International Journal of Economic Plants

https://ojs.pphouse.org/index.php/IJEP

Crossref

IJEP March 2025, 12(2): 01-06

Article IJEP5993a

Full Research

Stress Management

Doi: HTTPS://DOI.ORG/10.23910/2/2025.5993a

Effect of Root-knot Nematodes (*Meloidogyne incognita* and *M. enterolobii*) on Root and Shoot Biomass of *Psidium cattleianum* and Interspecific Hybrid Progenies of Guava

Ajay Kumar[1*], R. Umamaheswari[2] and C. Vasugi[1]

[1]Division of Fruit Crops, [2]Division of Crop Protection, ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka, (560 089), India

Corresponding Author

Ajay Kumar
e-mail: ajayaadihorti@gmail.com

Article History

Received on 14th December, 2024
Received in revised form on 05th March, 2025
Accepted in final form on 18th March, 2025
Published on 24th March, 2025

Abstract

The present experiment was conducted in the Division of Crop Protection at the ICAR-Indian Institute of Horticultural Research, Bengaluru (Karnataka), India during 2022–2023 for nine months to investigate the effect of root-knot nematodes (*M. incognita* and *M. enterolobii*) on the biomass of resistant wild parent *P. cattleianum*, common guava; *P. guajava* and the interspecific hybrid progenies. Results revealed significant variations in the growth of shoot and root parameters among the parents and hybrid progenies. Reduction in shoot and root weight was recorded in all the susceptible plants whereas, the resistant species recorded increased growth parameters of both shoot and root. In the susceptible plants inoculated with *M. enterolobii* a drastic reduction in shoot weight, root weight and root length were observed. However, in the resistant wild species (*P. cattleianum* var. *cattleianum* and *P. cattleianum* var, *lucidum*) the growth of shoot and root was increased as normal. In contrast, it was noticed that the root length was decreased in susceptible plants inoculated with *M. enterolobii* due to decomposition and deterioration of roots over three to nine months whereas, resistant wild species did not express these kinds of symptoms. Based on the shoot and root growth parameters, this study confirms that *M. enterolobii* is a more dangerous, devastating and virulent species compared to *M. incognita.* This indicates that these resistant species have the potential to exploit their resistance in guava breeding, especially the development of resistant varieties.

Keywords: Root-knot nematodes, *P. cattleianum*, interspecific hybrids

1. Introduction

Guava (*Psidium guajava* L.) is one of the most economically important fruit crops in India and in the world. It is called “poor man’s apple” and “the apple of the tropics” due to its round-the-year availability and affordability. India is the largest producer of guava with an area of 287-thousand-hectare area of guava producing 4304 thousand metric tonnes of guava. In terms of productivity, Brazil leads with 17.9 tons per hectare (Anonymous, 2021). Guava is well known for its pleasant flavour, sweetness, delicious taste, and great nutritional value. Fruits are a very good source of vitamins, minerals, and nutrients. It contains 241 mg/100 g ascorbic acid, 12.2% carbohydrates, 2.3% protein, 4.8% fibre, 0.24 mg/100 g iron, 0.22 mg/100 g zinc, and 17.63 mg/100 g calcium. It is a good source of energy which produces 68 calories per 100 g of fresh fruits and also a rich source of pectin (0.5–1.9%) (Naseer et al., 2018; Kumar et al., 2021; Jaglan et al., 2022).

The production of guavas is decreasing due to the disease complex caused by root-knot nematodes (RKNs) *Meloidogyne species* and *Fusarium oxysporum* f.sp. *psidii*. RKNs predispose guava roots to this fungus, which makes it more virulent and devastating (Gomes et al., 2014; Shukla et al., 2017; Singh, 2020). It is a plant-parasitic and polyphagous nematode, mainly attacking woody plants (Gomes et al., 2008; Pommer, 2012; Carneiro et al., 2012). It is comparatively more virulent and results in crop loss of up to 65% which is greater than any other RKN species in guava (Carneiro et al., 2012; Khan et al., 2022). It is widely acknowledged that *M. enterolobii* is a common and economically important disease that affects a variety of crops, especially guava in tropical nations (Rodriguez et al., 2003; Silva et al., 2008; Iwahori et al., 2009; Gomes et al., 2012; Poornima et al., 2016; Silva and Santos, 2017; Singh, 2020; Collet et al., 2021). In India, the first report of *M. enterolobii* came from Tamil Nadu in 2016 (Poornima et al., 2016). Now, it is reported from 11 states including Rajasthan, Madhya Pradesh, Uttar Pradesh, and Uttarakhand (Poornima and Walia, 2021; Singh, 2020). RKNs are rapidly threatening guava productivity because they cause severe damage to the root system, resulting in lower water and nutrient absorption. Ultimately, this impacts the guava plant's growth and yield (Vishwakarma et al., 2023; Miranda et al., 2012; Freitas et al., 2014).

