IDENTIFICATION AND DISTRIBUTION OF SOME PLANT-PARASITIC NEMATODES IN VINEYARDS OF SOUTH – WESTERN OF IRAN

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A B S T R A C T

Grape (Vitis spp) belonging to family Vitaceae is a commercially important fruit crop. The most grape producing countries have one or more soil problems such as, salinity, drought and harmful biotic agents such phylooxera, nematodes and fungal pathogens. Nematodes are one of the most important soil pathogenic agents and can cause considerable damage to grapes in high populations. There are no studies on biodiversity of plant parasite nematodes in Vineyards of Chaharmahal and Bakhtiyari province of Iran. So, in order to identify the plant parasitic nematodes in Vineyards of Chaharmahal and Bakhtiyari province, south-western of Iran, 350 soil samples were collected from different regions during years 2019-2020. The nematodes were extracted by centrifugal flotation technique and tray methods. Then, they were fixed and transferred to glycerin. The permanent slides were prepared and the nematodes were studied by light microscopy and valid keys. In this study, 30 Species belonging to 21 genera were identified: Amplimerlinius globigerus, Aphelechnus avenae, Aphelenchoides limberi, Basiria gramminophila, Boleodorus thylostacus, Coslenchus polygyrus, Ditylenchus dipcasi, D. parvus, D. tenuiids, Filenchus vulgaris, Helicotylenchus vulgaris, H. digonicus, H. minzi, H. pseudorobustus, Irantylenchus vicinus, Merlinius brevidens, M. microdorus, Mesocriconema xenoplax, Neopsilenchus magnidens, Nothotylenchus hexagonalhus, Pratylenchoids ritteri, P. erzumensis, Pratylenchus neglectus, P. thornei, Psilenchus iranicus, P. aestuarius, Scutylenchus rugosus, Tylenchus arcuatus, Zygonylenchus guevaria, Xiphinema index. Among them, the highest percentage of abundance, were Helicotylenchus vulgaris, Filenchus vulgaris, Xiphinema index, Pratylenchus neglectus by 50%, 42%, 38% and 31%, respectively.

Keywords: Chaharmahal and Bakhtiyari, province, Grapes, Iran, Plant parasitic nematode.

INTRODUCTION

Grape (Vitis vinifera) is a dicotyledonous plant belonging to family Vitaceae. This plant is one of the most important commercial plants in Iran (Rossetto, 2002). It is native to Asia Minor and the Caucasus region, was distributed throughout Europe, and is now extensively grown in the Mediterranean Basin, the subtropical regions of Australia, Southern Africa, and North and South America (Brown, 1993). Today, grapes are grown in more than 40 countries around the world. Over the last three decades, the area under cultivation of this crop has been steadily increasing (Porica, et al, 2015). The major grape producing countries are China, Italy, USA, France, Spain and Turkey. According to FAO statistics in 2017, Iran is one of the most important grape producing countries in the world and is ranked eighth in terms of area under grape cultivation (FAO, 2017). Chaharmahal and Bakhtiyari province is one of the producers of grapes in Iran. In general, grape cultivars cultivated in Iran are: Maleki, Sahebi, Asgari, Razeghi, Hosseini, Rish Baba, Sabz bi daneh, Yaghoti, Siah Sardasht, Fakhri, Keshmeshi and Shirazi (SPCRI, 2020). Global data show that income from grape exports in Iran is over $ 150 millions for one year and, Iran was also the third largest exporter of raisins in the world in 2019 with exports worth $ 166.8 millions (FAO, 2019). Annually, pests, diseases and weeds spread in the vineyards and cause a lot of damage to the producers of this valuable product.
Therefore, identification and management of these harmful factors, including nematodes, can increase performance and thus economic profitability play a big role (Quist et al., 2015). Considering, that plant parasitic nematodes are serious challenge to productivity of many fruits and horticultural trees including grapes (Askary and Haidar 2010). It is important to know the nematode species present and to estimate their approximate population. Due to the role, economic importance and global position of grape production, extensive studies have been conducted to identify plant parasitic nematodes worldwide and in Iran. Nearly, 2500 species of plant parasitic nematodes have been reported in the world, of which around 1600 are associated with grapevines (Askary et al., 2018). Plant parasitic nematodes have often been found in soils where grapevines showed reduced vigor (Brown et al., 1993). However, not all of these species have been recognized as causing economically significant damage (Nicol et al., 1999). According to previous reports of the existence these nematodes in Iran, this article discusses the distribution and frequency of identified nematodes from vineyards of Chaharmahal and Bakhtiyari province. The distribution of any nematode was determined by considering the region and location of sampling. The frequency of identified species in terms of percentage was calculated based on the number of samples with the desired species in relation to the total samples.

