The University of Tehran Press

Iranian Journal of Plant Protection Science

Online ISNN: 2008-4781

Homepage: http://ijpps.ut.ac.ir/

Plant-Parasitic Nematodes (Nematoda: Tylenchomorpha) Associated with Different Crops in the Damavand Region, with Descriptions of Two New Records for Iran

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Article Info

Article type:

Research Article

Article history:

Received: 14 April 2025

Revised: 29 May 2025

Accepted: 31 May 2025

Published online: Spring and Summer 2025

Keywords:

Identification,

Morphology,

Paratylenchus aciculus,

Rotylenchus elegans,

Taxonomy.

ABSTRACT

Plant-parasitic nematodes are among the most important groups of nematodes due to their interactions with plants and their economic consequences for a wide range of crops. Faunistic surveys play a crucial role in accurate species identification, forming the foundation for effective management and control strategies. To investigate plant-parasitic nematodes in Damavand County, Tehran Province, 184 soil samples were collected from the rhizosphere of various crops in orchards and fields during 2021-2022. Nematodes were extracted, fixed, and mounted on permanent microscopic slides for morphological and morphometric analysis. A total of 49 species belonging to 23 genera within the infraorder Tylenchomorpha were identified. The nematodes recovered belonged to eight families: Anguinidae, Aphelenchoididae, Criconematidae, Dolichodoridae, Hoplolaimidae, Pratylenchidae, Tylenchidae, and Tylenchulidae. Among these, Tylenchidae was the most widely distributed family, with a frequency of 17.1%. Although they were highly abundant, these nematodes are often considered to have limited direct economic crop damage potential. Among the notable plant-parasitic nematodes (PPNs), in the Damavand region, Helicotylenchus vulgaris (6%) and Pratylenchus neglectus (5.4%) were the most prevalent species. Of the identified species, Rotylenchus elegans and Paratylenchus aciculus are reported for the first time in Iran, and their morphological descriptions are provided in this study. The identification of plant-parasitic nematode species in the Damavand region provides valuable baseline information for understanding their distribution and for developing effective management strategies.

Cite this article: Fekrat, F., Ghaderi, R., Pourjam, E. & Karegar Bideh, A. (2025). Plant-Parasitic Nematodes (Nematoda: Tylenchomorpha) Associated with Different Crops in the Damavand Region, with Descriptions of Two New Records for Iran. *Iranian Journal of Plant Protection Science*, 56 (1), 63-78. DOI: https://doi.org/10.22059/ijpps.2025.400520.1007089

Publisher: The University of Tehran Press.

DOI: https://doi.org/10.22059/ijpps.2025.400520.1007089

Extended Abstract

Introduction

Agricultural crops worldwide continually face threats from plant pathogens, including fungi, bacteria, viruses and nematodes. Among these, plant-parasitic nematodes—often referred to as the “hidden enemies” of plants—are frequently overlooked by farmers despite their significant impact (Kleynhans, 1996). Effective management of plant-parasitic nematodes requires a thorough understanding of their pathogenic effects on crops, which, in turn, depends on the precise identification of the nematode species. Accurate identification serves as the foundation for assessing nematode population dynamics and developing effective management

strategies (Seesao *et al*., 2017). Numerous plant-parasitic nematodes from the infraorder Tylenchomorpha De Ley and Blaxter, 2002, have been reported from various agricultural regions in Iran (Ghaderi *et al.*, 2018).

Several studies have examined nematode fauna in Tehran and Alborz provinces. Mojtahedi *et al*., (1980) identified 31 species across different genera within the family Tylenchorhynchidae in Iran. Notable species recovered from agricultural and horticultural hosts in these provinces include *Merlinius brevidens* from Ovin, *Quinisulcius acti* from Varamin, *Tylenchorhynchus clarus* from Savojbolagh, Taleqan, and Shahriar, *Merlinius grandis* from Karaj, *M. stegus* from Hesark, Shahriar and Savojbolagh and *Amplimerlinius socialis* from Hashtgerd and Savojbolagh. Additionally, the root-lesion nematode *Pratylenchus vulnus*, a highly damaging species, was also reported from the roots of plane trees (Barooti & Alavi, 2002). Saeedizadeh (2016) identified 28 species from 19 genera of plant-parasitic nematodes in Tehran's green landscapes, with the genera *Filenchus*, *Criconemoides*, *Helicotylenchus*, *Criconema* and *Pratylenchus* exhibiting the highest species diversity.

Several other studies have also documented multiple species of plant-parasitic nematodes from different crops and localities whitin provinces (Hojjat Jalali, 1974; Karimipour Fard *et al*., 2002; Barooti & Khazini, 2008; Salehi, 2009; Lotfi & Gharekhani, 2013). Although the Damavand region covering 11,500 hectares of orchards and farmlands, comprehensive research on plant-parasitic nematode in this area remains limited. Consequently, this study aims to address this gap through morphology-based identification of plant-parasitic nematodes affecting diverse crops across the Damavand region.

Materials and Methods

To identify plant-parasitic nematodes in the orchards and fields of the Damavand region, 184 soil and root samples were collected from various rhizosphere soil of the crops during 2021-2022 (Table 1). Nematodes were extracted using the tray method (Whitehead & Hemming, 1965) and the sucrose centrifugation technique. (Jenkins, 1964). For light microscopy, specimens were heat-killed in a 4% formaldehyde solution and cleared with anhydrous glycerin following the De Grisse (1969) method.

Permanent microscope slides were prepared from the extracted nematodes. Measurements were taken with a Nikon E600 light microscope equipped with a drawing tube, and data were recorded and analyzed using Microsoft Office Excel® 2013. Nematode species were identified using standard nematology resources and estabilished identification keys.

The relative frequency of plant-parasitic nematodes was calculated using the formula:

Relative Frequency (%) = (No. of sampling units in which species occur)/ (Total number of sampling units used in the study) *100

soil sample per unit volume= 100 grams dry soil

This provided an estimate of the prevalence of each species within the sampled area.