Although nematodes are managed using chemicals, farmers are not usually drawn to use them because of the high cost and potentially harmful side effects. One of the safe, practical, and environmentally friendly alternatives for managing root-knot nematodes is the use of nematode-resistant cultivars. Interspecific hybridization in guava has been presented as a viable strategy for enhancing resistance to RKNs. However, not much research has been carried out on how these nematodes affect the biomass of the roots and shoots of interspecific hybrids and their parents. Understanding these interactions is crucial for developing resistant cultivars with higher yields. Keeping this in mind, this study aimed to investigate the changes in root and shoot biomass of plants infected with RKNs (*M. incognita* and *M. enterolobii*).

2. Materials and Methods

The present experiment was carried out in a glasshouse at the Division of Crop Protection of ICAR-Indian Institute Horticultural Research, Bengaluru, Karnataka (India) during 2022–23 for nine months. Four months old seedlings of interspecific hybrid progenies (Arka Poorna×*Psidium cattleianum* var. *cattleianum*), *P. guajava P. cattleianum* var. *cattleianum* and *P. cattleianum* var. *lucidum* were subjected to challenge inoculation with *M. incognita* and *M. enterolobii.* The seedlings were raised in black polythene covers that could hold one kg of sterilized soil. A total of 650 plants consisting of both parents and hybrid progenies were subjected to screening as described by Coyne and Ross (2014). The culture of *M. incognita* and *M. enterolobii* was obtained from susceptible tomato plants. Egg masses were handpicked and kept for hatching on a wire mess that was blotted with filter paper in a Petri plate containing water. The hatched-out juveniles (J2) were collected in a beaker and homogenised the suspension culture by stirring it. Further, J2 was quantified in the suspension culture under the microscope, and then J2 was inoculated in the root zone of the plants @ 1000 J2 plant^{-1}.

The 300 interspecific hybrid progenies were used for inoculation with *M. incognita* while 200 for *M. enterolobii.* 30 plants from each *Psidium species* were used for inoculation with *M. incognita* and *M. enterolobii*. The observations *viz.,* shoot length (cm), root length (cm), shoot weight (g) and root weight (g) were recorded at 3 months, 6 months and 9 months after challenge inoculation with *M. incognita* and *M. enterolobii*.

3. Results and Discussion

Results revealed that the maximum shoot length was observed in *P. cattleianum* var. *cattleianum* (36.43 cm, 42.56 cm, and 48.72 cm, respectively) at 3, 6 and 9 months of challenge inoculation with *M.* incognita. The shoot length ranged from 32.79–7.38 cm for *P. guajava* and 34.82 to 40.24 cm for interspecific hybrid progenies (Figure 1). Root length was also recorded maximum for *P. cattleianum* var. *cattleianum* (30.36 cm, 34.21 cm, and 39.74 cm, respectively) at 3, 6, and 9 months after inoculation whereas, it varied from 28.43–32.13 cm for *P. guajava* and 23.79–28.24 cm for interspecific hybrid progenies (Figure 1).

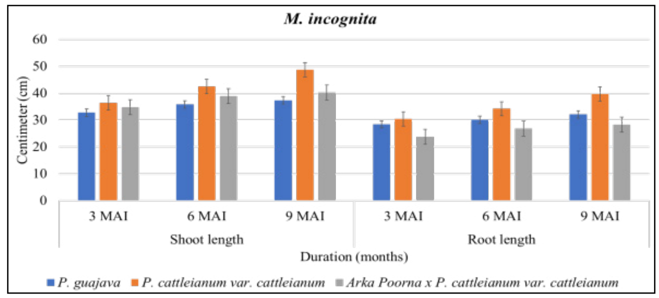

Figure 1: Effect of *M. incognita* on shoot and root length of interspecific hybrid (susceptible) and their parents

In *M. incognita* inoculated plants, the root weight was varied from 14.81–10.69 g for *P. guajava,* 10.32–15.53 g for *P. cattleianum* var. *cattleianum* and 12.40–9.37 g for an interspecific hybrid from 3 months to 9 months of period to inoculation (Figure 2). Shoot weight was observed to be varied from 22.78–14.21 g in *P. guajava,* 18.98–36.67 g in *P. cattleianum* var. *cattleianum*, and 16.34–6.82 g in interspecific hybrid on a period of 3 months to 9 months of inoculation (Figure 2).

