



CROP SCIENCE

First pathogenicity study of *Hippeastrum* sp. cultivars for the root-knot nematode *Meloidogyne enterolobii*

RHAYANE R. PILLAT & CLAUDIO MARCELO G. OLIVEIRA

Abstract: Amaryllis (*Hippeastrum* sp.) is an important ornamental plant, yet information on its interaction with phytonematodes, especially with the aggressive and emerging root-knot nematode *Meloidogyne enterolobii*, remains scarce. This study evaluated, under controlled greenhouse conditions, the reaction of two amaryllis cultivars to *M. enterolobii*. Two experiments were conducted using *Hippeastrum* cv. Red Bull (experiment 1) and *Hippeastrum* cv. Orange Sovereign (experiment 2). Bulbs were inoculated with 0 (control), 10,000, 20,000 and 40,000 eggs and juveniles of *M. enterolobii*. Plant growth parameters, including fresh belowground biomass (FBB), fresh shoot biomass (FSB) and the reproduction factor of *M. enterolobii* (RF) were evaluated. Nematodes failed to establish on either *Hippeastrum* cultivars (RF < 1), indicating that both cultivars behave as inadequate hosts, yet nematode parasitism reduced plant growth parameters. The Red Bull cultivar presented a 30% reduction in FBB when inoculated with a population dose of 40,000 nematodes, exhibiting symptoms of intolerance to high inoculum densities in *M. enterolobii* infections. The Orange Sovereign cultivar, even though it showed a tendency towards a reduction in FBB and FSB, this reduction was not significant, and the plants were classified as resistant. This is the first study reporting the parasitic behavior of *M. enterolobii* in *Hippeastrum* cultivars.

Key words: Amaryllis, Resistance, Intolerance, Ornamental plant, Guava root-knot nematode.

INTRODUCTION

The Brazilian flower and ornamental plant market is an important sector that has been standing out in recent decades. According to the Brazilian Institute of Floriculture and the Center for Advanced Research in Applied Economics, in 2024, the sector grew by 9.9% compared to the previous year, generating approximately R\$21.2 billion (Ibraflor & Cepea 2025). In this context, interest in bulbous flowers of the Amaryllidaceae family has increased, with amaryllis species (*Hippeastrum* spp.) being among the main cut and potted flowers cultivated and sold in Brazil (Tombolato et al. 2010). *Hippeastrum* has a high commercial value, mainly due to

the production being focused on export, with approximately 60% of all production destined for international trade (Tombolato et al. 2010). However, *Hippeastrum* production and its consequent commercialization can be reduced due to the action of various pathogens, such as plant-parasitic nematodes.

Among the plant-parasitic nematodes, root-knot nematodes, belonging to the genus *Meloidogyne*, stand out as some of the most destructive nematodes (Jones et al. 2013). Several species are of interest, however, *Meloidogyne enterolobii* (syn. *M. mayaguensis*) has been gaining prominence. This species has been

reported as an emerging threat in various crops worldwide, currently posing a significant danger to agricultural production (Elling 2013, Santos et al. 2019). Attention to this pathogen is so great that some European countries, such as those constituting the United Kingdom, have regulated *M. enterolobii* as a quarantine pest, while other countries have included it on the alert list of the European and Mediterranean Plant Protection Organization, which recommends the pathogen be regulated as a quarantine pest (EPPO 2025). Considering that the majority of *Hippeastrum* production is exported, the presence of a quarantine pest like *M. enterolobii* could impose severe trade barriers and economic losses for Brazilian producers.

Meloidogyne enterolobii exhibits high pathogenicity and has a wide range of susceptible hosts due to its polyphagous habit, including fruit crops (Carneiro et al. 2001), vegetables (Philbrick et al. 2020) and ornamental plants (Kokalis-Burelle et al. 2017). This plant-parasitic nematode causes significant productivity losses as well as a reduction in product quality, which is an extremely important characteristic when dealing with ornamental plants. Such aggressiveness and polyphagous capacity are factors that must be considered when choosing management techniques for these parasites. In general, genetic resistance, achieved through the identification of resistant cultivars, is an effective and sustainable control strategy aimed at overcoming the problems caused by plant-parasitic nematodes. However, studies have reported the ability of *M. enterolobii* to overcome resistance genes that are typically effective against other *Meloidogyne* species, making the management of this root-knot nematode species more challenging (Kiewnick et al. 2009). Even so, the search for resistant cultivars remains a viable and sustainable alternative for managing

plant-parasitic nematodes, especially in high-value ornamental crops such as *Hippeastrum*.

