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A review of studies carried out on plant-parasitic nematodes infecting legumes and oilseed crops in Iran

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Abstract

Plant-parasitic nematodes cause economic damage to most agricultural crops including legumes and oilseed crops. In the present review, published data in Iran dealing with the importance of plant-parasitic nematodes on various legumes i.e. bean, broad bean, chickpea, lentil, mung bean, and oilseeds such as rapeseed and soybean are discussed. Generally, four categories of the studies were analyzed in this review: *i*) the population density of the plant-parasitic nematodes without considering the damage thresholds; *ii*) data on the evidences of the nematode impact e.g. observation of infection symptoms or evaluation of the host response in a pathogenicity test; *iii*) evaluation the importance of plant-parasitic nematodes indirectly by implementing certain management measures and *iv*) resistance reaction screening in legume and oilseed cultivars. The plant-parasitic nematodes reported from bean (39 species), broad bean (30 species), chickpea (45 species), lentil (33 species), mung bean (3 species), rapeseed (67 species) and soybean (32 species) in Iran until 2020 are also catalogued. The world's most important plant parasitic nematodes on legumes and oilseed crops and their distribution are introduced, and the possible threats of the world's important plant nematodes for the country's legumes and oilseed discussed.

Keywords: Damage threshold, pathogenicity, population density

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مروری بر مطالعات انجام شده روی نماتدهای انگل گیاهی در حبوبات و گیاهان دانه روغنی در ایران

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چکیده

نماتدهای انگل گیاهی باعث خسارت اقتصادی به اکثر محصولات کشاورزی از جمله حبوبات و گیاهان دانه روغنی می‌شوند. در این بازبینی، پژوهش‌های انجام شده در ایران روی نماتدهای انگل گیاهی مرتبط با انواع حبوبات مانند لوبیا، باقلا، نخود، عدس، ماش و گیاهان دانه‌های روغنی از جمله کلزا و سویا بررسی می‌شوند. به طور کلی، چهار دسته از پژوهش‌ها در این زمینه مورد تحلیل قرار می‌گیرند: ۱) مطالعات مربوط به تراکم جمعیت نماتدهای انگل گیاهی بدون در نظر گرفتن آستانه اقتصادی؛ ۲) مطالعات تأثیر نماتد روی گیاهان ازجمله مشاهده علائم بیماری و ارزیابی پاسخ میزبان در آزمون بیماری‌زایی؛ ۳) بررسی‌های مرتبط با اهمیت نماتدهای انگل گیاهی به طور غیرمستقیم با انجام برخی روش‌های مدیریتی و ۴) غربال ارقام مختلف حبوبات و گیاهان دانه‌های روغنی برای تعیین میزان مقاومت. هم‌چنین فهرست نماتدهای انگلی گیاهی گزارش شده تا سال ۱۳۹۹ از کشور ایران روی حبوبات مختلف شامل لوبیا (۳۹ گونه)، باقلا (۳۰ گونه)، نخود (۴۵ گونه)، عدس (۳۳ گونه)، ماش (۳ گونه)، کلزا (۶۷ گونه) و سویا (۳۲ گونه) ارائه شده است. مهم‌ترین نماتدهای انگل گیاهی حبوبات و گیاهان دانه روغنی در دنیا و پراکنش آنها معرفی شده و نیز تهدیدات احتمالی نماتدهای قرنطینه‌ای کشور روی این محصولات مورد بحث قرار گرفته است.

واژه‌های کلیدی: آستانه اقتصادی، بیماری‌زایی، تراکم جمعیت

Introduction

Legumes are the second most important plant source of protein-rich foods for humans after cereals. Also, these plants cause improvement of soil structure by biological nitrogen fixation. In the year 2018-2019 in Iran, about 1085346 hectares were under cultivation of legumes and oilseed crops (soybean and rapeseed). The yield production of legumes and oilseed crops in the country was estimated about 1167557 tons (Agriculture statistics 2020). Plant pathogens are one of the most important limiting factors of legumes and oilseed production in the world; for example, chickpea is attacked by 67 species of fungi, three species of bacteria, 22 species of viruses and phytoplasmas and 80 species of nematodes, some of which are of economic importance (Parsa & Bagheri 2008). The history of nematology in Iran dates back to 60 years ago. The updated list of identified nematodes in Iran, including surveys and taxonomic studies of the nematodes, has already been documented by Ghaderi *et al.* (2018). Plant-parasitic nematodes are important damage agents of crop production, in some documents the rate of nematode damage on plants is estimated about 12%, which is a very high rate (Sasser 1989). More than 70 species of nematodes have been reported from legume and oilseed fields in the world, of which *Meloidogyne javanica*, *M. incognita*, *Heterodera ciceri*, *Pratylenchus thornei* and *Ditylenchus dipsaci* caused the most damage to these plants. The damage rate of *H. ciceri* in chickpea fields is estimated to be between 20 to 50%. Root-lesion nematodes, *Pratylenchus neglectus* and *P. thornei* have reduced crop yields by 25 to 60% on chickpea fields in Australia (Thompson *et al.* 2000). In addition, in dryland lentil farms, infection by *Pratylenchus neglectus*, *P. thornei* and *P. hamatus* showed symptoms such as decreased growth, wilting and yellowing and 40% yield reduction (Riga *et al*. 2008). Soybean cyst nematode (*Heterodera glycines* Ichinohe, 1952) is one of the major limiting factors of soybean production in the world, the nematode can reduce 3025400 tones in annual yield in 10 major soybean producing countries in the world and has considered as the most important economic disease of soybeans in the world (Wrather *et al*. 1997).

In Iran, nearly little researches have been carried out on the pathogenicity and crop losses due to plant-parasitic nematodes on legumes and oilseed crops, so, these data cannot provide a real estimate of the damage value of the pathogens. The aim of this study, therefore was to collect the published documents regarding the pathogenicity and damage of parasitic nematodes on legumes and oilseeds, to have a better view of the amount of nematode damage and related research conducted in the country, as well as understanding the future research needs and gaps in this field.

Bean (*Phaseolus vulgaris* L.)