**MATERIALS AND METHODS**

**Soil sampling:** Soil and root samples were randomly collected from the rhizosphere of Vineyards in Chaharmahal and Bakhtiyari province, South-Western of Iran. A total of 350 samples were collected with a shovel from the depth of 10-40 cm, placed in polyethylene bags, with necessary labeled and brought to the laboratory and processed.

**Processing of samples:** Nematodes were extracted from soil samples by using the rapid centrifugal-flotation method (Jenkins, 1964) and tray method (Whitehead and Hemming, 1965), killed and fixed according to (De Grisse, 1969). Genera and species were identified based on morphological and morphometric characters (Siddiqi, 2000; Geraert, 2008). Specimens were heat-killed by adding boiling 4% formalin solution, and were then transferred to anhydrous glycerin according to De Grisse, 1969. Permanent slides were prepared and studied using a light Olympus CX31 microscope. Measurements and drawings were performed using a drawing tube attached to an Olympus CX31 light microscope (LM). Morphometric abbreviations and ratios were used in the present study (Siddiqi, 2000). Nematodes were identified based on morphological and morphometric characteristics, using available identification keys and original descriptions (Raski, 1975; Brzeski, 1991 and Geraert, 2008).
Measurement and drawings: Measurements were taken with an ocular micrometer of "Olympus CX31" model microscope. Drawings were made with drawing tube attached to the compound microscope.

RESULTS AND DISCUSSION
Nematological survey of vineyards in Chaharmahal and Bakhtiyari Province revealed the presence of many plant-parasitic nematode genera and species. In total, 30 species belonging to 21 genera were identified in present study. Survey results are summarized in (Table 1, Figure 2). 29 species belong to the infra order Tylenchomorpha and one species (Xiphinema index) belongs to the order Dorylaimida. Most of the identified species belonged to the genera Helicotylenchus, Pratylenchus and Ditylenchus. Among them, the highest percentage of abundance, were Helicotylenchus vulgaris, Filenchus vulgaris, Xiphinema index and Pratylenchus neglectus by 50%, 42%, 38% and 31% respectively in surveyed areas (Table 1). Next were other root-lesion nematodes (Z. guevarai and P. thornei) were detected in moderate (20%) to low (7.1%) frequencies in soil and root samples. The lesion nematodes such as P. neglectus, P. thornei, and Z. guevarai, are common parasites of monocotyledonous and dicotyledonous weeds and are not expected to cause important economic damage to grapevines (Castillo, 2007). Also according to the data in Table 1, can be said, among the identified nematodes, Scutytlenchus rugosus has a frequency of 23%. The abundance of M. xenoplax in the studied vineyards is 15%. Feeding of this nematode on grapevine was reported to cause rapid darkening and destruction of root tissues, thus resulting in stunted root systems with a few feeder roots (Santo and Bolander, 1977). In addition, the frequency of other identified nematodes varies between 5 to 20%. Root knot nematodes (Meloidogyne spp) are the most important group of plant parasitic nematodes due to their have a broad host range wide, global distribution and interaction with some fungi and plant pathogenic bacteria (sasre, 1979). Therefore, the presence of this genus of nematodes in the soil around the roots of grape trees is very likely. However, in this study, the root knot nematode was not found in soil and grape roots.