Even with its extensive and continuous spread across different agricultural crops, to date there are no reports of the interaction between *M. enterolobii* and *Hippeastrum* sp., just as there are no studies that explore the pathogenicity reaction of the nematode in this ornamental crop. Therefore, given the economic importance of *Hippeastrum* in the ornamental plant market and the high pathogenic potential of *M. enterolobii* to various plant species, it is essential to investigate the plant-pathogen interaction, particularly because ornamental crops, despite their smaller cultivated area, represent a disproportionately high phytosanitary risk due to the international trade and movement of bulbs, which can facilitate the spread of nematodes over long distances to previously uninfected areas. Such studies can enhance understanding of the plant's response to nematode infection, identify potential sources of resistance, support gene-level resistance research, and aid in developing effective management strategies for this pathogen across different hosts. Therefore, this study aimed to evaluate, under greenhouse conditions, the response of two *Hippeastrum* cultivars to the nematode *M. enterolobii*.

MATERIALS AND METHODS

Experimental design

Eggs and juveniles of *M. enterolobii* were extracted from roots of bell pepper (*Capsicum annuum*) infected with the pathogen, from the municipality of Campinas, state of São Paulo, using the method of Coolen & D'Herde (1972) with modifications. The roots were carefully washed and crushed in a blender with a 0.25% sodium hypochlorite solution (NaClO). The resulting suspension was passed through overlapping sieves of 20 and 500 mesh, with

the material retained on the 500 mesh sieve being collected. Kaolin was then added, and the suspension was centrifuged for 5 minutes at 1800 rpm, discarding the supernatant. The pellet was resuspended in a sucrose solution (density 1.15) and subjected to another centrifugation for 1 minute at 1800 rpm. The supernatant was then collected on a 500 mesh sieve and taken for microscopic examination. This same inoculum was used in both experiments, being inoculated immediately after extraction.

The response of bulbs from two *Hippeastrum* cultivars, Red Bull and Orange Sovereign, produced in the regions of Mogi Mirim and Casa Branca in the state of São Paulo, respectively, was evaluated. Each *Hippeastrum* cultivar constituted an experiment, resulting in two greenhouse experiments: Experiment 1 - *Hippeastrum* cv. Red Bull and Experiment 2 - *Hippeastrum* cv. Orange Sovereign. The experiments were conducted simultaneously, under similar greenhouse conditions. In each experiment, the experimental design was completely randomized, with four treatments corresponding to four population densities of *M. enterolobii*, each with four replicates, totaling 32 experimental units.

The *Hippeastrum* bulbs, transplanted into 3800 cm³ pots containing commercial substrate Tropstrato®, were inoculated with *M. enterolobii* population densities of 0 (control plants), 10,000, 20,000, and 40,000 eggs and second-stage juveniles (J2) per plant. Inoculation was performed by pipetting the aqueous inoculum suspension into two holes around the base of each plant. Additionally, four pots containing tomato (*Solanum lycopersicum* cv. Dwarf) seedlings, a species known to be susceptible, were simultaneously inoculated with 10,000 *M. enterolobii* specimens to confirm the viability of the inoculum used in the study.

The experiments were evaluated 75 days after inoculation. Firstly, the roots were evaluated in relation to the gall index (Taylor & Sasser 1978), which was established by the following classification scale: 0) root without galls; 1) root with 1-2 galls; 2) root with 3-10 galls; 3) root with 11-30 galls; 4) root with 31-100 galls; and 5) root with more than 100 galls. Roots were processed using the method of Coolen & D'Herde (1972), and the extracted nematodes were quantified on a Peter's counting slide under a Leica light microscope, model DMLS. The vegetative development variables fresh belowground biomass (roots + bulb, FBB) and fresh shoot biomass (FSB) were measured. The final nematode population (FP) was estimated, and the reproduction factor (RF) (Oostenbrink 1966) of the nematode was subsequently calculated using the ratio $RF = FP/IP$ (where IP = initial population).

The effects of *M. enterolobii* parasitism on *Hippeastrum* bulbs were evaluated according to the criteria of Dropkin & Nelson (1960), which propose a classification based on the integration of multiple characteristics of the plant-nematode interaction, and not only on the pathogen's reproduction (Oostenbrink 1966). In this framework, the classification approach distinguishes host suitability related to nematode reproduction (resistance or susceptibility) from vegetative damage caused by the pathogen (tolerance or intolerance). Therefore, we report whether the cultivar is a suitable host for nematode multiplication (RF) and whether plant growth is negatively affected by increasing inoculum densities. The combination of these two dimensions, nematode reproduction factor (RF) and vegetative performance, results in the four host-response categories described by Dropkin & Nelson (1960): susceptible ($RF > 1$ + reduction of plant growth parameters), resistant ($RF < 1$ + there is no reduction in plant

growth parameters), tolerant ($RF > 1$ + there is no reduction in plant growth parameters), or intolerant ($RF < 1$ + reduction of plant growth parameters).