The reported plant-parasitic nematode species associated with bean from Iran are: *Amplimerlinius macrurus, A. paraglobigerus, Aphelenchoides centralis, A. cyrtus, Aphelenchus avenae, A. isomerus, Boleodorus thylactus, Criconemoides parvus, Ditylenchus affinis, D. dipsaci, D. kheirii, D. medicaginis, D. parvus, Heterodera glycines, Helicotylenchus digonicus, H. pseudorobustus, H. tunisiensis , H. vulgaris, Meloidogyne incognita, M. javanica, M. microcephalus, Merlinius brevidens, M. microdorus, Mesocriconema antipolitanum, Neopsilenchus magnidens, Paratylenchus coronatus, P. idalimus, P. similis, Pratylenchoides ritteri , Pratylenchus neglectus, P. penetrans, P. pseudopratensis, P. scribneri, P. thornei, Scutylenchus rugosus, S. stegus, Tylenchus minutus, Xiphinema pachtaicum,* and *Zygotylenchus guevarai* (Azizi & Karegar 2014; Azizi *et al*. 2016; Ghaderi *et al*. 2020).

In a host screening of 11 common bean cultivars including Akhtar, Daneshkade, Derakhshan, Sayad, Dehghan, Goli, Talash, Naz, Contender, Sunray and Khomein against HG Type 0 (race 3) of *H. glycines*, the cultivars Dehghan and Sayad were classified as moderately resistant and Contender as the most susceptible (Heydari *et al*. 2008a). Whilst in a similar study conducted in both greenhouse and field conditions, most of the common bean cultivars were evaluated as susceptible / moderately susceptible to *H. glycines* HG Type 0 (race 3). In greenhouse trial, Sayad and Dehghan cultivars were classified as moderately resistant while the two cultivars showed moderately resistant and moderately susceptible, respectively under field conditions (Heydari *et al*. 2010).

The interaction between root-knot nematode *M. javanica* and *Rhizobium leguminosarum* pv. *phaseoli* on kidney bean that was studied under greenhouse conditions, revealed that the single application of bacterium increased the dry root weight and the level of nitrogen in roots and shoots, moreover the nematode population decreased after the application of the bacterium. It was suggested that inoculation the plants with bacteria might increase the tolerance to a high population of nematodes due to increasing of root system or modification of root metabolites (Jafarzadeh *et al*. 2006).

The inoculation of *M. javanica* and *Fusarium oxysporum* on red bean cultivars under greenhouse conditions showed maximum wilt symptoms in those cultivars that simultaneously treated with both nematode and fungus (Faraji *et al*. 2007). The greatest reduction in growth parameters was obtained in an interaction study of *M. javanica* and *Macrophomina phaseolina* in green bean *cv*. 418 Jamaran under greenhouse conditions (Imani *et al*. 2014).

The impact of irrigation intervals was studied on the reproduction factor of root-knot nematode, and its damage on navy bean under greenhouse conditions, as well. The understudy cultivars showed different reactions to nematode damage under different irrigation intervals, so that, the number of galls, egg sac, final nematode population and reproductive factor were affected, so that, maximum and minimum rates of all the four factors were related to 48h and 96h irrigation cycles, respectively, indicating less aggressiveness of nematode in the low soil moisture (Kamelmanesh & Yarmahmoodi 2013).

In a greenhouse study, bean cultivars *viz* Derakhshan, Akhtar, Azna, Naz, Jamaran, Goli, Sayad and Khomein showed different susceptibility to *M. javanica*. Regarding the growth-factors, Sayad, Azna and Akhtar cultivars were significantly affected less than the other cultivars. In case of nematode-reproduction parameters, Khomein, Jamaran and Derakhshan cultivars showed less susceptibility (Ghayedi & Abdollahi 2014). Resistance of some bean cultivars namely Naz, Sayad, Dorsa and Almas and the lines COS16, D81083, KS21191, KS31169 and KS21676 were evaluated against *M. javanica* under greenhouse conditions, results showed that Almas, Dorsa, Naz and Sayad cultivars are tolerant to the nematode while the lines KS21676, KS21191, KS31169, COS16 and D81083 were susceptible. The highest fresh shoot weight observed in line COS16. The cultivar Sayad and line D81083 revealed the highest and lowest number of seeds per pod, respectively (Rahimi *et al*. 2018).

About 95% of the studied bean fields of Markazi province were found infected with *Pratylenchoides ritteri* Sher, 1970. Density of the mixed populations of *P. ritteri* and *Pratylenchus neglectus* (Rensch, 1924) Filipjev and Schuurmans Stekhoven, 1941 ranged from 20 to 430 nematodes per 250 cm^3 of soil (Hatamabadi Farahani & Tanha Maafi 2018). Furthermore, 93%, 42% and 22% of the studied bean fields of Khomein, Arak and Shazand were found infected with *P. neglectus*, respectively. The population ranges were obtained 50-530 nematode / 250 cm^3 of soil (Hatamabadi Farahani & Tanha Maafi 2018). The multiplication rate of *P. neglectus* and *P. thornei* on common bean were recoded as 1.47 and 6.65 times, respectively under greenhouse conditions (Ghaderi *et al*. 2009).

Broad bean (*Vicia faba* L.)

The following plant-parasitic nematode species associated with broad bean have been reported from Iran so far: *Amplimerlinius paraglobigerus, Aphelenchoides cyrtus*, *Aphelenchus avenae, A. isomerus, Ditylenchus gigas, D. medicaginis, D. parvus, Filenchus vulgaris, Helicotylenchus scoticus, H. tunisiensis, H. vulgaris, Hoplolaimus seinhorsti*, *Merlinius brevidens, M. microdorus*, *Nagelus obscurus*, *Paratylenchus coronatus*, *Paratylenchus similis*, *Pratylenchoides ritteri*, *Pratylenchus crassi*, *P. neglectus*, *P. pseudopratensis, P.delattrei*, *P. scribneri, P. teres*, *P. thornei*, *P. zeae*. *Scutylenchus rugosus, S. tartuensis, Tylenchorhynchus parvus, Zygotylenchus guevarai*. (Azimi & Mahdikhani‑Moghadam 2013; Azizi & Karegar, 2014; Mohammadi Zameleh *et al.* 2018; Ghaderi *et al*. 2020).

Ditylenchus gigas Vovlasa, Troccolia, Palomares-Riusb, De Lucaa, Lie´banasc, Landab, Subbotinde & Castillob, 2011 and *D. dipsaci* seem to be the only plant parasitic nematodes reported from aboveground of broad bean in Iran. The infection symptoms caused by *D. gigas* including necrotic lesions on the stem surface and reduction of the length of internodes were observed in the aboveground of broad bean plants in the fields. About 48% of the 23 collected samples of broad bean cv. Barekat in Mazandaran and Golestan provinces in the northern Iran were found infected by the stem nematode, *D. gigas* mostly with a high population density, meanwhile in Lorestan and Kermanshah provinces in the western Iran, 77% of the collected samples of cv. Shakhbozy were found infected by *D. gigas* (Tanha Maafi *et al*. 2013).