Results and Discussion

Based on morphological and morphometric characteristics, 49 nematode species from 23 genera within the infraorder Tylenchomorpha were identified. The recovered nematodes belong to eight families: Anguinidae, Aphelenchoididae, Criconematidae, Dolichodoridae, Hoplolaimidae, Pratylenchidae, Tylenchidae and Tylenchulidae. Tylenchidae was the most widely distributed family, with a frequency of 17.1%. Despite their high abundance, these nematodes are often considered non-significant due to yield reductions. The recorded frequency percentages for major plant-parasitic nematodes within the families Hoplolaimidae, Pratylenchidae, Dolichodoridae, Criconematidae and Tylenchulidae were 11.4%, 8.7%, 8.7%, 5.4% and 5.4%, respectively.

Among economically important plant-parasitic nematodes, *Helicotylenchus vulgaris* and *Pratylenchus neglectus* were the most prevalent nematodes in the Damavand region, occurring in 6.0% and 5.4% of samples, respectively (Table 1). This study provides full descriptions, including morphological and morphometric diagnostic characters, line drawings and photomicrographs, for the two newly recorded species from Iran: *Paratylenchus aciculus* Brown, 1959 and *Rotylenchus elegans* (Khan & Khan, 1982) Fortuner, 1987.

Author Contributions

"Conceptualization, Farnaz Fekrat and Reza Ghaderi ; methodology, Farnaz Fekrat.; software, Farnaz Fekrat.; validation, Farnaz Fekrat and Reza Ghaderi., formal analysis, Farnaz Fekrat.; investigation, Farnaz Fekrat, Reza Ghaderi, Ebrahim Pourjam and Akbar Karegar Bideh; resources, Farnaz Fekrat; data curation, Farnaz Fekrat.; writing—original draft preparation,

Farnaz Fekrat.; writing—review and editing, Farnaz Fekrat and Reza Ghaderi.; supervision, Reza Ghaderi.; project administration, Farnaz Fekrat and Reza Ghaderi.; funding acquisition, Shiraz University and University of Jiroft. All authors have read and agreed to the published version of the manuscript."

All authors contributed equally to the conceptualization of the article and writing of the original and subsequent drafts.

Data Availability Statement

Not applicable.

Acknowledgements

The authors would like to thank Shiraz University, Tarbiat Modares University and University of Jiroft for preparing the fund of research and also all participants of the present study.

Ethical considerations

The study was approved by the Ethics Committee of Shiraz University. The authors avoided data fabrication, falsification, plagiarism, and misconduct.

Conflict of interest

Nematology, Taxonomy.

نشریه دانش گیاهپزشکی ایران، دوره ۵۶، شماره ۱

انتشارات دانشگاه تهران

شاپا الکترونیکی: ۷۸۶۸-۲۴۲۳

Homepage: http://ijpps.ut.ac.ir/

نماتدهای انگل گیاهی (Nematoda: Tylenchomorpha) منطقه‌ی دماوند، با توصیف دو گزارش جدید از ایران

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اطلاعات مقاله

نوع مقاله:

مقالهٔ پژوهشی

تاریخ دریافت: ۱۴۰۴/۰۱/۲۵

تاریخ بازنگری: ۱۴۰۴/۰۳/۰۸

تاریخ پذیرش: ۱۴۰۴/۰۳/۱۰

تاریخ انتشار: بهار و تابستان ۱۴۰۴

کلیدواژه‌ها:

شناسایی، ریخت شناسی، Paratylenchus aciculus، Rotylenchus elegans، طبقه بندی.

چکیده

نماتدهای انگل گیاهی به دلیل تعامل با گیاهان و تاثیر اقتصادی بر محصولات مختلف از مهمترین گروههای نماتدی محسوب میشوند. مطالعات فون نقش مهمی در شناسایی دقیق گونه ها ایفا می کند و پایه و اساس استراتژی های مدیریت کنترل موثر را تشکیل می دهد. برای بررسی نماتدهای انگل گیاهی در شهرستان دماوند (استان تهران)، ۱۸۴ نمونه خاک از ریزوسفر محصولات مختلف باغات و مزارع طی سالهای ۱۴۰۱-۱۴۰۲ جمع‌آوری شد. نماتدها استخراج، تثبیت و بر روی اسلایدهای میکروسکوپی دائمی برای تجزیه و تحلیل ریخت‌شناسی و ریخت‌سنجی ایجاد و مورد بررسی قرار گرفتند. در مجموع ۴۹ گونه متعلق به ۲۳ جنس از فوق بالاخانواده Tylenchomorpha شناسایی شد. نماتدهای شناسایی شده متعلق به هشت خانواده شامل Anguinidae، Aphelenchoididae، Criconematidae، Dolichodoridae، Hoplolaimidae، Pratylenchidae، Tylenchidae و Tylenchulidae بودند. در میان این خانواده‌ها، Tylenchidae با فراوانی ۱۷/۱٪، گسترده‌ترین خانواده بود که با وجود فراوانی بالای آنها، این نماتدها از لحاظ خسارت اقتصادی اهمیت چندانی ندارند. در بین نماتدهای انگل گیاهی مهم، شایع ترین گونه‌ها در منطقه دماوند *Helicotylenchus vulgaris* (۶ درصد) و *Pratylenchus neglectus* (۵/۴ درصد) بودند. از بین گونه‌های شناسایی شده، *Rotylenchus elegans* و *Paratylenchus aciculus* برای اولین بار در ایران گزارش شده‌اند که در این مطالعه توصیف ریخت شناسی آنها ارائه شده است. شناسایی گونه‌های نماتدهای انگل گیاهی در منطقه دماوند، اطلاعات پایه و ارزشمندی برای درک پراکنش آن‌ها و تدوین راهکارهای مدیریتی مؤثر فراهم می‌کند.