Statistical analysis

The experimental data were tested for normality by the Shapiro & Wilk (1965) test. Subsequently, they were submitted to analysis of variance (ANOVA), with treatment means compared by LSD test ($p < 0.05$), using the Agricolae package in software R v.4.5.0 (R Core Team 2026).

RESULTS

The tomato plants used as indicator plants presented an average final population of 74,941 specimens of *M. enterolobii*, with a high reproduction factor ($RF = 7.5$) and a high index

of root galls (gall index = 5), thus proving the viability of the inoculum used in the experiments (Figure 1).

The mean values of fresh belowground biomass (FBB), fresh shoot biomass (FSB), and total population of *M. enterolobii* specimens present in the roots of the two *Hippeastrum* cultivars studied, 75 days after inoculation, are presented in Table I.

Overall, based on the analysis of the reproductive data obtained in both experiments, it was found that the nematodes did not establish themselves on *Hippeastrum* cv. Red Bull and Orange Sovereign plants, regardless of the initial inoculated population density, demonstrating that *Hippeastrum* is not a suitable reproductive host for *M. enterolobii*. The final population in all treatments, regardless of the cultivar studied, was significantly reduced, always with a RF lower



Figure 1. Tomato plant used as an indicator plant. a) Whole plant; b) Roots displaying numerous root galls.

than one. Furthermore, no root galls, a typical symptom of the species, were observed, with both cultivars having a root gall index = 0 (Figure 2).

For the Red Bull cultivar, no significant differences in FBB were observed between the control and the treatments with initial doses of 10,000 and 20,000 eggs and J2 per plant, indicating that these densities did not compromise the production of fresh belowground biomass. However, plants that received the highest population dose, 40,000 nematodes per plant, showed a significant reduction in FBB compared to the control, corresponding to 30.0%. Similarly, a 30.3% reduction in FSB was observed in plants with a dose of 40,000 nematodes compared to control plants, although this difference was not significant. When associating the vegetative data with the low reproductive values, it was found that the Red Bull cultivar can be

considered resistant up to a certain nematode population density. However, the plants of this cultivar that received the population dose of 40,000 nematodes were classified as intolerant to the pathogen, because even though *M. enterolobii* was unable to reproduce, presenting a RF lower than 1, the phytonematode caused significant damage to the plants, according to the classification method of Dropkin & Nelson (1960).

In the Orange Sovereign cultivar, plants did not show significant differences in FBB and FSB between the control and the treatments inoculated with different population densities. However, although without statistical significance, a downward trend was observed in both FBB and FSB in plants inoculated with *M. enterolobii*, except for FBB in the treatment with 40,000 nematodes. By associating the vegetative data (FBB and FSB) with the reduced

Table I. Average values of the mass (g) of the fresh belowground biomass (FBB), fresh shoot biomass (FSB), and the final population (FP) of *Meloidogyne enterolobii* specimens present in the roots of *Hippeastrum* cultivars Red Bull and Orange Sovereign and nematode reproduction factor (RF), 75 days after inoculation.

Treatments (Initial number of nematodes/plant)	FBB	FSB	FP	RF	Effect of parasitism (Dropkin & Nelson 1960)
Red Bull					
0 (control)	318.7a	231.5ab	0	0.0000	-
10000	348.0a	312.7a	0	0.0000	Resistant
20000	331.8a	241.5ab	3	0.0003	Resistant
40000	223.0b	161.4b	0	0.0000	Intolerant
Orange Sovereign					
0 (control)	294.2a	413.4a	0	0.0000	-
10000	282.0a	306.0a	3	0.0003	Resistant
20000	276.1a	369.4a	0	0.0000	Resistant
40000	360.7a	297.2a	0	0.0000	Resistant
Tomato	17.3	-	74,941	7.5000	Susceptible

RF (less than 1), all treatments were classified as resistant to *M. enterolobii* (Table I).

The reductions caused by the phytonematode in FBB are demonstrated in Figure 2. It is worth noting that, in tomato, RF = 7.5 was obtained, proving the viability of the inoculum.