Table 1. List of identified nematodes from Grapes in this study, with morphometric characters and their abundance. All measurements are in μm.

| No. | Nematode species                  | Abundance (%) | Morphometric Characters                                                                 |
|-----|-----------------------------------|--------------|----------------------------------------------------------------------------------------|
| 1   | Amplimerliniusglobigerus          | 9.4          | 6♀ L=749.5(723.35-880.6); a=33.55 (29.5-35.4); b=4.9 (4.7-5.2); c=17.38 (15.2-22.5); c`= 2.8 (2.4-3.6); V=55.3 (53-60); stylet=21 (19.76-22.8); Tail =39.4 (33.44-47.12); Tail annuli = 37-40. |
| 2   | Aphelenchusavenae                 | 6            | 9♀ L=680 (566.1-893.18); a=32 (29.5-37.5); b=5 (4.4-5.6); b`=4 (3.5); c=34.5 (27.5-38.1); c`=1.8 (1.6-2.1); V=75 (67-80); stylet=17.8 (15.2-21.28); Tail =20.1 (18.24-22.8). |
| 3   | Aphelenchoideslimberi            | 2.8          | 5♀ L=548.4 (377.4-616.4); a=31.98 (27.5-330.7); b=4.3 (4.2-4.5); c=19.32 (18.6 20); c`=2.6 (2.5-2.8); stylet=16.4 (15.2-18.24); Tail =26.1 (19.76 30.4); Gubernaculum = 15.2; Spicules = 6.69 (4.56-9.12). |
| 4   | Basiriagraminophila              | 5.7          | 8♀ L=706.9 (660.45-817.7); a=36.5 (30.1-44.8); b=5.1 (4.1-5.7); c=7.5 (4.3-8.6); c`=9.92 (6.9-12.5); V=65.8 (61-80); V`=81.2 (8083); stylet=9.96 (9.3-10.64); Tail =127.7 (94.84-148.8). |
| 5   | Boleodorushylactus               | 2.8          | 4♀ =L=688.7 (641.58-723.35); a=38 (33.9-42.2); b=6.3 (5.6-7.7); c=11.3 (8.9-12.9); c`=5.35 (4.7-6.2); V=77.5 (73-81); stylet=8.06 (7.44-8.60); Tail =77.5 (62-77.5). |
6 *Coslenchus polygyrus* 10.5 8♀: L=693.4(566.1-943.5); a=33.6(31.35-35); b=5.5(5.6-2); c=5(3.3-6.3); c'=11.8(9.1-15.7); V=66.7(61-67); stylet=11.9(10.5-15.2); Tail=128.6(96.1-144.4); Reos=57(56-58); Rex=41(40-43); Rvu=151(145-155); Rvan=41(40-43).

7 *Ditylenchus dipaci* 12 8♀: L=798.5(597.55-947.95); a=39.8(34.4-47.9); b=6.2(5.9-6.8); c=12.6(9.5-16.5); c'=5.2(4.1-6.2); V=80(78-82); stylet=9.1(7.6-10.6); Tail length=79(76-91.2). 5♂: L=844.4(673.03-1132.2); a=38.83(36.8-41.3); b=5.07(4.6-5.6); c=14.6(12.4-17.7); c'=5.05(4.5-6.1); stylet=9.12(7.6-12.6); Tail=7.18(48.64-63.84); Gubernaculum=8.36(7.6-12.16); Spicules=22.04(16.72-27.36).

8 *Ditylenchus parvus* 16.2 14♀: L=573.9(553.52-792.54); a=40.2(30.4-46.6); b=5.4(5.1-6.1); c=6.6(5.9-10.2); c'=8.06(5.9-9.2); V=76.5(68-85); stylet=7.7(7.6-8.68); Tail=89.6(88.16-132.2).