استناد: فکرت، فرناز؛ قادری، رضا؛ پورجم، ابراهیم و کارگر بیده، اکبر (۱۴۰۴). نماتدهای انگل گیاهی (Nematoda: Tylenchomorpha) منطقه‌ی دماوند، با توصیف دو گزارش جدید از ایران. *نشریه دانش گیاهپزشکی ایران*، ۵۶ (۱)، ۷۸-۶۳. DOI: https://doi.org/10.22059/ijpps.2025.400520.1007089

ناشر: مؤسسه انتشارات دانشگاه تهران.

DOI: https://doi.org/10.22059/ijpps.2025.400520.1007089

مقدمه

Table 1. A list of the recovered nematodes of infraorder Tylenchomorpha from soil of orchards and farms in the Damavand region, along with information on their relative frequency (RF), associated plant and locality.

Species	RF%	Associated Plant	Locality
Hoplolaimidae	11.4	-	-
Helicotylenchus vulgaris	6.0	Cherry, Apricot, Apple, Plum, Almond, Walnut	Sadat Mahalleh, Ayneh Varzan, Saqqez Darreh, Qalfak, Garmabsard, Gilavand, Ana.
Helicotylenchus digonicus	1.6	Plum, Apple, Pear, Walnut	Abasrd, Gilaavand, Aharan, Aineh Varzan
Helicotylenchus pseudorobustus	1.6	Walnut	Absard, Zan, Gilavand
Helicotylenchus abunaamai	1.1	Walnut	Hesar Bala
Helicotylenchus dihystera	0.5	Pear	Ghazlar
Helicotylenchus varicaudatus	0.5	Walnut, Alfalfa	Gilavand
Rotylenchus elegans	0.5	Apple	Jaban
Pratylenchidae	8.7	-	-
Pratylenchus neglectus	5.4	Green bean, Pear, Apple, Walnut, Oat	Sarcheshmeh, Sarbandan, Wadan, Islam Abad, Abasard
Pratylenchus andinus	0.5	Walnut	Ayineh Varzan
Zygotylenchus guevarai	2.2	Walnuts, Pear, Apple, Alfalfa	Aharan, Vadan, Kiriton, Zan, Abasrd
Dolichodoridae	8.7		
Scutylenchus rugosus	2.7	Wheat, Apple, Walnut, Cherry, Sunflower	Absard Bala, Zan, Sarbandan, Saghez Dareh, Golek, the source.
Merlinius brevidens	1.6	Walnuts, Apple, Alfalfa	Saqz Darreh, Sarbendan, Abasrd
Nagelus obscurus	1.1	Walnut, Alfalfa	Absard, Chenaran
Amplimerlinius globigerus	1.1	Apricot, Walnut	Kriton, Sadat Mahaleh
Merlinius microdorus	0.5	Apple	Islaam Abad
Pratylenchoides ritteri	0.5	Alfalfa	Gilavand
Quinisulcius capitatus	0.5	Potato	Ahran
Trophurus ussuriensis	0.5	Alfalfa	Gilavand
Criconematoidae	**4.9**		
Criconemoides parvus	1.6	Plum, Apple	Sarbendan, Aineh Varzan
Mesocriconema ornatum	1.1	Plum, Apple	Abali, Sarbandan
Mesocriconema xenoplax	1.1	Walnut	Vadan, Darband
Mesocriconema curvatum	1.1	Apple	Abali, Qolfak
Tylenchulidae	**3.8**	-	-
Paratylenchus similis	1.3	Plum, Cherry	Sarbandan, Saqz Dare
Paratylenchus aciculus	0.5	Cherry	Hesare Pain
Paratylenchus coronatus	2	Apple	Sarbandan

Table 1. Continued.

Species	RF%	Associated Plant	Locality
Anguinidae	**3.6**	-	-
Ditylenchus myceliophagus	0.5	Wheat	Absard, Dr. Homayouni Mahaleh
Ditylenchus gilanicus	0.5	Walnut	Hesare Bala
Ditylenchus ferepolitor	0.5	Sweet Cherry, Green Bean	Sarcheshmeh
Ditylenchus valveus	0.5	Sweet Cherry, Green Bean	Sarcheshmeh
Ditylenchus triformis	0.5	Walnut	Absard Bala
Nothotylenchus geraerti	1.1	Sunflower, Apple	Sarcheshmeh, Abad Eslaam
Tylenchidae	17.1		
Filenchus thornei	2.7	Apple, Oat, Sweet Cherry	Jaban, Absard, Zan
Filenchus vulgaris	2.1	Sweet Cherry, Almond, Apple, Walnut	Ayineh Varzan, Ana, Absard, Zan
Filenchus pratensis	1.1	Apple, Pear,	Sarcheshmeh, Zan
Filenchus paravesiculosus	1.1	Apple	Khosravan
Filenchus facultativus	0.5	Apple	Garmabsard
Irantylenchus vicinus	0.5	Walnut	Zan
Boleodorus thylactus	5.0	Pear, Sweet Cherry, Apple, Apricot, Plum.	Yasin Nursery (Absard), Abali, Sadat Mahalleh,Sarbandan, Garm Absard, Ahran
Basiria graminophila	1.1	Sour Cherry, Sweet Cherry	Zan, Qolfak
Basiria gracilis	0.5	Wheat	Absard
Basiria duplexa	0.5	Walnut	Qolfak
Coslenchus franklinae	0.5	Plum	Sarbandan
Psilenchus aestuarius	0.5	Walnut	Kriton
Psilenchus cucumerus	0.5	Apple	Sarbandan
Psilenchus hilarulus	0.5	Sunflower	Sarcheshmeh
Aphelenchoididae	3.1		
Aphelenchoides bicaudatus	0.5	Apple	Qolfak
Aphelenchoides parietinus	1.1	Walnut	Sarbandan
Aphelenchoides cyrtus	0.5	Sweet Cherry	Sarcheshmeh
Ektaphelenchoides fuchsi	1	Plum	Sarbandan

***Paratylenchus aciculus* Brown, 1959** (Figs: 1 & 2; Table 2)

Female. Body curved ventrally, tapering towards both ends. Cuticle finely annulated, lateral field with three incisures (Fig. 1 H), two bright lines with a fainter one inside, occupying about 30% of the body diameter. Lip region almost rounded, indistinctly elevated and continuous with the body contour, measuring 5-6 µm at the base; submedian lobes not distinct from lateral view. Stylet long, delicate and flexible with rounded to slightly backwardly directed knobs; conus comprises more than 90% of the total stylet length. Dorsal pharyngeal gland opening (DGO) located approximately 7 µm behind the stylet knobs. Secretory-excretory pore positioned near the beginning of the pharynx and close to stylet knobs. Hemizonid located 2-3 annules behind the secretory-excretory pore (Fig. 1 D).