DISCUSSION

The results of this study demonstrated that the *Hippeastrum* Red Bull and Orange Sovereign cultivars are not good hosts for *M. enterolobii*, exhibiting low nematode reproduction factors, regardless of the initially inoculated population density. The results obtained in this study are from a single experimental cycle and therefore represent initial evidence of the reaction of

Hippeastrum to *M. enterolobii*. Based on these observations, we plan future studies with multiple cycles and different experimental conditions to corroborate the results presented here. From a phytosanitary point of view, these characteristics suggest that bulbs of these cultivars present a lower risk of acting as a source of pathogen dissemination between production areas. On the other hand, the results also show that, although the nematode does not multiply, very high populations can still reduce fresh root biomass, which can compromise the vigor and uniformity of the marketed bulbs. However, it should be noted that this variable includes both roots and bulbs, where, anatomically, the bulb is not part of the root system, and its inclusion may partially mask nematode effects specifically on

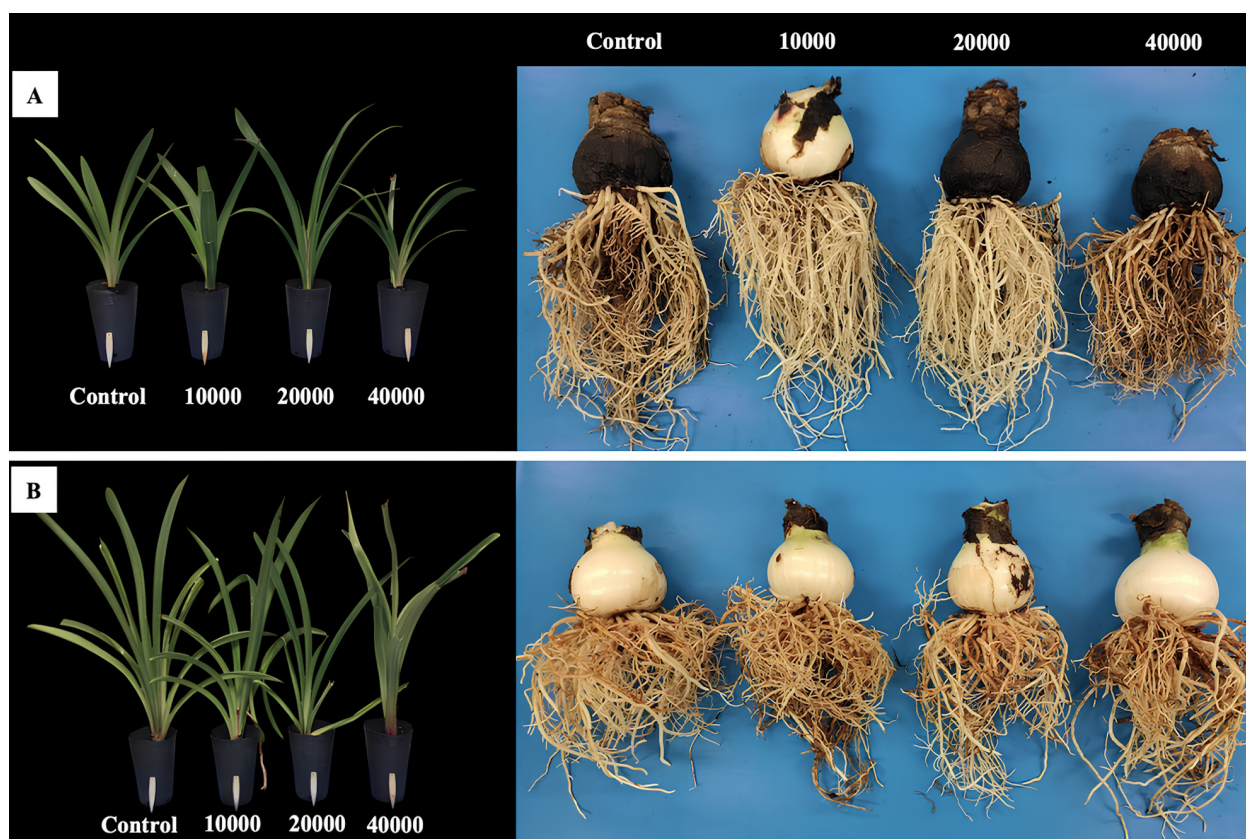


Figure 2. Whole plant and root system (bulbs and roots) of amaryllis cultivars. a) Red Bull, and b) Orange Sovereign inoculated with different population densities of *Meloidogyne enterolobii* specimens (0 - control, 10,000, 20,000 and 40,000 nematodes), 75 days after inoculation.

roots by diluting the magnitude of root biomass reductions. Bulb uniformity is a characteristic of commercial relevance, as it directly influences market value, consumer acceptance, and export viability. This aspect is especially important for the Brazilian *Hippeastrum* sector, which allocates approximately 60% of its production to the external market (Tombolato et al. 2010). Thus, these cultivars show promise for use in areas with a history of *M. enterolobii*, provided they are associated with management strategies that keep nematode populations below the tolerance limits of each cultivar, simultaneously contributing to the commercial quality of *Hippeastrum* bulbs and mitigating the risk of pathogen dissemination.