Chickpea (*Cicer arietinum* L.)

Forty-five species of plant-parasitic nematodes associated with chickpea have been reported from Iran: *Aphelenchoides cyrtus, Aphelenchoides graminis, A. obtusus, A. spicomucronatus, Aphelenchus avenae, A. isomerus, Atetylenchus abulbosus, Basiria gracilis, B. tumida, Ditylenchus adasi, D. dipsaci, D. equalis, D. medicaginis, D. myceliophagus, D. parvus, Filenchus andrassy, F. cylindricaudus, F. facultativus, F. hamatus, F. thornei F. vulgaris, Geocenamus tenuidens, Helicotylenchus ciceri, H. scoticus, H. tunisiensis, H. vulgaris, Meloidogyne incognita, M. javanica, Merlinius brevidens, M. microdorus, Nagelus obscurus, Neopsilenchus magnidens, Nothotylenchus adasi, Paratylenchus coronatus, P. elachistus, P. similis, Pratylenchoides ritteri, Pratylenchus neglectus, P. pseudopratensis, P. thornei, Scutylenchus rugosus, S. tartuensis, Trophorus ussuriensis, Tylenchorhynchus parvus,* and *Zygotylenchus guevarai* (Azizi & Karegar 2014; Ghaderi *et al.* 2018; Mohammadi Zameleh *et al*. 2018; Ghaderi *et al.* 2020; Ahmadi *et al.* 2014).

The main studies on chickpea were focused on the interactions between root knot nematodes and root lesion nematodes with *Fusarium* wilt disease. *Meloidogyne incognita* Kofoid & White, 1919 race 1 caused breakdown of host resistance to *Fusarium oxysporum* f. sp. *ciceri* on cultivar Pusa 212 as a resistant cultivar. Meanwhile, the treatment of nematodes alone decreased dry weight of roots and shoots and reduced the number of nitrogen nodes, compared to other treatments. Maximum wilting symptoms, growth reduction and the reduced number of nitrogen nodes were observed when both nematode and fungus were simultaneously inoculated (Hosseini Nejad & Khan 2001).

The highest reduction in fresh/dry weights of plants, the number of pods/plant and delay in flowering were observed in an interactive effect of *M. incognita* and *Fusarium oxysporum* f. sp. *ciceri* in plants that were simultaneously inoculated with the both causal agents (Ramazani 2006).

Interaction of *M. javanica* and *Rhizobium leguminosarum* bv. *phaseoli* on lentil, Iranian chickpea, French chickpea and beans showed highest growth index in Iranian chickpea treated with bacterium alone; however, bacterial colonization was reduced in the presence of nematode in the root and *vice versa*, the number of produced galls and egg masses by the nematode was also reduced in the presence of the bacterium (Tabatabaei & Saeedizadeh 2017).

The results of interaction between *P. thornei* and *Fusarium oxysporum* f. sp. *ciceri* on chickpea cultivars ILC 482 and Bionij indicated that the treatment of the nematode alone caused a reduction in fresh/dry weights and plant length. Wilting severity increased in the presence of nematode, as compared to plants inoculated only with the fungus. The greatest damage to the cultivars was observed when the nematode and fungus were simultaneously inoculated (Akbari *et al*. 2000).

Lentil (*Lens culinaris* L.)

The plant-parasitic nematode species reported from lentil rhizosphere in Iran are as follows: *Aphelenchoides limberi, A. cyrtus, A. graminis, A. spicomucronatus, Aphelenchus avenae, A. isomerus, Ditylenchus equalis, D. medicaginis, D. myceliophagus, D. parvus, D. tenuidens , Filenchus cylindricaudus F. thornei F. vulgaris, Geocenamus tenuidens, Helicotylenchus scoticus, H. tunisiensis, H. vulgaris, Meloidogyne* sp., *Merlinius brevidens, M. microdorus, Neopsilenchus magnidens, Paratylenchus coronatus, P. similis, Pratylenchoides ritteri, Pratylenchus neglectus, P. pseudopratensis, P. thornei, Scutylenchus rugosus, S. tartuensis, Tylenchorhynchus dubius, Tylenchorhynchus parvus* and *Zygotylenchus guevarai.* (Azizi & Karegar 2014; Ahmadi *et al.* 2014; Ghaderi *et al.* 2018; Mohammadi Zameleh *et al*. 2018; Ghaderi *et al.* 2020). Reaction of 22 lentil varieties to root-knot nematode (*Meloidigyne* sp.) was studied under greenhouse conditions, as a result, varieties of 7059 and 7072 were the most resistant and susceptible with 53 and 188 nematodes per 0.5 gram of roots, respectively; the number of nematodes varied between 53-188 per 0.5 g of roots in other varieties (Rasoulian 1970).

Mung bean (*Vigna radiata* L.)

Some endoparasitic nematodes associated with mung bean have been reported from the country viz. root-knot nematodes (*M. incognita* and *M. javanica*) from Esfahan and Yazd provinces (Barooti 1974; Akhiani *et al*. 1984), *Pratylenchus neglectus* from Golestan province (Saeedi *et al.* 2019) and *Trophurus ussuriensis* from East Azerbaijan (Azizi 2016). However, the damage potential of these nematodes has not been investigated yet.

Rapeseed (*Brassica napus* L.)

The following species of plant-parasitic nematode species have been recorded in association with rapeseed in Iran: *Amplimerlinius globigerus*, *Aphelenchoides centralis*, *A. composticola*, *A. confuses*, *A. daubichaensis*, *A. delhiensis*, *A. limberi*, *A. parabicaudatus*, *A. rutgersi*, *A. spicomucronatus*, *Aphelenchus avenae*, *Basiria tumida*, *Boleodorus thylactus*, *Coslenchus multigyrus*, *Ditylenchus acutus*, *D. medicaginis*, *D. myceliophagus*, *Filenchus afghanicus*, *F. cylindricaudus*, *F. thornei*, *F. vulgaris*, *Heterodera avenae*, *H. filipjevi*, *H. schachtii*, *H. trifolii*, *Helicotylenchus californicus*, *H. canadensis*, *H. crassatus*, *H. digonicus*, *H. dihystera*, *H. egyptiensis*, *H. exallus*, *H. pseudorobustus*, *H. tunisiensis*, *H. vulgaris*, *Megadorus megadorus* , *Merlinius brevidens*, *M. nanus*, *M. nothus*, *Mesocriconema xenoplax*, *Neopsilenchus magnidens*, *Psilenchus hilarulus*, *P. iranicus*, *Paratrophurus costarricensis*, *Paratylenchus coronatus*, *P. perlatus*, *P. similis*, *P. tateae*, *Pratylenchoides ritteri*, *Pratylenchus brachyurus*, *P. penetrans*, *P. neglectus*, *P. pseudopratensis*, *P. thornei*, *Quinisulcius acti*, *Scutylenchus quadrifer*, *S. rugosus*, *S. tartuensis*, *S. tessellatus*, *Trophorus lomus*, *Tylenchorhynchus brassicae*, *T. brevilineatus*, *T. dubius*, *T. goffarti*, *T. parvus*, *T. teeni* and *Zygotylenchus guevarai*. (Naseri *et al*. 2008; Baadl *et al*. 2010; Baadl *et al*. 2013; Ghaderi *et al*. 2018; Ghaderi *et al*. 2020).