9 *Ditylenchus tenuidens* 7.1 5♀: L=798.83(629-849.15); a=36.6(34.3-41.3); b=5.8(5-6.8); c=11.77(12-15.5); c'=6.05(3.8-4.4); V=78.5(64-85); stylet=9.1(8.68-9.92); Tail =59.3(53.94-65.1). 4♂: L=635.29(597.55-673.03); a=39.75(39.3-40.2); b=4.8(4.8-4.9); c=4(3-5); c'=18.6(15.5-21.7); stylet=7.75(7.44-8.06); Tail=34.72(3138.44); Gubernaculum=8.3(7.6-9.12); Spicules=17.05(15.5-18.6).

10 *Filenchus vulgaris* 42 15♀: L=704.48(578.68-773.67); a=34.1(26.1-42.4); b=6.4(5.2-7.8); c=7(5.9-7.8); c'=12.6(9.1-17); V=60.7(53-65); stylet=11.47(9.315.2); Tail=125.5(96.1-167.2). 4♂: L=668.3(566.1-754.8); a=34.25(22.6-43.4); b=5.8(5.3-6.8); c=7(5.9-7.8); c'=14.75(11.4-17.5); stylet=10.37(9.12-12.6); Tail length=131.8(99.2-159.6); Gubernaculum=7.22(6.08-7.6); Spicules=18.62(15.2-22.8).

11 *Helicotylenchus vulgaris* 50 6♀: L=944(723.35-1132); a=30.2(23.7-36); b=8.3(5.4-10.6); c=61.5(47.5-82.7); c'=0.9(69-12); V=56.78(50-62); stylet=31.6(30.434.96); Tail=15.5(13.68-18.6).

12 *Helicotylenchus digonicus* 12 9♀: L=762(566.1-943.5); a=28.1(24.8-34.4); b=8.3(5.4-10.6); b'=5.8(4.7-7.4); c=60.6(56.3-71); c'=0.8(0.6-1.5); V=57.5(52-68); stylet=27.9(21.08-31.92); Tail=17.2(15.2-19.76).

13 *Helicotylenchus minimi* 8.5 5♀: L=857(817.7-849.15); a=35.3(32.1-37.2); b=6.8(6.2-7.3); b'=6.25(5.7-6.5); c=43.9(38.3-50.7); c'=1.17(1.04-1.3); V=61.25(6062); stylet=24.32; Tail=20(15.5-25.42).

14 *Helicotylenchus pseudorobustus* 8.5 6♀: L=702.3(691.7-754.8); a=25.9(22.7-27.5); b=4.9(4.5-5.5); b'=4.4(4.1-5); c=37.85(32.5-47); c'=1.1(1.1-1.3); V=68; stylet=25.84; Tail=19.2(16.72-21.28).

15 *Irantylenchus vicinus* 18.5 10♀: L=723.2(660.45-880.06); a=41.5(32.3-48.2); b=7.1(6.1-8); b'=6.4(4.3-8.5); c=7.5(5.2-10); V=68.8(57-81); stylet=9.74(8.68-11.76); Tail=113.1(100-125.8).