In general, plant-parasitic nematodes cause severe economic losses to the ornamental plant industry due to the symptoms they induce in infested plants, leading to reduced yield and quality of the product, and often resulting in rejection for export (Howland & Quintanilla 2023).

In recent years, *M. enterolobii* has been increasingly reported worldwide parasitizing a wide range of plant species, including several ornamental plants, such as *Caladium* (Kokalis-Burelle et al. 2017), *Callistemon* sp., *Cereus hildmannianus*, *Lampranthus* sp. (Santos et al. 2019), *Celosia argentea* (Ho et al. 2022), *Euphorbia pulcherrima* (Liang & Chen 2022), *Ixora chinensis* (Fan et al. 2022), and *Antirrhinum majus* (Lu et al. 2023). However, to date, no studies have examined its interaction with *Hippeastrum*. Thus, this is the first study to assess the parasitic behavior of *M. enterolobii* in *Hippeastrum* cultivars.

One possible reason for high adaptive capacity of *M. enterolobii* to different hosts and environmental conditions may be related to its reproductive mechanism. The species reproduces exclusively by mitotic parthenogenesis, a form of

asexual reproduction (apomixis), without male contribution. Consequently, its genetic variation may be environmentally influenced, promoting adaptive evolution. Thus, *M. enterolobii* may exhibit enhanced adaptability to diverse hosts and environments due to epigenetic factors (Castagnone-Sereno 2006, de Oliveira Costa et al. 2025).

Given its emerging status, studying *M. enterolobii* in agricultural crops is extremely important, considering its rapid geographical spread reported in multiple countries, and its broad parasitic ability in diverse crops, including ornamental species. Its rapid dissemination may be associated with the trade of soil and/or seedlings infected by the pathogen (Oliveira & Guerreiro Filho 2022). The sale of certified seedlings is a simple and effective measure to ensure that nematodes such as *M. enterolobii* are not introduced into previously uninfested areas (Monteiro 1982). Climate change may also influence the distribution and abundance of *M. enterolobii*. Modeling studies, developed by Pan et al. (2023), based on climatic, topographic, and soil composition variables, developed to model potential suitable habitats for *M. enterolobii* and predict trends in its distribution and spread, have shown that under future climate scenarios, the pathogen tends to gradually expand into higher-latitude countries. This suggests that ongoing global warming could offer the nematode new opportunities to expand, becoming a potential risk even for currently nematode-free countries (Pan et al. 2023). In this context, once again, the use of nematode-free certified seedlings as a control measure is emphasized.

Another factor contributing to the rapid expansion of *M. enterolobii* is its ability to overcome genetic resistance sources used against other *Meloidogyne* species, such as the *Mi-1* gene in resistant tomato varieties and the *N* gene in resistant bell pepper varieties (Kiewnick

et al. 2009). This characteristic poses major challenges for its control. Therefore, materials resistant or highly tolerant to *M. enterolobii*, like the Red Bull *Hippeastrum* cultivar evaluated in this study, may represent promising candidates for further investigation in breeding programs. However, additional multiple cycles and environments trials are needed to confirm the stability and durability of this response as their resistance-associated genes may be explored and incorporated into the development of cultivars of susceptible crops, with genetic engineering being a useful tool for this purpose. Additionally, resistant cultivars may serve as an alternative for planting in areas already infested with root-knot nematodes.

Host response in *Hippeastrum* has also been evaluated for other nematode species. Similarly to our findings, Sara et al. (unpublished data) reported that *Heterodera glycines* could not reproduce in *Hippeastrum* plants, even at different population densities. However, in the present study, despite its low reproductive rates, *M. enterolobii* caused damage to *Hippeastrum* cv. Red Bull plants, which were classified as intolerant to the pathogen. The intolerance observed in this *Hippeastrum* cultivar at the highest inoculum level (40,000 eggs and J2) is similar to the intolerance reported by Oliveira & Oliveira (2013) in a study evaluating the effect of different initial population densities of *Pratylenchus brachyurus* on lily (*Lilium* sp. cv. Muscadet) plants. As in the present study, the nematode exhibited low reproductive rates ($RF < 1$), but the fresh root biomass of infected lily plants was also reduced (12.4%). Furthermore, the authors used the statistical nonlinear model of Seinhorst (1965), demonstrating that the lily cultivar displayed considerable tolerance to the nematode, being negatively affected only at populations above the limit of 8,500 nematodes. Both the findings of those authors and the