Hatching activity, invasion rate and reproduction rate of *Heterodera schachtii* (Schmidt, 1871) Skarbilovich, 1959 were studied on Cobra, Global, Kl6 and Tower cultivars of rapeseed under greenhouse conditions. The hatching rates in root leachates were 24.5, 17.4, 9 and 8% for Cobra, Global, Kl6 and Tower cultivars, respectively. The J2s of the nematode penetrated to the roots of all cultivars (Fatemy & Abootorabi 2002). In a greenhouse study, the tested cultivars showed different susceptibility to *H. schachtii*. The number of cysts and reproduction factor for the cultivars Licord, Eural and Okapi were higher than that of Honson and Fornax cultivars (Ahmadian Yazdi & Moravej 2006). In a field trial with initial population density of 2100 eggs and J2/100 g of soil of sugar beet cyst nematode, yields in cultivars of rapeseed Colvert, Honson, Eural, Fornax and RegentX Cobra were 2544, 2416, 2399, 2325 and 2070 kg/ha, respectively (Ahmadian Yazdi 2008).

sefaensis, *P. thornei*, *Psilenchus hilarulus*, *Rotylenchus lobatus*, *Tylenchorhynchus brassicae*, *T. crassicaudatus*,

Fatemy *et al*. (2006) reported large numbers of *P. neglectus* and *P. thornei* from the rhizosphere and in roots of rapeseed at different regions of Iran. An average of 28 and 321 individuals of *P. thornei* were found per gram of Regents × Cobra and Orient cultivars root, respectively. An average of 30, 1026, 626, and 450 individuals of *P. neglectus* per gram of root were detected from RegentX Cobra, Orient, Okapi, and GLSIO, respectively. Heavily infected plants were stunted and had dark lesions on roots, a typical symptom of root lesion nematodes on host plants, greater population density of nematode was revealed in roots compared with soil.

Root lesion nematodes, *P. neglectus* and *P. thornei* were also reported from root samples collected from rapeseed fields in Esfahan province as well, so that 81% of the soil samples were found infected by juveniles and adults of the both species, while *P. neglectus* was found in 77% of soil samples. The mean population density of *P. thornei* and *P. neglectus* were 3 and 20 nematodes per g of fresh root which followed by the frequency of 4% and 67% of root samples, respectively (Karimipourfard 2008). *Pratylenchus neglectus* showed higher reproduction rate on rapeseed compared to *P. thornei* in a greenhouse study, 4.48 *vs* 1.4 (Ghaderi *et al*. 2009).

AhmadianYazdi & Rastegar Peymani, (2012) reported that 83.3% of soil samples and 76.9% of root samples in rapeseed fields of Khorasan Razavi province were infected with *P. neglectus* and *P. thornei*, they also showed that *P. neglectus* was more common than *P. thornei* in soil and root samples. Population densities of *P. neglectus* and *P. thornei* were 96.8 and 73.5 nematodes per 100 cm^3 of soil and 428.2 and 84.8 per 1 g of root, respectively.

Soybean (*Glycine max* (L.) Merr.)

Aphelenchoides parabicaudatus, *Aphelenchus avenae*, *Boleodorus thylactus*, *Ditylenchus affinis*, *D. anchilisposomus*, *D. destructor*, *D. dipsaci*, *D. kheirii*, *Filenchus afghanicus*, *F. helenae*, *F. sandneri*, *Helicotylenchus digonicus*, *H. pseudorobustus*, *H. vulgaris*, *Heterodera glycines*, *Irantylenchus clavidorus*, *Meloidogyne hapla*, *M. incognita*, *M. javanica*, *Merlinius brevidens*, *M. microdorus*, *Pratylenchoides ritteri*, *Pratylenchus neglectus*, *P. penetrans*, *P.*

T. graciliformis, *Tylenchus davainei* have been reported from the rhizosphere and root of soybean from Iran (Ghaderi *et al*. 2020).

Studies by Tanha Maafi *et al*. (2008) revealed that the infestation of soybean fields of Mazandaran and Golestan provinces with soybean cyst nematode (*H. glycines*) were 19% and 26%, respectively. The population densities of J2s and eggs ranged from 500-60000 and 500 to ≥100,000 per 250 cm^3 of soil, respectively. Race 3 or HG Type 0 with a frequency of 94% was the most common race in Iran, while race 6 or HG Type 7 was only found in 6% of the tested populations. Most populations of *H. glycines* race 3 parasitized the PI88788 and PI548316 indicator lines. Out of eight soybean cultivars commonly tested against *H. glycines* race 3, seven cultivars, including Sepideh, Sahar (Pershing), Gorgan 3, Williams 82, JK (Sari), BP (Telar) and Hill, had high female indices and were evaluated as susceptible to race 3, whilst only the cultivar DPX showed low female indices and reported as resistant to the race (Tanha Maafi *et al*. 2008). Susceptibility of more members of soybean cultivars i.e. Sepideh, Sahar, Gorgan 3, Sarigol, Zane, Clark, 033, 032, M9, L17, Hill, BP, Williams, Tiffin, 29/I and M7) to Hg Type 0 of soybean cyst nematode was proved in further research, obviously DPX showed less susceptibility (Heydari *et al*. 2008b). Further evaluation of soybean lines and cultivars against dominant race of *H. glycines* were conducted by several researchers (Dehghanzadeh *et al*. 2016; Shahabi *et al*. 2010; Solimani *et al*. 2018).