Corpus long with a distinct valve; pear-shaped small terminal bulb set off from intestine. Ovary functional but short, about 59 µm in length. Oocytes arranged in single row, and the elongated ellipsoid spermatheca contains distinct sperm cells within the wider region of uterus (Fig. 1 E). Vulva without lateral flaps. Vagina extends inward and more than half of the corresponding body diameter. A post uterine sac present (Fig. 1 G). Tail ventrally curved, with a finely rounded terminus (Fig. 2).

Male. Not found.

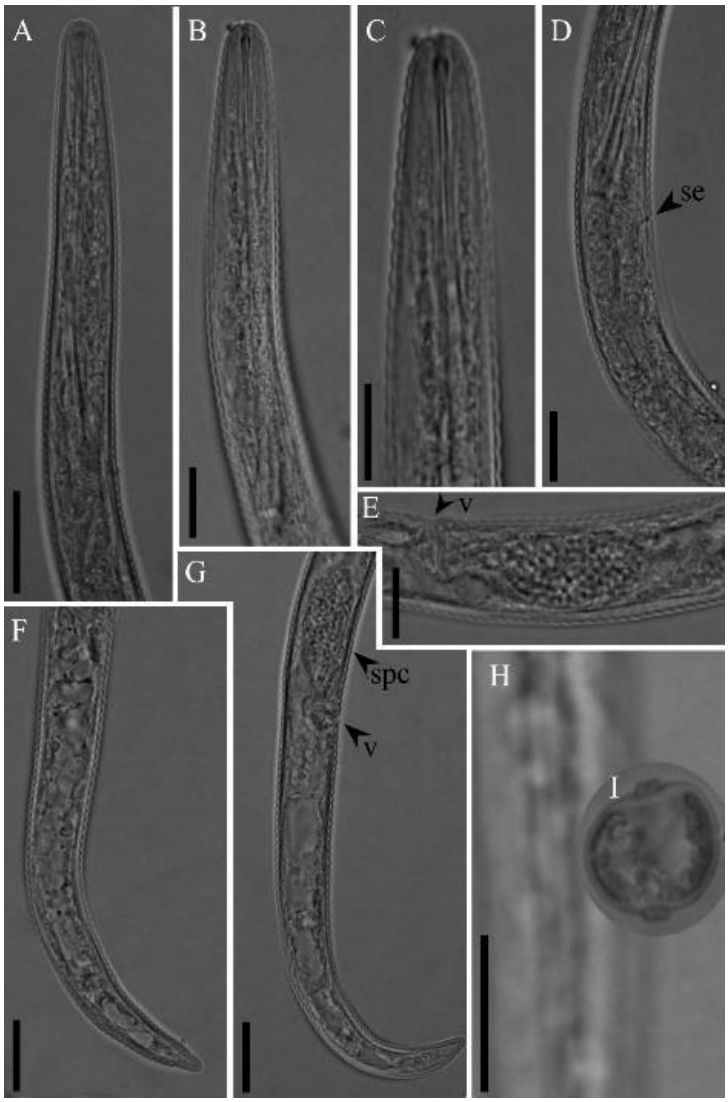

Figure 1. Diagnostic characters of the females of *Paratylenchus aciculus*. A-C: Stylet and anterior end; D: Position of secretory-excretory pore; E: Spermatheca filled with sperm; F & G: Vulval region and posterior end, H & I: Lateral fields and cross-section (All scale-bars = 10 µm). [se = secretory-excretory pore; spc = spermatheca; v = vulva]