results of the present study show that high initial nematode densities are required to affect amaryllis and lily plants. Additionally, studies with botanically closer hosts of *Hippeastrum* within the order Asparagales, such as that of Wilcken & Ferraz (1997), evaluated different initial inoculum densities of *M. javanica* and *M. incognita* (0, 1,000, 4,000, 16,000 and 64,000) in *Gladiolus* cultivars. The authors observed that only one of the evaluated cultivars showed significant impairment in vegetative growth due to nematode parasitism at the highest inoculum levels. However, unlike what was observed in the present study, in this cultivar the reproduction factor (RF) of both nematodes was high (5.2 - 52.4). These contrasting results demonstrate that different host-pathogen combinations can result in both high reproduction rate associated with reduced vegetative growth, as observed in *Gladiolus*, and damage under low reproduction, as verified here for *Hippeastrum* at high initial densities.

There are also reports of *Hippeastrum* susceptibility to other nematode species. Nong & Weber (1965), in pathogenicity studies of *Pratylenchus scribneri* and *Scutellonema brachyurum* on *Hippeastrum* under greenhouse conditions, observed that both nematode species were pathogenic to the crop, with the inoculation period being a determining factor for symptom expression. Two months after inoculation with *P. scribneri*, *Hippeastrum* roots exhibited lesions, although no symptoms appeared on the foliage. However, after four months, most roots were completely destroyed, and foliage was significantly reduced. In contrast, plants infected with *S. brachyurum* showed reduced root damage even after four months, with only scattered superficial red lesions. These results are similar to the results presented in the present study, considering that both *Hippeastrum* cultivars had reductions in

their vegetative development at 75 days after inoculation with *M. enterolobii*.

Other *Pratylenchus* species have also been reported to damage *Hippeastrum* seedlings. In a study on the reaction of ornamental plants to *Pratylenchus coffeae*, Pinochet & Duarte (1986) showed that *Hippeastrum vittatum* plants initially inoculated with 1,000 nematodes were considered good hosts, with a final population of about 6,637 nematodes after four months. Likewise, *Pratylenchus penetrans* was identified and reported for the first time in Portugal by Rusinque et al. (2020) parasitizing *Hippeastrum* seedlings, which were also considered good hosts of *P. penetrans*. The infected plants showed symptoms ranging from mild to severe, including failure of bulb emergence. Similarly, *Pratylenchus jordanensis* was reported for the first time in Australia by Stirling & Stirling (2002) on bulbs and roots of *Hippeastrum* cv. Donna Marie. Greenhouse and field tests confirmed that the nematode caused significant damage to root development, characterized by discoloration and root rot.

CONCLUSIONS

The increasing spread of *M. enterolobii* represents a significant threat to agricultural production. Therefore, investigating the interaction of this pathogen with different hosts is essential to support its management, particularly in ornamental plants, and to guide phytosanitary policies among countries that trade these plants. The results obtained in this study indicate that the evaluated *Hippeastrum* sp. cultivars are not favorable hosts for *M. enterolobii*, as the nematode did not multiply on the plants, regardless of the inoculated population density. However, at certain population levels, *M. enterolobii* demonstrated the ability to cause damage to the evaluated *Hippeastrum* plants.

Therefore, it is important to emphasize the need for ongoing monitoring of *M. enterolobii* spread and its potential impact on ornamental plants. Since the results presented in this work are based on a single experimental cycle, further studies involving repeated experiments and additional *Hippeastrum* cultivars are needed to confirm the host response classifications, in order to deepen our understanding of the observed resistance.

Acknowledgments

The authors would like to thank Terra Viva and Ecoflora for providing the *Hippeastrum* bulbs used in the study, and FLORTEC for its partnership in developing this research.