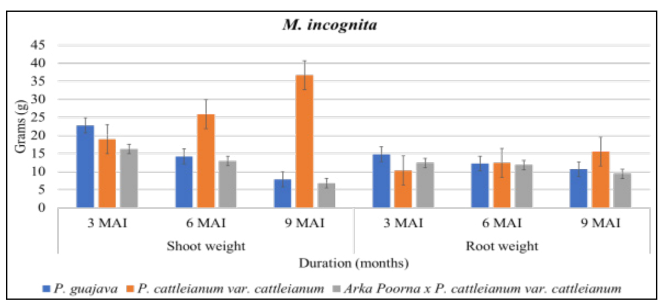

Figure 2: Effect of *M. incognita* on shoot and root weight of interspecific hybrid (susceptible) and their parents

The plants inoculated with *M. enterolobii* showed that shoot length range from 33.08–36.24 cm in *P. guajava*, 30.68–42.92 cm in *P. cattleianum* var. *cattleianum,* and 32.91–47.44 cm in *P. cattleianum* var. *lucidum,* whereas, in interspecific hybrids, it was ranged from 34.87–38.72 cm over a period from 3 months to 9 months after inoculation (Figure 3). The root length was observed in *P. guajava* (12.92–5.96 cm), *P. cattleianum* var. *cattleianum* (26.82–34.79 cm) *P. cattleianum* var. *lucidum* (28.91 to 38.94 cm) and in interspecific hybrids it was observed 31.48–18.38 cm period of 3 months to 9 months of inoculation (Figure 2). Root weight and shoot

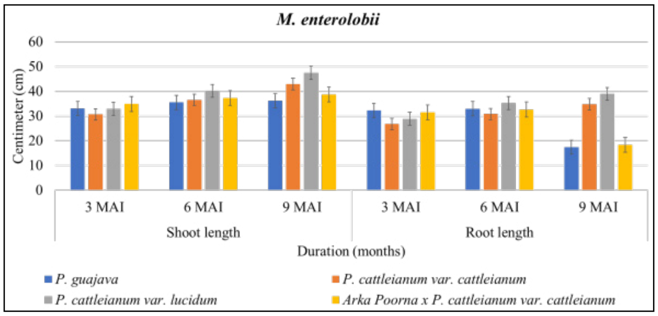

Figure 3: Effect of *M. enterolobii* on shoot and root length of Psidium species and interspecific hybrid (susceptible)

weight was also recorded in a similar way of *M. incognita.* The variation was observed in shoot weight for *P. cattleianum* var. *cattleianum* and *P. cattleianum* var. *lucidum* (14.31–30.40 g and 15.64–34.93 g, respectively), *P. guajava* (20.59–5.24 g) and interspecific hybrids (17.29–6.69 g) whereas, root weight was varied from 10.13 to 16.21 g in *P. cattleianum* var. *cattleianum,* 10.87 to 18.02 g in *P. cattleianum* var. *lucidum,* 12.92–5.96 g in *P. guajava* and interspecific hybrid, it was observed from 10.86–6.48 g over 3 months to 9 months of challenge inoculation (Figure 4). Infected plants suffer from a lack of nutrients, photosynthates, energy, and water, which impedes the formation and expansion of leaf tissues and their important elements, notably chlorophyll pigments. The increase of biomass above ground (shot weight and shoot length) was consequently inhibited by the infection in the roots of susceptible plants (*P. guajava* and interspecific hybrids). However, it was noticed that growth was not inhibited by nematode infection in resistant plants (*P. cattleianum* var. *cattleianum* and *P. cattleianum* var. *lucidum*). These findings were closely aligned with the findings of Vishwakarma et al. (2023).