16 *Merliniush brevidens* 18 10♀: L=697(578.68-691.9); a=31.93(26.1-36.8); b=5.7(4.2-7.5); c=12.87(10.9-15.1); c'=3.19(2.5-3.8); V=53.7(51-59); stylet=16.14(14.88-18.24); Tail=44.9(34.1-49.6); Tail annuli=35-45.
| Species                        | Males | Females | Length (μm) | Width (μm) | Tail Length (μm) | Stylet Length (μm) |
|-------------------------------|-------|---------|-------------|------------|------------------|-------------------|
| **Merlinius microdorus**      | 20    | 17      | 79.2        | 38.7       | 20.5             | 10.3              |
| **Mesocriconema xenoplax**    | 15    | 14      | 79.2        | 38.7       | 20.5             | 10.3              |
| **Neopsilenchus magnidens**   | 10    | 9       | 79.2        | 38.7       | 20.5             | 10.3              |
| **Nothotylenchus hexaglyphus**| 7.1   | 6.8     | 79.2        | 38.7       | 20.5             | 10.3              |
| **Pratylenchoides ritteri**   | 8.2   | 7.8     | 79.2        | 38.7       | 20.5             | 10.3              |
| **Pratylenchoides zurnensis** | 4     | 3.5     | 79.2        | 38.7       | 20.5             | 10.3              |
| **Pratylenchus thornei**      | 31    | 28      | 79.2        | 38.7       | 20.5             | 10.3              |
| **Pratylenchus neglectus**    | 7.1   | 6.7     | 79.2        | 38.7       | 20.5             | 10.3              |
| **Psilenchus iranicus**       | 5.7   | 5.2     | 79.2        | 38.7       | 20.5             | 10.3              |
| **Psilenchusa estuarius**     | 5.7   | 5.2     | 79.2        | 38.7       | 20.5             | 10.3              |
| **Scutylenechus rugosus**     | 23    | 20      | 79.2        | 38.7       | 20.5             | 10.3              |
| **Tylencyhanus arucatus**     | 7.1   | 6.7     | 79.2        | 38.7       | 20.5             | 10.3              |
| **Zygotylenchusguevaria**     | 20    | 18      | 79.2        | 38.7       | 20.5             | 10.3              |
| **Xiphinema index**           | 38    | 35      | 79.2        | 38.7       | 20.5             | 10.3              |
Figure 2. Histogram of Plant parasite nematodes associated with Grapes in Chaharmahal and Bakhtiyari province (South-Western of Iran) with their abundance.

Table 2. Distribution of Plant parasite nematodes in Grapes of various regions in Chaharmahal and Bakhtiyari province (South-Western of Iran)