REFERENCES

- CARNEIRO RMDG, MOREIRA WA, ALMEIDA MRA & GOMES ACMM. 2001. Primeiro registro de *Meloidogyne mayaguensis* em goiabeira no Brasil. *Nematol Bras* 25: 223-228. Available at: <http://www.alice.cnptia.embrapa.br/alice/handle/doc/134548>.
- CASTAGNONE-SERENO P. 2006. Genetic variability and adaptive evolution in parthenogenetic root-knot nematodes. *Heredity* 96: 282-289. <https://doi.org/10.1038/sj.hdy.6800794>.
- COOLEN WA & D'HERDE CJ. 1972. A method for quantitative extraction of nematodes from plant tissue. Merelbeke: State Nematology Research Station, 77 p.
- DE OLIVEIRA COSTA SN, RIBEIRO JM, DA CUNHA E CASTRO JM & FERNANDES KVS. 2025. Tackling the plant parasitic nematode *Meloidogyne enterolobii*: challenges and strategies for control in relevant crops. *Trop Plant Pathol* 50: 39. <https://doi.org/10.1007/s40858-025-00734-z>.
- DROPKIN HV & NELSON PE. 1960. The histopathology of root-knot nematode infections in soybeans. *Phytopathology* 50: 442-447.
- ELLING AA. 2013. Major emerging problems with minor *Meloidogyne* species. *Phytopathology* 103: 1092-1102. <http://dx.doi.org/10.1094/PHYTO-01-13-0019-RVW>.
- EPPO. 2025. EPPO global database, electronic resource. Available at: <https://gd.eppo.int/taxon/MELGMY/categorization>. Accessed on: June 14, 2025.

- FAN W, ZHOU Y, ZHAO W, YANG X, XIAO S & LIU G. 2022. First report of *Meloidogyne enterolobii* infecting *Ixora chinensis* in China. Plant Dis 106: 2270. <https://doi.org/10.1094/PDIS-11-21-2602-PDN>.
- HO JT, LIANG CC & CHEN PJ. 2022. First report of root-knot nematode *Meloidogyne enterolobii* on cockscomb (*Celosia argentea* var. *cristata*) in Taiwan. Plant Dis 106: 2000. <https://doi.org/10.1094/PDIS-10-21-2126-PDN>.
- HOWLAND AD & QUINTANILLA M. 2023. Plant-parasitic nematodes and their effects on ornamental plants: a review. J Nematol 55: 20230007. <https://doi.org/10.2478/jofnem-2023-0007>.
- IBRAFLOR & CEPEA – INSTITUTO BRASILEIRO DE FLORICULTURA & CENTRO DE ESTUDOS AVANÇADOS EM ECONOMIA APLICADA. 2025. Diagnóstico do setor ornamental do Brasil 2024, electronic resource. Available at: <https://www.ibraflor.com.br/n%C3%BAmoros-do-setor-c%C3%B3pia>. Accessed on: June 15, 2025.
- JONES JT ET AL. 2013. Top 10 plant-parasitic nematodes in molecular plant pathology. Mol Plant Pathol 14: 946-961. <https://doi.org/10.1111/mpp.12057>.
- KIEWNICK S, DESSIMOZ M & FRANCK L. 2009. Effects of the Mi-1 and the N root-knot nematode-resistance gene on infection and reproduction of *Meloidogyne enterolobii* on tomato and pepper cultivars. J Nematol 41: 134-139.
- KOKALIS-BURELLEN, BRITO J & HARTMAN RD. 2017. Susceptibility of seven Caladium (*Caladium × hortulanum*) cultivars to *Meloidogyne arenaria*, *M. enterolobii*, *M. floridensis*, *M. incognita*, and *M. javanica*. J Nematol 49: 457-461.
- LIANG CC & CHEN PJ. 2022. First report of root-knot nematode *Meloidogyne enterolobii* on poinsettia “Luv U Pink” in Taiwan. Plant Dis 106: 1764. <https://doi.org/10.1094/PDIS-09-21-1899-PDN>.
- LU XH, SOLANGI GS, HUANG JL, LIU ZM & QIN LP. 2023. First report of root-knot nematode *Meloidogyne enterolobii* on *Antirrhinum majus* in China. Plant Dis 107: 2555. <https://doi.org/10.1094/PDIS-02-23-0282-PDN>.
- MONTEIRO AR. 1982. Não se deve plantar nematoides. Publicação da Sociedade Brasileira de Nematologia 5: 13-23. Available at: <http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=PASCALZOO LINEINRA82X0318380>.
- NONG L & WEBER GF. 1965. Pathological effects of *Pratylenchus scribneri* and *Scutellonema brachyurum* on Amaryllis. Phytopathology 55: 228-230.
- OLIVEIRA CMG & GUERREIRO FILHO O. 2022. “Não se deve plantar nematoides” – produção de mudas de café de alta qualidade agrônômica e sanitária. Revista Cultivar Grande Culturas 283: 12-14.
- OLIVEIRA SA & OLIVEIRA CMG. 2013. Efeito de diferentes densidades populacionais iniciais de *Pratylenchus brachyurus* no desenvolvimento de plantas de lírio. Nematol Bras 37: 48-52. Available at: <https://journals.flvc.org/nematropica/article/view/64251/0>.
- OOSTENBRINK M. 1966. Major characteristics of the relation between nematodes and plants. Meded Landbouwhogeschool 66: 1-46.
- PAN S, PENG D-L, LI Y-M, CHEN Z-J, ZHAI Y-Y, LIU C & HONG B. 2023. Potential global distribution of the guava root-knot nematode *Meloidogyne enterolobii* under different climate change scenarios using MaxEnt ecological niche modeling. J Integr Agric 22: 2138-2150. <https://doi.org/10.1016/j.jia.2023.06.022>.
- PHILBRICK AN, ADHIKARI TB, LOUWS FJ & GORNY AM. 2020. *Meloidogyne enterolobii*, a major threat to tomato production: current status and future prospects for its management. Front Plant Sci 11: 606395. <https://doi.org/10.3389/fpls.2020.606395>.
- PINOCHET J & DUARTE O. 1986. Additional list of ornamental foliage plants host of the lesion nematode *Pratylenchus coffeae*. Nematropica 16: 11-19. Available at: <https://journals.flvc.org/nematropica/article/view/63870>.
- R CORE TEAM. 2026. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna. Available at: <https://www.r-project.org/>. Accessed on: March 02, 2026.
- RUSINQUE LC, VICENTE CS, INÁCIO ML, NÓBREGA F, CAMACHO MJ, LIMA A & RAMOS AP. 2020. First report of *Pratylenchus penetrans* associated with amaryllis (*Hippeastrum × hybridum*) in Portugal. Plant Dis 104: 2740. <https://doi.org/10.1094/PDIS-03-20-0524-PDN>.
- SANTOS D, ABRANTES I & MALEITA C. 2019. The quarantine root-knot nematode *Meloidogyne enterolobii* – a potential threat to Portugal and Europe. Plant Pathol 68: 1607-1615. <https://doi.org/10.1111/ppa.13079>.
- SEINHORST JW. 1965. The relation between nematode density and damage to plants. Nematologica 11: 137-154. <https://doi.org/10.1163/187529265X00582>.
- SHAPIRO SS & WILK MB. 1965. An analysis of variance test for normality (complete samples). Biometrika 52: 591-611. <https://doi.org/10.1093/biomet/52.3-4.591>.
- STIRLING AM & STIRLING GR. 2002. Root rot of *Hippeastrum* sp. caused by lesion nematode (*Pratylenchus jordanensis*). Australas Plant Pathol 31: 427. <https://doi.org/10.1071/AP02052>.

