPH 708, CNPH 702, CNPH 705, CNPH 707, CNPH 712, CNPH 717, CNPH 718, CNPH 727, CNPH 728, and CNPH 728 are resistant based on the reproduction factor, and highly resistant based on the reproduction index to *Meloidogyne javanica*. For *M. incognita* race 3, six genotypes (CNPH 146, CNPH 698, CNPH 701, CNPH 702, CNPH 717, and CNPH 718) are resistant and/or highly resistant. The genotypes CNPH 698, CNPH 701, CNPH 702, CNPH 717, and CNPH 718 are simultaneously resistant to *M. incognita* race 3 and *M. javanica*. No evaluated *C. annuum* genotype is resistant to *M. enterolobii*.

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