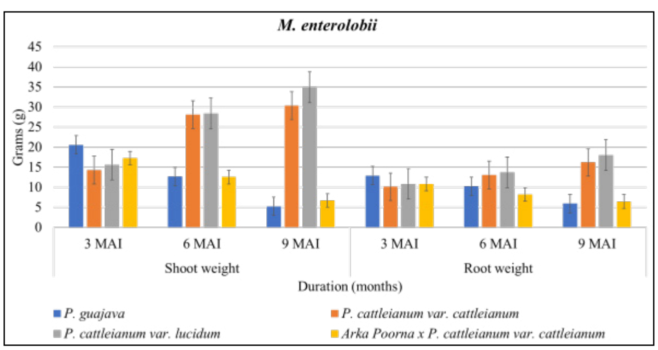

Figure 4: Effect of *M. enterolobii* on shoot and root weight of *Psidium* species and interspecific hybrid (susceptible)

In the current study, variation was detected in the plant biomass (shoot length, shoot weight, root length, and root weight) of *Psidium species* and hybrid progenies from 3 to 9 months after challenge inoculation with *M. incognita* and *M. enterolobii.* Percentage of changes in shoot length, root length, shoot weight and root weight over 3 months to 9 months after challenge inoculation with *M. incognita* and *M. enterolobii.* In this study, *M. enterolobii* was found to be a more devastating, dangerous and virulent species compared to *M. incognita.* Results revealed an increasing trend in shoot length and root length for all inoculated plants (Table 1). However, shoot weight and root weight increased in *P. cattleianum* var. *cattleianum* (93.20% and 50.48%, respectively), while a reduction in shoot and root weight was observed in *P. guajava* (-65.41% and -27.82%, respectively) and the interspecific hybrid (-58.00% and -24.44%, respectively) inoculated with *M. incognita* (Table 1). A higher percentage of the increasing shoot and root length was observed in *P. cattleianum* var. *cattleianum* (33.74% and 50.48%, respectively) whereas, in *P. guajava* it was very low (14.00% and 13.01%, respectively). In plants inoculated with *M. enterolobii, an* increase in shoot length was observed in all the inoculated plants. The highest percentage increase was recorded for *P. cattleianum* var. lucidum and *P. cattleianum* var. *cattleianum* (44.15% and 39.90%, respectively), while the lowest was observed for *P. guajava* and interspecific hybrids (9.55% and 11.04%, respectively) (Table 2). Root length, shoot and root weight were observed to increase for *P. cattleianum* var. *cattleianum* (29.72%, 112.44%, and 60.02%, respectively) and *P. cattleianum* var. *lucidum* (34.70%, 123.33%, and 65.78%, respectively). However, there were observed reductions in *P. guajava* (-46.0%, -74.56%, and -53.87%, respectively) and interspecific hybrids (41.61%, 61.30% and 40.33%, respectively). Root-knot nematode females promote gall development after entering the roots, resulting in severe disruption of xylem tissues. The upward transport of water and nutrients is significantly reduced as a result of substantial xylem channel damage. It also has a significant effect on root permeability to water. Female root-knot nematodes induce nurse cell networks for constant feeding in infected roots, resulting in increased transfer of photosynthates to these infection sites, whereas the aboveground parts experience acute nutritional deprivation (Di Vito et al., 2004). This study demonstrates that root-knot nematode infection did not affect growth metrics in resistant species (*P. cattleianum* var. *cattleianum* and *P. cattleianum*

Table 1: Effect of *M. incognita* on the increment of shoot and root biomass of *Psidium* species and interspecific hybrid

Psidium species and hybrid	Per cent increment (%)			
	Shoot length (cm)	Shoot weight (g)	Root length (cm)	Root weight (g)
P. guajava	14.00	-65.41	13.01	-27.82
P. cattleianum var. *cattleianum*	33.74	93.20	30.90	50.48
Arka poorna×*P. cattleianum* var. *cattleianum*	15.57	-58.00	18.71	-24.44

Table 2: Effect of *M. enterolobii* on the increment of shoot and root biomass of *Psidium* species and interspecific hybrid