TAYLOR AL & SASSER JN. 1978. Biology, identification and control of root-knot nematodes (*Meloidogyne* species). Raleigh: Department of Plant Pathology, North Carolina State University and the United States Agency for International Development, 111 p.

TOMBOLATO AFC, UZZO RP, JUNQUEIRA AH, PEETZ MS, STANCATO GC & ALEXANDRE MA. 2010. Bulbosas

ornamentais no Brasil. Ornamental Hortic 16: 127-138. <https://doi.org/10.14295/rbho.v16i2.553>.

WILCKEN SR & FERRAZ LCC. 1997. Danos causados por *Meloidogyne incognita* raça 2 e *M. javanica* a diferentes cultivares de gladiolo. Nematol Bras 21: 59-66.

RHAYANE R. PILLAT¹

<https://orcid.org/0000-0003-2387-8636>

CLAUDIO MARCELO G. OLIVEIRA²

<https://orcid.org/0000-0002-1677-6853>

¹Universidade Estadual de Campinas, Departamento de Fisiologia Vegetal, Rua Monteiro Lobato, 255, Cidade Universitária, 13083-862 Campinas, SP, Brazil

²Instituto Biológico, Laboratório de Nematologia, Alameda dos Vidoeiros, 1097, Sítios de Recreio Gramado, 13101-680 Campinas, SP, Brazil

Correspondence to: **Rhayane Resende Pillat**

E-mail: rhayane_pillat@hotmail.com

Author contributions

Rhayane R. Pillat: Have made substantial contributions to conceptualization and design, investigation, formal analysis of data and writing original draft, review and editing this manuscript. Claudio Marcelo G. Oliveira: Have made substantial contributions to conceptualization and design, formal analysis of data, supervision and writing original draft, review and editing this manuscript.

How to cite

PILLAT RR & OLIVEIRA CMG. 2026. First pathogenicity study of *Hippeastrum* sp. cultivars for the root-knot nematode *Meloidogyne enterolobii*. An Acad Bras Cienc 98: e20251132. DOI 10.1590/0001-3765202620251132.

Manuscript received on October 17, 2025;
accepted for publication on March 25, 2026

Handling editor

Pablo Bolaños-Villegas

Data availability

All data generated or analyzed during this study are available in this manuscript and additional information can be further made available upon request to the corresponding author.