| Sampling location | No. | Nematode species                                      | Shahrekord | Saman | Eshkaftak | Farokh shahr | Naghan | Lordegan |
|-------------------|-----|------------------------------------------------------|-------------|-------|-----------|---------------|--------|----------|
| 1                 | Amplimerliniusglobigerus | +          | +     | -      | -            | -      | -        |
| 2                 | Aphelenchusavenae        | +          | +     | -      | -            | -      | -        |
| 3                 | Aphelenchoideslimberi    | -          | -     | -      | -            | -      | +        |
| 4                 | Basiria gramininophila   | +          | -     | -      | -            | -      | -        |
| 5                 | Boleodorus thylactus     | +          | +     | -      | -            | -      | -        |
| 6                 | Costenchus polygyrus     | +          | -     | +      | -            | -      | -        |
| 7                 | Ditylenchus dipcasi      | +          | +     | -      | -            | -      | -        |
| 8                 | Ditylenchus parvis       | -          | +     | -      | -            | +      | -        |
| 9                 | Ditylenchus tenuidens    | +          | -     | -      | -            | -      | -        |
| 10                | Filenchus vulgaris       | +          | +     | +      | -            | -      | +        |
| 11                | Helicotylenchus vulgaris | +          | +     | +      | +            | +      | +        |
| 12                | Helicotylenchus digonicus| -          | +     | -      | -            | -      | -        |
| 13                | Helicotylenchus minzi    | +          | -     | -      | -            | -      | -        |
| 14                | Helicotylenchus pseudorobustus | -      | -     | +      | -            | -      | -        |
| 15                | Irantylenchus vicinus    | +          | +     | -      | -            | -      | +        |
| 16                | Merlinius brevidens      | +          | -     | -      | -            | -      | +        |
| 17                | Merlinius microdorus     | +          | +     | +      | -            | -      | -        |
| 18                | Mesocriconema xenoplax   | -          | +     | -      | -            | +      | -        |
| 19                | Neopsilenchus maginidens | -          | +     | -      | -            | -      | -        |
| 20                | Nothotylenchus hexaglyphus| -          | -     | -      | +            | -      | -        |
| 21                | Pratylenchoidea ritteri  | +          | -     | -      | -            | -      | -        |
| 22                | Pratylenchoidea erzumensis| -          | -     | -      | -            | +      | -        |
| 23                | Pratylenchus neglectus   | +          | +     | -      | +            | -      | -        |
| 24                | Pratylenchus thornei     | +          | -     | +      | -            | -      | -        |
| 25                | Psilenchus iranicus      | -          | -     | -      | -            | -      | +        |
| 26                | Psilenchus aestuarius    | -          | -     | -      | -            | -      | +        |
| 27                | Scutlenchus rugosus      | +          | +     | -      | -            | -      | -        |
| 28                | Tylenchus arcatius       | -          | +     | -      | -            | -      | -        |
| 29                | Zygotylenchusguevaria    | +          | -     | +      | +            | -      | -        |
| 30                | Xiphinema index          | +          | +     | +      | +            | +      | +        |
As mentioned in the table above, individual species distribution differed. The distribution of the obtained species were highest in Shahrekord and Saman regions and lowest in Lordegan and Naghan regions. According to the data obtained from Table 2, several cases are briefly mentioned: Helicotylenchus vulgaris, Xiphinema index were found in all of soil samples in the province and widely distributed. In other words, they were the most prevalent species identified. Conversely Helicotylenchus pseudorobustus, Pratylenchoides ritteri, Psilenchus iranicus and Psilenchus aestivali were found only in the soil of the Eahkaftak, Shahrekord and Lordegan regions respectively. Amplimerlinius gobiigerus, Aphelenchus avenae, Boleodorus thylactus, Ditylenchus dipcasi and Scutlenchus rugosus were found in the soil of the Shahrekord and Saman regions. Mesocriconema xenoplax and Ditylenchus parvus were found in soil and root samples from Saman and Naghan areas. Filenchus vulgaris was found in almost all sampled areas except Farkashar and Naghan regions. Pratylenchoides erzumensis was found only in a single vineyard located in Naghan and the last case, Irancylenchus vicinus was found in soil and root samples from Shahrekord, Saman and Naghan areas. Tylrenchus arcuatus, Neopsilenchus magnidens and Helicotylenchus digonicus were found only in the soil of the Saman region. (Table 2). There was a noticeable difference observed between distribution of nematodes from these vineyards. We do not know the cause of the between state differences in the grape PPN communities. This dispersion can be caused by the diversity of soil texture, physical and chemical properties of soil, temperature, amount and distribution of water in the soil profile and the transfer of seedlings from other areas are connected to these vineyards. Obviously, insufficient attention to seedlings containing soil contaminated with nematodes during transmission and distribution, can lead to increased diversity of plant parasitic nematodes and their further distribution.

CONCLUSION
The main goal of this study was to determine the extent of soil infestation by plant-parasitic nematodes in vineyards of key grapevine-growing areas of Chaharmahal and Bakhtiyari province of Iran. The fauna of plant parasite nematodes in Vineyards, were investigated, and 30 species belonging to 21 genera were identified. As a result of nematode infection there is slight yellowing of the leaves and decline in the plant health and vine vigour. Moreover, the injuries thus caused by nematodes on plant root tissues are predisposed for further infection by other pathogens present in the soil such as bacteria and fungi. Therefore, in order to improve the production and increase the yield of grapes, it is necessary to manage plant parasitic nematodes using methods that minimize economic, health and environmental risks. The results of this study will facilitate management decisions regarding plant parasitic nematodes for Chaharmahal and Bakhtiyari province, grape growers.