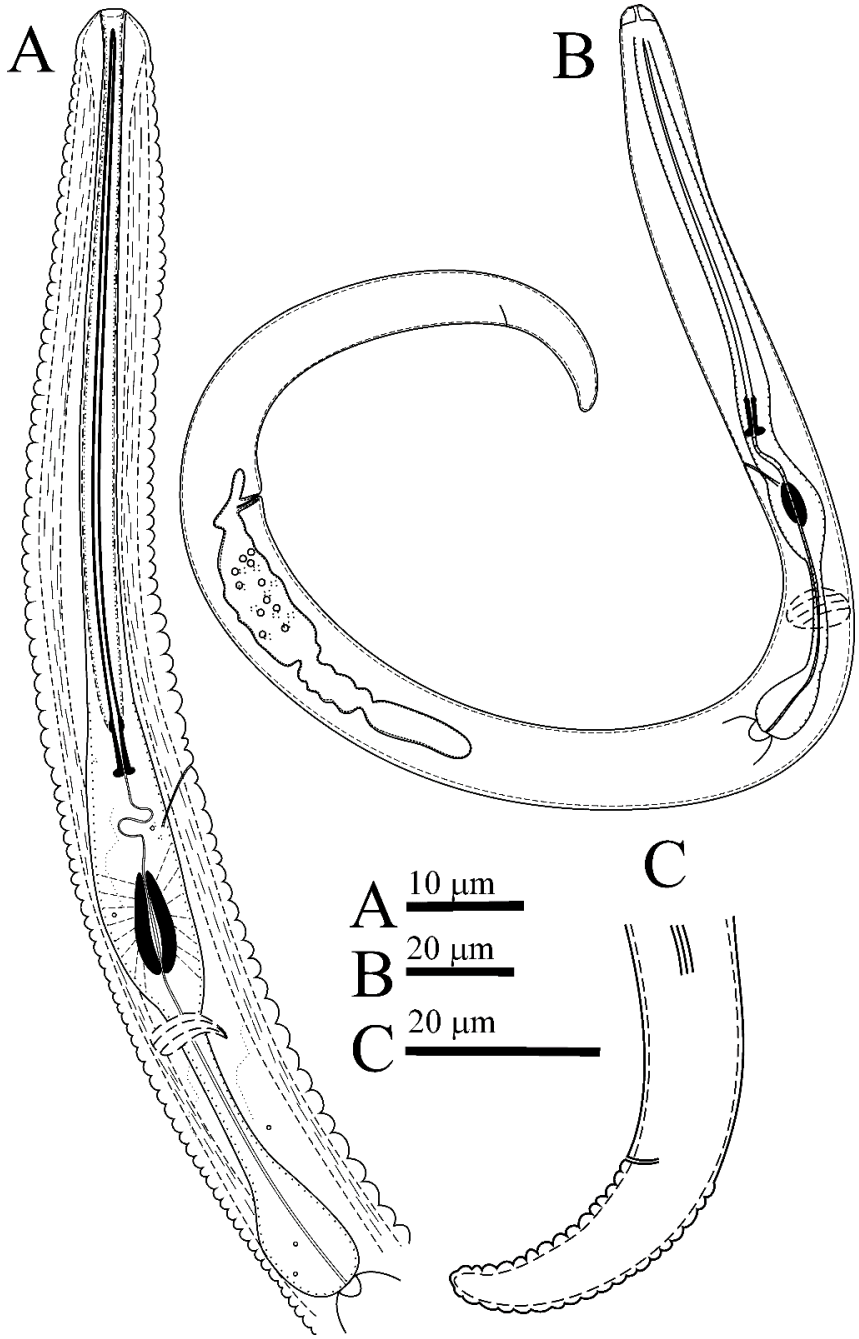

Figure 2. Diagnostic characters of the females of *Paratylenchus aciculus*. A: anterior end and pharynx; B: general body and ovary; C: Female posterior end.

Diagnosis and relationships:

The diagnostic characteristics of the present population were relatively in agreement with the original description and subsequent reports (Table 2). No notable difference was observed between this population and those previously recorded from Poland, Botswana, Guadeloupe and Spain (Brzeski & Szczgiel, 1963; Van den Berg, 1989; Van den Berg & Quénéhervé, 1999; Clavero-Camacho et al., 2021). The Iranian population exhibited slightly higher maximum values in the *c* ratio (18.8 vs. 15.9) and maximum body length (340 µm vs. 310 µm) compared to the original description (Brown, 1959**).** Additionally, the DGO in the present population, is positioned slightly

more posteriorly compared to the type population (7 vs. 5 µm) (Brown, 1959). The morphometric and descriptive characteristics of the Iranian *P. aciculus* population largely agree with the data reported by Clavero-Camacho *et al.* (2021). Body length, stylet length, vulva position, and other key morphometric indices fall within the ranges presented in their study. A small post-uterine sac observed in the Iranian population of *P. aciculus*, was not reported in the original species description (Brown, 1959) or in previous records. However, we consider these minor variations to be intraspecific, supporting the identification of our population as *P. aciculus*. The presence or absence of post-uterine sac has already been considered as a non-stable diagnostic character which cannot be used for species discrimination reliably (Ghaderi *et al.*, 2014). With a stylet longer than 40 µm, three longitudinal lines in the lateral field, and the absence of advulval flaps, *P. aciculus* falls into Group 9 of the 11-groups classification scheme of *Paratylenchus* species (Ghaderi *et al.*, 2016). It differs from *P. musae* (Shahina & Maqbool, 1993) Brzeski, 1998 by having longer stylet (62-71 vs. 42-44 µm) and more anteriorly positioned vulva (69-75 vs. 82-84). Additionally, it can be distinguished from other species in the Group 9, except *P. costatus* (Raski, 1976) Siddiqi, 1986 and *P. anchorous* (Mohilal & Dhanachand, 2004) (Ghaderi *et al.*, 2014), by its finely rounded tail terminus (vs. lobed or broadly rounded). From *P. costatus* and *P. anchorous*, *P. aciculus* can be differentiated by shorter female stylet (62-71 vs. 70-87 µm) (Table 2).

Table 2. Morphometric characteristics of the *Paratylenchus aciculus* population recovered from Damavand region and its comparison with the original description and other worldwide populations. Measurements are in µm and in the form mean ± standard deviation (minimum-maximum).

Populations Characters	**Present study**	**Brown, 1959**	**Brzeski & Szczgiel (1963)**	**Van den Berg 1989**	**Van den Berg & Quénéhervé (1999)**	**Clavero-Camacho *et al.*, 2021**
n	**15** ♀	**25** ♀	**12** ♀	**9** ♀	**8** ♀	**12** ♀
L	310 ± 17.7 (279-340)	240-310	290-310	280-320	270-310	285–339
a	24.5 ± 1.5 (21.4-27.2)	18.4 -23.6	21-22	15-19	19-26	17.0–21.5
b	2.6 ± 0.1 (2.4-2.9)	2.4-2.7	2.6-2.7	2.5-2.7	2.5	2.2–2.8
C	15.2 ± 2.1 (12.7-18.8)	10-15.9	13-15	12-17	13-17	10.3–14.8
C'	2.8 ± 0.3 (2.2-3.5)	-	-	2.5-3	3-4	2.6–3.5
V	71.5 ± 1.3 (69.3-74.5)	68.3-69	73-75	77-80	72-76	72.3–74.7
Stylet	65.5 ± 2.8 (62-71)	61-69	64-69	64-73	68-79	67.5–75.0
Anterior end to center of corpus	79.6 ± 2.2 (75-82)	-	-	-	-	79.0–89.0
S. E. pore	74.7 ± 3.8 (68-84)	-	-	-	-	72.5–91.0
Pharynx	117. ± 3.5 (112-123)	-	-	-	-	109.0–138.0
Anterior end to vulva	222 ± 14.2 (199-245)	-	-	-	-	-
Vulval body width	11.4 ± 0.5 (11-12)	-	-	-	-	-
Body width	12.6 ± 0.2 (12.5-13)	-	-	-	-	14.0–20.0
Tail length	20.6 ± 2.3 (17-25)	-	-	-	-	20.5–33.0
Anal body width	7.1 ± 0.4 (6.6-8)	-	-	-	-	7.5–10.0