The biology of SCN was studied under growth chamber and field conditions. There were five generations of *H. glycines* during a growing season in Mazandaran province, which was same as the results of growth chamber studies. However, the development of juveniles from third to fourth stage was obviously suppressed in the resistant cultivar DPX (Heydari *et al*. 2010).

The yield losses affected by soybean cyst nematode, HG Type 0 was studied on susceptible and resistant soybean cultivars in naturally infested fields. The mean yield for the resistant cultivar DPX was 48% higher than the susceptible cultivar BP. Also, compared to untreated plots, the yield of BP increased by 16% in treated plots with application of fenamiphos nematicide. The resistant cultivar was also found to suppress the rate of reproduction of *H. glycines* (Heydari *et al.* 2012). The interaction of *H. glycines* Type 0 and *Bradyrhizobium japonicum* was also studied on two soybean cultivars, DPX and JK resistant and susceptible to *H. glycines*, respectively (Ghafari *et al.* 2012). The results showed that *H. glycines* Hg Type 0 (race 3) cause significant decrease on bacterial growth parameters and plant growth factors, in all combinations of *B. japonicum* and SCN.

Discussion

Table 1 presents the most important nematode parasites of legumes and oilseeds crops in the world and their distribution, the legumes and oilseed crops that are associated with or as host for the nematodes in Iran have also been given.

Several documentations of damages caused by the most important plant parasitic nematodes reported on legumes and oil seed crops in the world are presented and discussed. The growth reduction of bean in soil infested with *M. javanica* at 10 egg/g of soil was recorded as 82% in glasshouse experiments, and 35-53% reduction with *M. javanica* at 4 eggs/cm^3 of soil in pot experiments (Crozzoli *et al.* 1997) . False root-knot nematode, *Nacobbus aberrans*, reduced crop yields by 36% on bean fields (Manzanilla-Lopez *et al*. 2002) and pigeon pea cyst nematode, *H. cajani*, reduced by 24% (Zaki & Bhatti 1986). *Aphelenchoides besseyi* is known to be the causal agent of black spot disease in beans (Chaves *et al*. 2013).

The damage rate of *D. dipsaci* giant race (now known as *D. gigas*) in broad bean fields is estimated at the level of 60 - 100% (Decker 1969) .The threshold level of *H. goettingiana* on broad bean was reported 0.8 eggs/g soil, although 64 eggs/g soil resulting in complete crop failure (Greco *et al*. 1991).

Table 1. The world's most important legumes and oilseed nematode parasites and their distribution, plants marked in bold are in association or as host for the nematodes in Iran

Species	Important hosts	Distribution	Species	Important hosts	Distribution
Meloidogyne arenaria	Bean, Broad beans, Chickpea, Soybean	worldwide	*P. neglectus*	**Bean, Chickpea, Lentil,** Rapeseed	worldwide
M. artiellia *	Broad beans, Chickpea	Russia, China, Turkey, Syria, Jordan, Greece, Italy, Spain, Britain, France	*P. penetrans*	**Bean,** Rapeseed	worldwide
*M. brasiliensis**	Bean	Brazil	*P. pinguicaudatus**	Bean, Chickpea	England
*M. chitwoodi**	Bean	Turkey,Some American and European countries, South Africa and Mozambique	*P. pratensis**	Chickpea	USA, India and Pakistan
M. hapla	Bean, Rapeseed,	worldwide	*P. thornei*	**Bean, Chickpea, Lentil**	worldwide
M. incognita	**Bean**, Broad beans, **Chickpea**, Lentil, Mung bean, Rapeseed, **Soybean**	worldwide	*P. scribneri*	Bean**,**	Pakistan, Mangolia, Turkey, Italy, Cameroon, USA
M. javanica	**Bean**, Broad beans, **Chickpea**, Lentil, Mung bean, **Soybean**	worldwide	*P. zeae*	Bean, Chickpea	worldwide
*Heterodera cajani**	Bean. Soybean	Pakistan, India, Myanmar and Egypt	*Nacobbus aberrans**	Bean	Mexico, USA, Argentina, Bolivia, Chile, Peru, Ecuador
*H. ciceri**	Chickpea, Lentil	Turkey, Syria, Jordan, Italy, Netherlands and Spain	*Radopholus similis**	Soybean	worldwide
H. cruciferae	Rapeseed	Iran, Russia, Pakistan, Turkey, Algeria, England, Switzerland	*Rotylenchus reniformis*	Bean, Chickpea, Lentil, Mung bean, Rapeseed, Soybean	worldwide
H. glycines	**Bean,** Mung bean, Rapeseed**, Soybean**	Many Asian and American country, Russia, Italy	*Ditylenchus africanus**	Bean, Chickpea, Soybean	South Africa and Mozambique
H. goettingiana	Broad beans**,** Chickpea	Many Asian and European country, Algeria, USA	*D. dipsaci*	**Bean,** , Broad beans, **Chickpea,** Lentil	worldwide
H. trifolii	Chickpea, Rapeseed	worldwide	*D. gigas*	**Broad beans**	Iran, Syria, Europe, Algeria, Morocco
*Pratylenchus alleni**	Bean	England	*Aphelenchoides besseyi*	Bean	worldwide
P. brachyurus	Soybean	worldwide	*A. ritzemabosi*	Bean	worldwide
P. crenatus	Chickpea	Iran, USA, Canada, Europe, Japan	*Xiphinema americanum*	Bean, Soybean	worldwide
P. fallax	Rapeseed	Turkey, USA, Canada,some European country, South Africa	*Belonolaimus* spp*	Bean	American countries
*P. goodyi**	Bean	African countries, China, Pakistan, Spain, Portugal, Greece and Australia	*B. longicaudatus**	Soybean	Turkey, Saudi Arabia, Pakistan and USA
P. mediterraneus	Chickpea	Some European, Asian and African country	*Hoplolaimus columbus**	Soybean	India, Pakistan, Egypt and USA

*: species that not reported from Iran

The global damage caused by nematodes in chickpeas is estimated about 13.7% (Sharma *et al*. 1992). *Meloidogyne incognita* and *M. javanica* cause yield losses of 19 - 40% in India (Ali & Sharma 2003). *Meloidogyne artiellia* with 2000 nematodes per liter of soil at planting time causes yield losses of 50 to 80% (Di Vito & Greco 1988). *Pratylenchus thornei* and *P. neglectus* have reduced chickpea yields by 25-60% in Australia (Thompson *et al*. 2000). In chickpea fields with 11600 individuals of *P. thornei*/kg soil at the time of planting, there was a 25% yield loss (Thompson *et al*. 2000; Reen *et al*. 2014). *Pratylenchus thornei* with 2000 nematodes per liter at planting time resulted in yield losses of up to 58% under field conditions in Syria (Di Vito *et al.* 1992). *Heterodera cajani* caused a 70% reduction in the total number of dry pods in Egypt (Aboul-Eid & Ghorab 1974). Yield losses of 20 and 50% occurred in fields infested with 8 and 16 eggs of *H. ciceri* /cm^3 of soil, respectively. Complete crop losses occurred in fields infested with more than 60 eggs/cm^3 soil (Greco *et al.* 1988). Ten individuals of *Rotylenchulus reniformis*/g soil caused an 80% reduction in pea growth (Mahapatra & Padhi 1986).