REFERENCES
Askary TH, and H. M. 2010. Plant parasitic nematodes associated with forest nurseries. Indian Journal of Nematology, 40: 239–240.
Askary, T. H., A. Khalil, A. A. Khan and N. Nazir. 2018. Population Fluctuation of Plant Parasitic Nematodes Associated With Grapevine under Hi-Tech and Low-Tech Polyhouse Conditions. International Journal of Current Microbiology and Applied Sciences, 7: 2133-2140.
Brown, D., A. Dalmaso and D. Trudgill. 1993. Nematode pests of soft fruits and vines. Plant parasitic nematodes in temperate agriculture: 427-462.
Brzeski, M. W. 1991. Review of the genus Ditylenchus Filipjev, 1936 (Nematoda: Anguinidae). Revue de Nématologie, 14: 9-59.
Carisse O., B. R., Lasnier J. and Mc fadden-Smith W. 2006. Identification guide to the major diseases of grape. Agriculture and Agri.-Food Canada, Publication 10092: 31.
Castillo P., T. D., B. Landa, F. P. Camacho, J. Rafael. 2007. Plant-Parasitic Nematodes Infecting Grapevine in Southern Spain and Susceptible Reaction to Root-Knot Nematodes of Rootstocks Reported as Moderately Resistant. The American Phytopathological Society, 91: 1147-1154.
De Grisse, A. T. 1969. Redescription ou modifications de quelques technique utilis [a] es dan l’etude des n [a] ematodes phytoparasitaires, 34: 351-369.
FAO. 2017. Food and Agricultural Organization, Production Year Book, FAO, Rome, Italy.
FAO. 2019. Food and Agricultural Organization, Production Year Book, FAO, Rome, Italy.
Geraert, E. 2008. The Tylenchidae of the world: identification of the family Tylenchidae (Nematoda). Academia Press, P.139.
Jenkins, W. 1964. A rapid centrifugal-flotation technique.
for separating nematodes from soil. Plant disease reporter, 48: 692.

Nicol, J. M., G. R. Stirling, B. J. Rose, P. May and R. Heeswijck. 1999. Impact of nematodes on grapevine growth and productivity: current knowledge and future directions, with special reference to Australian viticulture. Australian Journal of Grape and Wine Research, 5: 109-127.

Porica, H., M. Jagadeesha, and M. Suchitera. 2015. Effect of pruning severity on quality of grapes, cv. red globe for summer season. Advances in crop science and technology, 400.

Quist, C. W., G. Smant and J. Helder. 2015. Evolution of Plant Parasitism in the Phylum Nematoda. Annual Review of Phytopathology, 53: 289-310.

Raski, D. 1975. Revision of the genus Paratylenchus Micoletzky, 1922 and descriptions of new species. Part II of three parts. Journal of Nematology, 7: 274.

Rossetto, M., J. McNally and R. J. Henry. 2002. Evaluating the potential of SSR flanking regions for examining taxonomic relationships in the Vitaceae. Theoretical and Applied Genetics, 104: 61-66.

Santo, G. and W. Bolander. 1977. Effects of Macroposthonia xenoplax on the growth of Concord grape. Journal of Nematology, 9: 215.

Sasser, J. and S. JN. 1979. Pathogenicity, host ranges and variability in Meloidogyne species. In: E. Lamberti and C. E. Taylor (eds.), Root–knot nematodes (Meloidogyne spp.) systematics, biology and control. Academic Press, New York, PP. 477.

Siddiqi, M. R. Order. 2000. Tylenchida. Tylenchida: parasites of plants and insects. CABI, pp. 86-121.

SPCRI. 2020. Seed and Plant Certification and Registration Institute (http://www.spcri.ir).

Whitehead, A. G. and J. R. Hemming. 1965. A comparison of some quantitative methods of extracting small vermiform nematodes from soil. Annals of Applied Biology, 55: 25-38.

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| Author               | Contribution                                      |
|----------------------|---------------------------------------------------|
| Maryam Fayaz         | Help in writing manuscript, data collection and analysis |
| Esmat M. Moghadam    | Write original manuscript and conduct research     |
| Ali A. F. Tehrani    | Help in writing manuscript                         |