Distribution and host range:

The present population of *P. aciculus* was collected from the rhizosphere of sour cherry trees in Hesar Bala, Damavand, Tehran province, Northern Iran. To date, this species has been reported from *Poa palustris*, *Mesembryanthemum* sp., maple, pine, peach, coffee, strawberry, and clover from different regions in the world (Brown, 1959; Brzeski & Szczgiel, 1963; Van den Berg, 1989; Van den Berg & Quénhérvé, 1999). This is the first report of *P. aciculus* from Iran.

Rotylenchus elegans (Khan & Khan, 1982) Fortuner, 1987

(Figs. 3 & 4; Table 3)

Female.

Body assumes a closed C-shape to slightly spiral upon relaxation. Cuticle coarsely annulated, with annules measuring 1.7-1.9 µm at mid-body. Lateral fields with four lines, occupying about one third of body diameter. Lip region truncate, continuous with the body contour, and marked by 5-6 annules (Fig. 3 E); 8 µm wide at the base and 4 µm high. Cephalic framework strongly sclerotized, its outer margins extending posteriorly two annules from the basal plate. Stylet strong, with its conical part approximately half the length of stylet (m = 48-51). Stylet knobs well developed, rounded or directed laterally. Dorsal pharyngeal gland opening is located about 7 µm behind stylet knobs, about 31-38% of stylet length. Median bulb distinct and oval, measuring 13.8 µm long and 9.5 µm wide, with developed valve and a depression anterior to the median bulb (Fig. 3 B, C, D). Secretory-excretory pore located at or just posterior the pharyngo-intestinal junction. Hemizonid distinct, one to three body annules anterior to secretory-excretory pore. Pharyngeal glands overlap the intestine dorsally or sub-dorsally. Both ovaries equally developed and functional. Vulva a transverse slit. Epiptygma absent. Spermatheca rounded, distinctly set off (Fig. 3 I), and contains sperm cells. Phasmids pore-like and located about 6-7 annules anterior to the anus (Fig. 3 L). Tail hemispherical and annulated, consists of 9-11 annules at terminus (Fig.3 M).

Male. Rare; only one specimen was detected. Stylet slightly shorter and slenderer than that of the female, with indistinct knobs (Fig. 3F). Spicules robust, and nearly ventrally arcuate. Gubernaculum normal. Bursa 41 µm long and extended to tail terminus (Fig. 3 K). Tail tapering, with a rounded-pointed tip (Figs. 3 K; 4).