Psidium species and hybrid	Per cent increment			
	Shoot length (cm)	Shoot weight (g)	Root length (cm)	Root weight (g)
P. guajava	9.55	-74.56	-46.00	-53.87
P. cattleianum var. *cattleianum*	39.90	112.44	29.72	60.02
P. cattleianum var. *lucidum*	44.15	123.33	34.70	65.78
Arka poorna×*P. cattleianum* var. *cattleianum*	11.04	-61.30	-41.61	-40.33

var. *lucidum*), possibly due to the inhibitory impact of root exudates (Li et al., 2018; Forghani and Hajihassani, 2020). The root exudate of *P. cattleianum* var. *cattleianum* and *P. cattleianum* var. *lucidum* may have nematicidal properties due to their resistance to *M. incognita* and *M. enterolobii* (Carneiro et al., 2007, 2012; Miranda, 2012; Freitas et al., 2014; Biazatti et al., 2016; Chiamolera et al., 2018) (Figure 5).

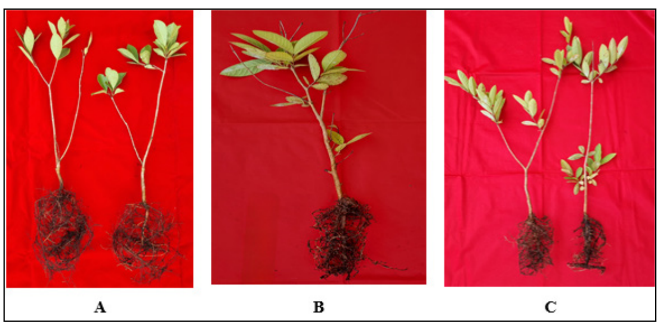

Figure 5: Plants are inoculated with *M. incognita* after 9 months of challenge inoculation. A: *P. cattleianum* var. *cattleianum*, B: *P. guajava* and C: interspecific hybrid (Arka Poorna×*P. cattleianum* var. *cattleianum*)

In the present study, the root length decreased in susceptible plants inoculated with *M. enterolobii.* It might be due to the decomposition, decaying and rotting of roots in susceptible plants inoculated with *M. enterolobii*. At the same time, symptoms were not noticed in the roots of resistant wild (*P. cattleianum* var. *cattleianum* and *P. cattleianum* var. *lucidum*) parents inoculated with *M. incognita.* It could be due to the nematicidal effect of root exudates on RKNs. This indicates that these species have the potential to exploit their resistance in guava breeding, especially the development of resistant varieties. After 9 months of inoculation with the root-knot nematodes (*M. incognita* and *M. enterolobii*), there was a decrease in shoot weight and root weight and a very slight increase in shoot length in the susceptible plants (*P. guajava* and interspecific hybrids). Due to the formation of heavy galls on the roots, susceptible plants have reduced root and shoot weight. This is linked to impaired water and nutrient supply to the shoot system, which in turn causes a reduction in photosynthetic rate, stomatal conductance, ion uptake, pigment synthesis, photolysis, and the induction of stunting, wilting, yellowing, and chlorosis of leaves (Grundler and Hofmann, 2011). After root-knot nematode infection, susceptible genotypes of guava (Gomes et al., 2012; Ashokkumar et al., 2014), olive cv. 'Zard' (Afshar et al., 2014), pomegranate (Poornima, 2020), and cucumber (Mukhtar and Kayani, 2019; El-Eslamboly et al., 2019) showed a reduction in plant growth parameters (shoot length, shoot weight, root length, and root weight).

Figure 6: Plants are inoculated with *M. enterolobii* after 9 months of challenge inoculation. A: *P. cattleianum* var. *cattleianum*, B: *P. cattleianum* var. *lucidum*, C: *P. guajava*, D: Interspecific hybrid (Arka Poorna×*P. cattleianum* var. *cattleianum*)

4. Conclusion

Root-knot nematodes had a great impact on susceptible interspecific hybrid progenies and *P. guajava* seedlings while resistant species *i.e. P. cattleianum* var. *cattleianum* and *P. cattleianum* var. *lucidum* did not express any symptoms. The reduction in root and shoot biomass of susceptible plants was observed but contrastingly, the root and shoot biomass was observed to be in increasing trend throughout inoculation time in resistant species.

5. Future Thrust

The present study confirmed that *P. cattleianum* var. *cattleianum* and *P. cattleianum* var. *lucidum* were resistant to *M. incognita* and *M. enterolobii,* whose growth was not affected by the RKNs. These resistant species can be utilized effectively in crop improvement programs of guava to develop resistant cultivars.