Yield losses of 50% occurred in fields infested with more than 64 eggs/cm^3 soil of *H. ciceri* infested field (Greco *et al*. 1988). *Pratylenchus neglectus* and *P. thornei* cause symptoms such as stunting, wilting and yellowing in irrigated lentil fields and reduced yield of 40% (Riga *et al*. 2008). Another nematode that reduced yields is the giant race of *D. dipsaci*. Nematodes other than *H. ciceri* are also found in associated with legumes and oil seeds Iran (Table 1).

In mung bean, co-infection with *M. incognita* and *R. reniformis* showed a 28% reduction in yield (Castillo *et al*. 1977). Yield losses of 18-90% occurred in mung bean fields infested with *Meloidogyne* spp. (Khan *et al*. 2010; Ali & Singh 2007).

Heterodera cajani reduced soybean yields by 24%. Losses of 90% by *M. incognita* have been reported from Florida (Kinloch 1974). *Heterodera glycines* is an important limiting factor in Italy (Manachini 2000) and a yield reduction of 10 to 80% has been attributed to this nematode (Jacobsen *et al*. 1983).

Azizi (2022) reported that broad bean, soybean, lentil, bean, mung bean and chickpea are hosts for *P. ritteri* and under greenhouse conditions this nematode caused reduction in most of growth indices of the plants.

Many of the nematode species reported on legumes and oil seed crops in the world are distributed and also reported in Iran, whereas there is no evidence of the presence of some species in Iran, as such *M. chitwoodi*, *M. artiellia, H. cajani, H. cicero* and *Nacobbus aberrans*.

It is obvious that in both cases, the known and unknown situation of parasitic nematodes in legume fields in Iran, the internal and external quarantine regulations must be very alert throughout the country to check the imported seeds in terms of soil and plant materials residues and to monitor the bean fields for possible infestation by unreported plant parasitic nematodes.

In the present study a list of plant parasitic nematodes reported on legumes and oilseeds from 1970 to 2020 are given. Generally, four categories of research works are discussed in this review: *i*) the population density of the plant-parasitic nematodes without considering the damage thresholds; *ii*) data on the evidences of the nematode impact e.g. observation of infection symptoms or evaluation of the host response in a pathogenicity test; *iii*) evaluation the importance of plant-parasitic nematodes indirectly by implementing certain management measures and *iv*) resistance reaction screening in legume and oilseed cultivars. Due to the varied climatic conditions across Iran, cultivation of different crops and high distribution of plant parasitic nematodes in the country, there are great gaps and shortcomings in the documented data on the damage and pathogenicity of many parasitic nematodes including nematodes from the families of Pratylenchidae, Anguinidae, Dolichodoridae, Hoplolaimidae and others on various agricultural crops especially legumes and oilseed crops. Furthermore, in some cases, the available information is limited to the research carried out under laboratory and greenhouse conditions, which is likely show various results with that of farm conditions.

Many nematode species have been reported with a widely distribution from different regions in Iran. Nevertheless, there is no information about the damage rate imposed by the nematodes. It is worthy of note that the most research works do not follow a continuous and successive plan for all the necessary steps of research from identification to evaluation of potential damage caused by the identified nematode species on certain crops and ultimately suitable management approaches, so, it is clear that all these factors could be led to a successful, fruitful and excellent researches. However, researches on potential pathogenicity of plant parasitic nematodes and crop losses in the world are focused to certain well-known parasitic nematodes and high value crops as well.

Following the correct identification of the nematode species, integration of management approaches such as use of resistant and tolerant crops along with appropriate agronomic practices such as effective rotations with non-hosts and fallow are considered as the safest, most practical, economic and effective strategies for management of plant-parasitic nematodes. Rotation with non-host crops, such as sun hemp and red clover, is an effective and practical method for reducing *Heterodera glycines* populations (Kushida *et al.* 2002; Warnke *et al*. 2008). Cultivation of green manure for two months decreased the density of SCN (Kushida *et al*. 2003). Studies by Chikamatsu *et al*. (2017) revealed that short-term growth of mung bean may be useful to decrease the density of *Heterodera glycines* in soil. Host-plant resistance for nematodes especially *Meloidogyne* spp. has been reported in many crop species. Finally, the future priority of nematology in Iran should be focused on finding and developing new and ecofriendly management strategies, so the farmers can use them for integrated management of nematodes purposes.

References

Aboul-Eid H.Z. & Ghorab A.I. 1974. Pathological effects of *Heterodera cajani* on cowpea. *Plant Disease Reporter* 58(12), 1130–1133.

Agriculture statistics 2019. 2020. Ministry of Jihad-e-Agriculture, Economic and planting assistance information and communication technology center. First volume, crop products 89 p (In Persian).

Ahmadi S., Mahdikhani Moghaddam E. & Baghaee Davari S. 2014. Identification of plant parasitic nematode collected from pulse fields in Northern Khorasan province. *Iranian Journal of Pulses Research* 5(2), 111-118. (In Persian with English summary).

Ahmadian Yazdi A. 2008. Investigations on tolerance and yield of different cultivars of rapeseed to sugar beet cyst nematode in Khorasan Razavi province. In *Proceedings of the 18th Iranian Plant Protection Congress* (p. 600). Hamadan, Iran.

Ahmadian Yazdi A. & Moravej G. 2006. Evaluation of the effects of some rape (*Brassica napus*) cultivars on the reproduction of sugar beet cyst nematode *(Heterodera schachtii)* in laboratory conditions. In *Proceedings of the 17th Iranian Plant Protection Congress* (p.116). Karaj, Iran.

Ahmadian Yazdi A. & Rastegar Peymani A. 2012. Status of root lesion nematodes (*Pratylenchus neglectus*, *P. thornei*) in rapeseed fields of Khorasan Razavi province. In *Proceedings of the 20th Iranian Plant Protection Congress* (p. 629). Shiraz, Iran.