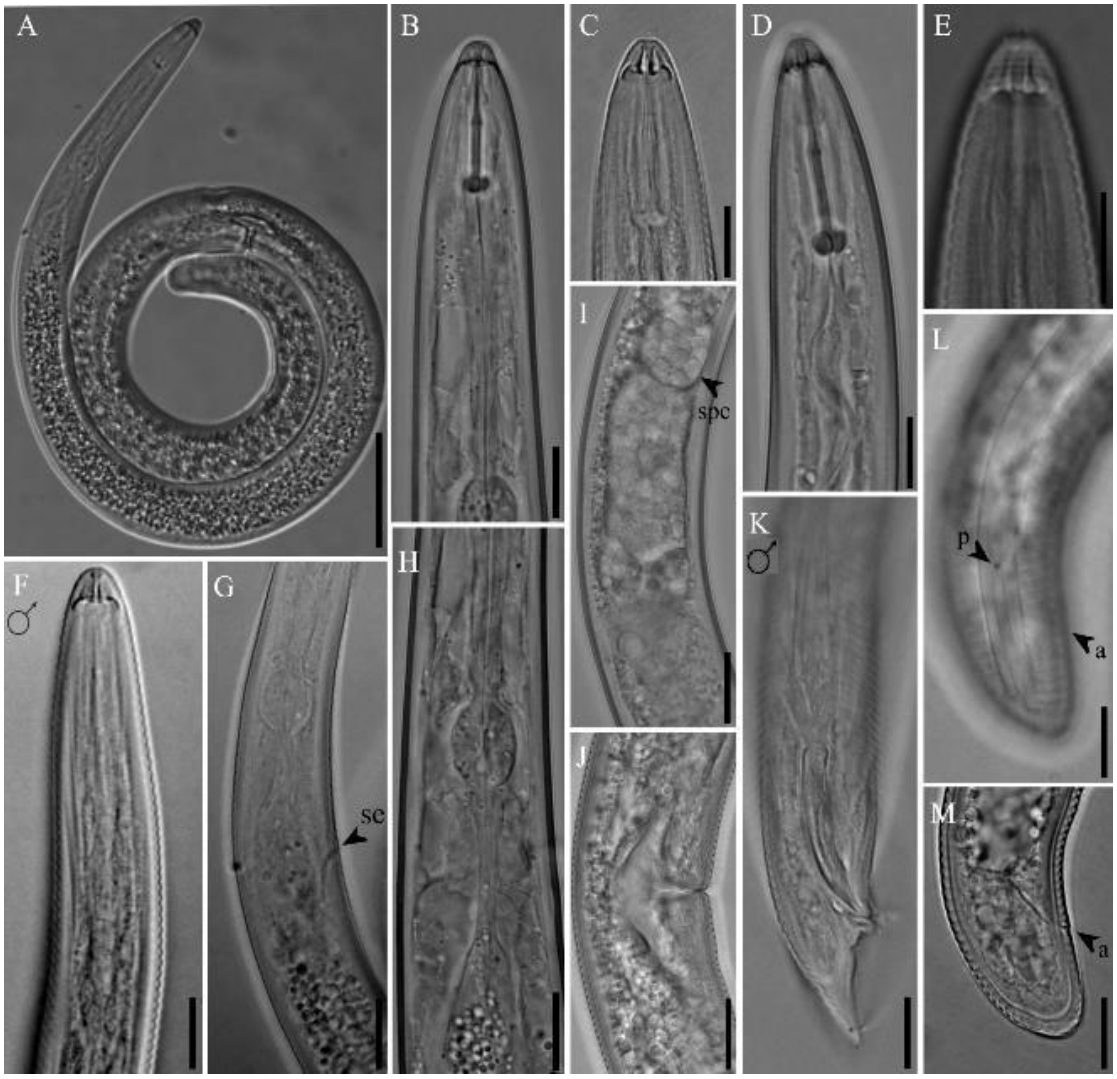

Figure 3. Diagnostic characters of *Rotylenchus elegans* females and male recovered from the Damavand region. A-E, G-J, L, M: Female; F, K: Male. A: Body habitus after fixation; B-E: Female anterior end; F: Male anterior end, G-H: Pharyngeal basal bulb overlapping, I: Rounded spermatheca; J: Vagina; K; Male posterior end; L: Phasmid location anterior to anus; M: Female posterior end. (All scale-bars = 10 µm). [a = anus; p = phasmid; se = secretory-excretory pore; spc = spermatheca]

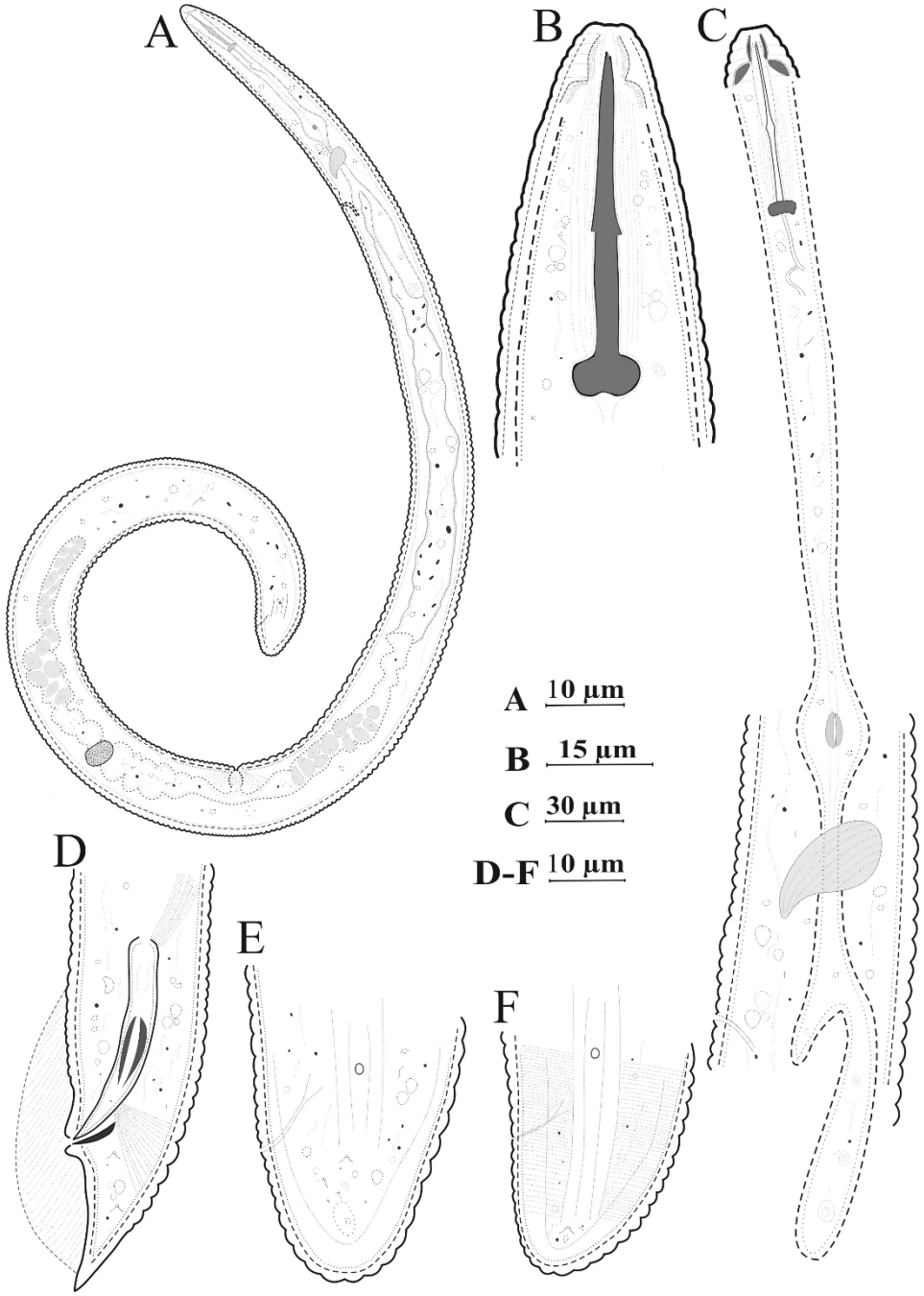

Figure 4. Diagnostic characters of *Rotylenchus elegans* recovered from Damavand region. A-C, E, F: Female; D: Male. A: Body habitus after fixation, with an outline of digestive and reproductive systems, Hemizonid located anterior to excretory pore, with cuticle slightly depressed; B: Anterior end and stylet, C: Anterior end and pharyngal region; D-F: Posterior end, phasmids position.