6. References

Afshar, J., Sasanelli, N., Hosseininejad, S.A., Tanha, M.Z., 2014. Effects of the root knot nematodes Meloidogyne incognita and M. javanica on olive plants growth in glasshouse conditions. Helminthologia 51(1), 46–52.

Anonymous, 2021. Statistics Division of Food and Agriculture Organization of the United Nations. FAOSTAT. http://www.fao.org/faostat/en/#data/QC. Accessed on 10th

December 2024

Ashokkumar, N., Poornima, K., Kalaiarasan, P., Kavino, M., 2019. Screening and histological characterization of guava (*Psidium guajava* L.) cultivars against root knot nematode, Meloidogyne enterolobii. Pest Management in Horticultural Ecosystems 25(1), 84–92.

Biazatti, M.A., Souza, R.M.D., Marinho, C.S., Guilherme, D.D.O., Campos, G.S., Gomes, V.M., Bremenkamp, C.A., 2016. Resistência de genótipos de araçazeiros a Meloidogyne enterolobii. Ciência Rural 46, 418–420.

Carneiro, R.M., Cirotto, P.A., Quintanilha, A.P., Silva, D.B., Carneiro, R.G., 2007. Resistance to Meloidogyne mayaguensis in Psidium spp. accessions and their grafting compatibility with *P. guajava* cv. Paluma. Fitopatologia Brasileira 32, 281–284.

Carneiro, R.M.D.G., De Freitas, V.M., Mattos, J.K., Castro, J.M.C., Gomes, C.B., Carneiro, R.G., 2012. Major guava nematodes and control prospects using resistance on *Psidium spp.* and non-host crops. In: Proceedings of the III International Symposium on Guava and other Myrtaceae. ISHS Acta Horticulturae 959, 41–49.

Chiamolera, F.M., Martins, A.B.G., Soares, P.L.M., Cunha-Chiamolera, T.P.L.D., 2018. Reaction of potential guava rootstocks to Meloidogyne enterolobii. Revista Ceres 65, 291–295.

Collett, R.L., Marais, M., Daneel, M., Rashidifard, M., Fourie, H., 2021. Meloidogyne enterolobii, a threat to crop production with particular reference to sub-Saharan Africa: an extensive, critical and updated review. Nematology 23(3), 247–285.

Coyne, D.L., Ross, J.L., 2014. Protocol for nematode resistance screening: Root knot nematodes, *Meloidogyne* spp. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, p. 27.

de Oliveira Costa, S.N., e Silva, M.V.T., Ribeiro, J.M., e Castro, J.M.D.C., Muzitano, M.F., da Costa, R.G., Oliveira, A.E.A., Fernandes, K.V.S., 2023. Secondary metabolites related to the resistance of *Psidium* spp. against the nematode *Meloidogyne enterolobii.* Heliyon 9(7).

Di Vito, M., Vovlas, N., Castillo, P., 2004. Host-parasite relationships of *Meloidogyne incognita* on spinach. Plant Pathology 53(4), 508–514.

El-Eslamboly, A., El-Wanis, A., Mona, M., Amin, A.W., 2019. Algal application as a biological control method of root-knot nematode Meloidogyne incognita on cucumber under protected culture conditions and its impact on yield and fruit quality. Egyptian Journal of Biological Pest Control 29(1), 1–9.

Freitas, V.M., Correa, V.R., Motta, F.C., Sousa, M.G., Gomes, A.C.M., Carneiro, M.D.G., Carneiro, R.M.D.G., 2014. Resistant accessions of wild *Psidium* spp. to *Meloidogyne enterolobii* and histological characterization of resistance. Plant Pathology 63(4), 738–746.

Gomes, V.M., Ribeiro, R.M., Viana, A.P., de Souza, R.M., Santos, E.A., Rodrigues, D.L., de Almeida, O.F., 2017. Inheritance of resistance to Meloidogyne enterolobii and individual selection in segregating populations of *Psidium* spp. European Journal of Plant Pathology 148, 699–708.

Grundler, F.M., Hofmann, J., 2011. Water and nutrient transport in nematode feeding sites. In: Genomics and molecular genetics of plant-nematode interactions. Springer, Dordrecht, 423–439. https://doi.org/10.1007/978-94-007-0434-3_20.