Akbari K., Minasian V., Hojat Jalali A. A. & Hosseni Nejad A. 2000. Interaction between lesion nematode *Pratylenchus thornei* and *Fusarium oxysporum* f. sp. *ciceri* on ILC 482 and Bionij cultivars of Kermanshah province. In *Proceedings of the 14th Iranian Plant Protection Congress* (p. 87) Esfahan, Iran.

Akhiani A., Mojtahedi H. & Naderi A. 1984. Species and physiological races of root-knot nematodes in Iran. *Iranian Journal of Plant Pathology* 20: 57-70. (In Persian with English summary).

Ali S.S. & Sharma S.B. 2003. Nematode survey of chickpea production areas in Rajasthan, India. *Nematologia Mediterranea* 31, 147–149.

Ali S.S. & Singh B. 2007. An overview of nematode constraints in pulses and their management. *Journal of Food Legumes* 20, 1–8.

Azimi S. & Mahdikhani‑Moghadam E. 2013. Root lesion nematodes associated with faba bean fields in Iran with two new records of *Pratylenchus crassi* Das & Sultana (1979) and *P. teres* Khan & Singh (1974). *Advanced Crop Science* 3(6): 398-404.

Azizi K. 2016. *Morphological and molecular identification of nematodes of the family Dolichodoridae (Tylenchomorpha) from some regions of northern and northwestern provinces of Iran.* (Doctoral dissertation, University of Zanjan, Iran).

Azizi K. 2022. Host preference and population levels of *Pratylenchoides ritteri* on six legume plants. *Plant Pathology Science* 11(1): 36-47 (In Persian with English summary).

Azizi K., Eskandari A., Karegar A., Ghaderi R., Van Den Elsen S., Holterman M. & Helder J. 2016. Morphological and molecular data support the monophyletic nature of the genus *Pratylenchoides* Winslow, 1958 (Nematoda: Merliniidae), and reveal its intrageneric structuring. *Nematology* 18(10), 1165-1183.

Azizi K. & Karegar A. 2014. Plant parasitic nematodes of legume fields and their distribution in Lorestan province, Iran. *Iranian Journal of Plant Pathology* 50 (3): 119-121. (In Persian with English summary).

Baadl S., Mahdikhani Moghadam E. & Rouhani H. 2010. Identification of plant parasitic nematodes in rapeseed fields in North Khorasan province. In *Proceedings of the 19th Iranian Plant Protection Congress* (p. 552). Tehran, Iran.

Baadl S., Mahdikhani Moghadam E. & Rouhani H. 2013. Identification of plant parasitic nematodes in rapeseed fields in North Khorasan province. *Journal* *of Plant Protection* 26(4), 370-379. (In Persian with English summary).

Barooti Sh. 1974. Prevalence and host range of root-knot nematode *Meloidogyne incognita* in Esfahan area. *Iranian Journal of Plant Pathology* 10, 78-84. (In Persian with English summary).

Castillo M.B., Alejar M.S. & Litsinger J.A. 1977. Pathological reactions and yield loss of mung bean to known populations of *Rotylenchulus reniformis* and *Meloidogyne acrita*. *Philippine Agriculturist* 61, 12–24.

Chaves N., Cervantes E., Zabalgogeazcoa I. & Araya C M. 2013. *Aphelenchoides besseyi* Christie (Nematoda: Aphelenchoididae), agente causal del amachamiento del frijol común. *Tropical Plant Pathology* 38, 243- 252.

Chikamatsu S., Xiaoman W., Ito D., Yamada E. & Toyota K. 2017. Effect of short-term growth of mung bean and its soil incorporation on the density of the soybean cyst nematode, *Heterodera glycines*, in pot experiments. *Nematology* 19(10), 1147-1155.

Crozzoli R., Greco N., Suarez A.C. & Rivas D. 1997. Patogenecidad del nematodo agallador, *Meloidogyne incognita*, en cultivares de *Phaseolus vulgaris* y *Vigna unguiculata*. *Nematropica* 27(1), 61–67.

Decker H. 1969. *Phytonematologie*. VEB Deutscher Landwirtschaftsverlag, Berlin, Germany.

Dehghanzadeh S., Tanha Maafi Z., Rahnama K., Mirabadi A. & Heydari R. 2016. Evaluation of some soybean lines to soybean cyst nematode (*Heterodera glycines*) under control conditions and field. *Iranian Journal of Plant Protection Science* 47(1), 1-9. (In Persian with English summary).

Di Vito M. & Greco N. 1988. The relationship between initial population densities of *Meloidogyne artiellia* and yield of winter and spring chickpea. *Nematologia Mediterranea* 16, 163–166.

Di Vito M. Greco N. & Saxena M.C. 1992. Pathogenicity of *Pratylenchus tornei* on chickpea in Syria. *Nematologia Mediterranea* 20, 71–73.

Faraji M., Kheiri A., Okhowat S. M. & Niknam GH. 2007. Interaction between artificial inoculation of *Meloidogyne javanica* and *Fusarium oxysporum* on two bean cultivars; under greenhouse conditions. *Iranian Journal of Agriculture Science* 38(1), 145-152. (In Persian with English summary).

Fatemy S. & Abootorabi E. 2002. Hatching activity, invasion rate and reproduction of *Heterodear schachtii* on oilseed rape cultivars. *Nematologia Mediterranea* 30, 163-166.

Fatemy S., Abootorabi E., Ebrahimi N. & Aghabeigi F. 2006. First report of *Pratylenchus neglectus* and *P. thornei* infecting canola and weeds in Iran. *Plant Disease* 90(12), 1555.

Ghaderi R., Karegar Bideh A. & Banihashemi Z. 2009. Aspects of biology of common root lesion nematodes (*Pratylenhus thornei* and *P. neglectus*) in the irrigated wheat and cornfields of Marvdasht, Fars province. *Iranian Journal of Plant Pathology* 45(2), 161-171. (In Persian with English summary).

Ghaderi R., Kashi L. & Karegar A. 2018. *Plant-parasitic nematodes in Iran*. Marjae-e-Elm and Iranian Society of Nematology, Tehran, Iran. [In Persian].

Ghaderi R., Miraeiz E., Hosseinvand M., Hashemi K., Jalalinasab P., Mokaram Hesar A., … and Fadakar S. 2020. *Plant nematology in Iran updated and annulated checklist of recorded taxa*. Chisinau, Glebe Edit.