Diagnosis and relationships:

Rotylenchus elegans is characterized by a truncate labial region, continuous with the body contour, with 5-6 annules, a rounded tail, stylet length less than 30 µm, and vulva position between 50-60% of the body length.

According to the identification key for *Rotylenchus* species (Geraert & Barooti, 1996), our population occupies an intermediate position between groups C and D concerning the V range.

However, the rounded hemispherical tail in females clearly places the species in group D. Within this group, the present population can be subclassified among species with phasmids located 3-7 annules anterior to anus, such as *R. elegans*, *R. alpinus* Eroshenko, 1976 and *R. basiri* (Khan & Khan, 1982) Fortuner, 1987. Regarding female stylet length, our population is more similar to *R. elegans* and differs from *R. alpinus* and *R. basiri* by shorter stylet (24-26 vs. 28-30 and 25-27 µm, respectively). Morphologically, *R. elegans* also closely resemble *R. varus* (Jairajpuri & Siddiqi, 1979) Siddiqi, 1986 but our population differs from *R. varus* in having a higher *O* value, shorter basal pharyngeal gland lobe and a broadly annulated rounded tail.

When our population was compared with previously reported species from Iran, it showed similarities with *R. cypriensis* Antoniou, 1980 and *R. glabratus* Kankina & Teben'kova, 1980. From the first species, the present population can be distinguished by tail shape (rounded vs. dorsally convex-conoid) and *c'* ratio (0.5-0.7 vs. 1.1-1.7). From the second species, it could be differentiated by tail shape (rounded vs. projected), *c'* value (0.5-0.7 vs. 1.2-1.9) and V value (58-62 vs. 62-67).

Several differences were observed between the Iranian population of *R. elegans* and its original description (Table 3). These differences include the presence of males, a slightly longer body (708-867 vs. 500-700 µm), smaller *a* value (25-29 vs. 32-34), and larger *c* ratio (56-78 vs. 40-55). Additionally, the number of tail annuli in the Iranian population is lower than in the original description (9-11 vs. 14-16).

Wide intra-specific variations in body length (L) within species of the genus *Rotylenchus* are commonly reported and significantly influence morphometric ratios such as *a*, *c*, and *c'*, which depend directly on total body length. For example, *R. robustus* exhibits a body length range of approximately 800–1870 µm (max:min ratio = 2.34) and *R. agnetis* shows a range from 600 to 1070 µm (max:min ratio = 1.78) for their different populations (Siddiqi, 2000; Castillo & Vovlas, 2007). Intra-specific variability in the body length even can be found in the same population for *R. goodeyi* in which female body length is ranging from 690 to 1060 µm equals to 1.54 for max:min ratio (Coomans, 1962). These broad ranges result in considerable variability in morphometric indices among individuals. We believe that differences relevant to body length and *a* ratio fit well in intra-specific variation ranges as max:min ratio for the female body length in *R. elegans* now is 1.73 comparable with variation observed in other species in the genus. Although males not reported in the original description, female spermatheca was described and illustrated having sperm cells indicating bisexual reproduction mode in the species. Overall, the tail is relatively short consequently, differences in *c* ratio and tail annuli could either fall in intra-specific variability or serve as diagnostic characters. Unfortunately, finding more specimens for further morphological or molecular work was not possible even by additional sampling efforts from the location.

Table 3. Morphometric characteristics of the *Rotylenchus elegans* population recovered from Damavand region and its comparison with the original description. Measurements are in µm and in the form mean ± standard deviation (minimum-maximum).

Populations Characters	**Damavand population**		**Khan & Khan, 1982**
n	**5♀**	**1♂**	**6♀**
L	790 ± 65.1 (708-867)	716	500-700
L´	778 ± 64 (698-856)	697	-
a	27.1 ± 1.9 (25.2-29.5)	34	32-34
b	7.9 ± 0.5 (7.1-8.5)	-	5.7-6.7
b´	5.8 ± 0.4 (5.2-6.4)	-	5-6
C	68.2 ± 9.9 (56.3-78.8)	37.6	40-55

C′	0.6 ± 0.0 (0.5-0.7)	1.3	-
V	59.9 ± 1.9 (58-62.3)	-	55-64
V′	60.2 ± 1.8 (58.2-62.6)	-	-
Stylet	25.1 ± 0.8 (24-26)	17	22-25
O	35.4 ± 2.8 (31.4-38.4)	35.2	32-42
Anterior end to secretory-excretory pore	108 ± 9 (95-116)	116	-
Pharynx	99.2 ± 6.4 (90-108)	108	-
Anterior end to end of pharyngeal gland	135 ± 7.4 (124-145)	-	-
Body width	29.2 ± 3.2 (24-33)	21	-
Anal body width	17.1 ± 1.5 (15-19)	13.7	-
Tail length	11.8 ± 2.1 (10-15)	19	-
Spicules	-	27	-
Gubernaculum	-	7	-

Distribution and host range:

During the present study, a bisexual population of *R. elegans* was recovered from the rhizosphere of apple trees in Jaban village, Damavand, Tehran province. This represents the second report of the species worldwide, following its initial recovery from vineyards in the type locality, Maharashtra, India (Khan & Khan, 1982).

Conclusions

This study elucidates a significant diversity of nematodes within the infraorder Tylenchomorpha inhabiting the Damavand region, confirming the presence of economically relevant plant-parasitic nematodes. The identification and first-time recording of *P. aciculus* and *R. elegans* for the Iranian nematofauna underscores the region's importance as a reservoir of nematode biodiversity. These findings provide a valuable foundation for future research endeavors aimed at the integrated management and control of PPNs in Damavand agroecosystems.

Acknowledgments

We thank Shiraz University and the University of Jiroft for the financial support of our research, and acknowledge that this work was conducted at the Nematology Laboratory of Tarbiat Modares University, Iran.

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