Iwahori, H., Truc, N.T.N., Ban, D.V., Ichinose, K., 2009. First report of root-knot nematode Meloidogyne enterolobii on guava in Vietnam. Plant Disease 93(6), 675–675.

Jaglan, P., Buttar, H.S., Al-bawareed, O.A., Chibisov, S., 2022. Potential health benefits of selected fruits: Apples, blueberries, grapes, guavas, mangos, pomegranates, and tomatoes. In: Functional foods and nutraceuticals in metabolic and non-communicable diseases, 359–370. Academic Press. https://doi.org/10.1016/B978-0-12-819815-5.00026-4.

Khan, M.R., Poornima, K., Somvanshi, V.S. and Walia, R.K., 2022. *Meloidogyne enterolobii*: a threat to guava (*Psidium guajava*) cultivation. Archives of Phytopathology and Plant Protection 55(17), 1961–1997.

Kumar, M., Tomar, M., Amarowicz, R., Saurabh, V., Nair, M.S., Maheshwari, C., Sasi, M., Prajapati, U., Hasan, M., Singh, S., Changan, S., 2021. Guava (*Psidium guajava* L.) leaves: Nutritional composition, phytochemical profile, and health-promoting bioactivities. Foods 10(4), 752.

Miranda, G.B., Souza, R.D., Gomes, V.M., Ferreira, T.D.F., Almeida, A.M., 2012. Avalia¸c~ao de acessos de Psidium spp. quanto a resist^ encia a *Meloidogyne enterolobii*. Bragantia 71(1), 52–58.

Mukhtar, T., Kayani, M.Z., 2019. Growth and yield responses of fifteen cucumber cultivars to root-knot nematode (*Meloidogyne incognita*). Acta Scientiarum Polonorum Hortorum Cultus 18(3), 45–52.

Naseer, S., Hussain, S., Naeem, N., Pervaiz, M., Rahman, M., 2018. The phytochemistry and medicinal value of *Psidium guajava* (guava). Clinical Phytoscience 4(1), 1–8.

Pommer, C.V., 2012. Guava worldwide breeding: major techniques and cultivars and future challenges. In III International Symposium on Guava and other Myrtaceae 959, 81–88.

Poornima, K., 2020. Studies on incidence of root knot nematode and its bio management in pomegranate (*Punica granatum* L.). Pest Management in Horticultural Ecosystems 26(2), 246–253.

Poornima, K., Suresh, P., Kalaiarasan, P., Subramanian, S., Ramaraju, K., 2016. Root knot nematode, *Meloidogyne enterolobii* in guava (*Psidium guajava* L.) a new record from India. Madras Agricultural Journal 103(10–12), 359–365.

Poornima, K., Walia, R.K., 2021. Horticultural nurseries and nematode dissemination. Current Science 119, 277–284.

Rodríguez, M.G., Sánchez, L., Rowe, J., 2003. Host status of acriculturally important plant familes to the root-knot nematode Melodogyne mayaguensis in Cuba. Nematropica, 125–130.

Shukla, P.K., Fatima, T., Rajan, S., 2019. Research on Fusarium wilt disease of guava. Indian Phytopathology 72(4), 629–636.

Silva, G.S., Pereira, A.L., Araújo, J.R.G., Carneiro, R.MD.G., 2008. Occurrence of *Meloidogyne mayaguensis* on *Psidium guajava* in the State of Maranhão, Brazil. (Ocorrência de Meloidogyne mayaguensis em Psidium guajava no estado do Maranhão). Nematologia Brasileira 32, 242–243.

Silva, M., Do Carmo Lopes, D.A., Santos, C.D.G., 2017. Distribution of Meloidogyne enterolobii in guava orchards in the state of Ceará, Brazil. Revista Caatinga 30, 335–342.

Singh, N., 2020. Emerging problem of guava decline caused by *Meloidogyne enterolobii* and *Fusarium oxysporum* f. sp. *psidii*. Indian Phytopathology 73(2), 373–374.

Vishwakarma, P.K., Vasugi, C., Umamaheswari, R., Sriram, S., Nandeesha, P., Sankaran, M., Shivashankara, K.S., 2023. Screening of *Psidium species* and their interspecific hybrid progenies for resistance to *Fusarium oxysporum* f. sp. psidii and southern root-knot nematode. South African Journal of Botany 155, 249–260.