Ghafari Sh., Tanha Maafi Z., Heydari R. & Eskandari A. 2012. Study on the interaction of *Heterodera glycines* and the symbiotic bacterium, *Bradyrhizobium japonicum* on susceptible and resistant soybean cultivars. *Applied Entomology and Phytopathology* 80(1), 33-39. (In Persian with English summary).

Ghayedi S. & Abdollahi M. 2014. Evaluation of eight bean cultivars for resistance to root-knot nematode (*Meloidogyne javanica*). *Seed and Plant Improvement Journal* 30(1), 17-36. (In Persian with English summary).

Greco N., Di Vito M., Saxena M.C. & Reddy M.V. 1988. Effect of *Heterodera ciceri* on yield of chickpea and lentil and development of this nematode on chickpea in Syria. *Nematologica* 34(1), 98–114.

Greco N., Ferris H. & Brandonisio A. 1991. Effect of *Heterodera goettingiana* population densities on the yield of pea, broad bean and vetch. *Revue de Nématologie* 14, 619–624.

Hatamabadi Farahani M. & Tanha Maafi Z. 2018. Identification of plant parasitic nematodes of bean fields in Markazi province. *Iranian Journal of Pulses Research* 9(2), 166-177. (In Persian with English summary).

Heydari R., Pourjam E., Tanha Maafi Z. & Safaie N. 2008a. Host suitability of some cultivars of common bean *Phaseolus vulgaris* to HG Type 0 (race3) *Heterodera glycines* in Iran. In *Proceedings of the 18th Iranian Plant Protection Congress* (p.558). Hamadan, Iran.

Heydari R., Pourjam E., Tanha Maafi Z. & Safaie N. 2008b. Evaluation of some common soybean cultivars to the major type of the soybean cyst nematode of Iran, *Heterodera glycines* HG type 0. *Iranian Journal of Plant Pathology* 44, 319-329. (In Persian with English summary).

Heydari R., Pourjam E., Tanha Maafi Z. & Safaie N. 2010. Comparative host suitability of common bean cultivars to the soybean cyst nematode, *Heterodera glycines*, in Iran. *Nematology* 12(3), 335-341.

Heydari R., Tanha Maafi Z. & Pourjam E. 2012. Yield loss caused by soybean cyst nematode, *Heterodera glycines*, in Iran. *Nematology* 14(5), 589-593.

Hosseini Nejad S. A. & Wajid Khan M. 2001. Interaction of root-knot nematode, *Meloidogyne incognita* (race 1), and wilt fungus *Fusarium oxysporum* f. sp. *ciceri*, on chick-pea cultivars. *Entomology and Phytopathology* 68(1), 1-12. (In Persian with English summary)

Imani S., Moosavi M. R. & Basirnia T. 2014. Interaction of *Macrophomina phaseolina* and *Meloidogyne javanica* on green Bean. *Journal of Research in Plant*

Pathology 2(3), 41-50. (In Persian with English summary).

Jacobsen B.J., Edwards D.F., Noel G.R. & Shurtleff M.C. 1983. *The soybean cyst nematode problem. Report on Plant Disease*, University of Illinois Cooperative Extension Service Bulletin 501.

Jafarzadeh B., Niknam Gh. & Aliasgharzadeh N. 2006. Study on the effect of root-knot nematode (*Meloidogyne javanica*) and *Rhizobium leguminosarum* bv. *phaseoli;* on nitrogen fixation of kidney-bean, *Phaseolus vulgaris* cv. COS-l6. *Journal of Agricultural Science* 16(2), 57-67. (In Persian with English summary).

Kamelmanesh M. M. & Yarmahmoodi M. 2013. Effect of irrigation cycle on the reproductive traits of root knot nematode (*Meloidogyne javanica*) in two white bean cultivars (*Phaseolus vulgaris*). *Iranian Journal of Plant Protection Science* 44(2), 339-349. (In Persian with English summary).

Karimipourfard H. 2008. Rapeseed fields infection to root-lesion nematodes (*Pratylenchus neglectus*, *P. thornei*) in Esfahan province, In *Proceedings of the 18th Iranian Plant Protection Congress* (p. 571). Hamadan, Iran.

Khan M. R., Jain R. K., Singh R. V. & Pramanik A. 2010. *Economically important plant parasitic nematodes distribution atlas*. New Delhi, Directorate of Information and Publications of Agriculture.

Kinloch R.A. 1974. Response of soybean cultivars to nematicidal treatments of soil infested with *Meloidogyne incognita*. *Journal of Nematology* 6, 7–11.

Kushida A., Suwa N. Ueda Y. & Momota Y. 2003. Effects of *Crotalaria juncea* and *C. spectabilis* on hatching and population density of the soybean cyst nematode, *Heterodera glycines* (Tylenchida: Heteroderidae). *Applied Entomology and Zoology* 38(3), 393-399.

Kushida A., Uehara T. & Momota Y. 2002. Effect of red clover on hatching and population density of *Heterodera glycines* (Tylenchida: Heteroderidae). *Japanese Journal of Nematology* 32(2), 69-76.

Mahapatra B.C. & Padhi N.N. 1986. Pathogenicity and control of *Rotylenchulus reniformis* on *Cicer arietinum*. *Nematologia Mediterranea* 14, 287-290.

Manachini D. 2000. First report of *Heterodera glycines* Ichinoe on soybean in Italy. *Bollettino di Zoologia Agraria e Bachicoltura* 32(2), 261–267.

Manzanilla-Lopez R.H., Costilla M.A., Doucet M., Franco J., Inserra R.N., Lehmann P.S. Cid del Prado-Vera I. Souza R.M. & Evans K. 2002. The genus *Nacobbus* Thorne & Allen, 1944 (Nematoda: Pratylenchidae): systematics, distribution, biology and management. *Nematropica* 32(2), 149–227.

Mohammadi Zameleh F., Karegar A. & Ghaderi R. 2018. Plant parasitic nematodes of legume fields and their distribution in Kermanshah province, Iran. *Journal of Plant Protection (Agricultural Science and Technology)* 32(3), 339-350. (In Persian with English summary).

Naseri B., Pourjam E. & Tanha Mafi Z. 2008. Some plant parasitic nematodes from canola growing regions of Iran. *Iranian Journal of Plant Pathology* 44: 319-329. (In Persian with English summary).

Parsa M. & Bagheri A. 2008. *Legumes*. Mashhad, Jahad-Daneshgahi Publications. [In Persian].

Rahimi M., Olia M., Tadayon M. & Heydari F. 2018. Investigation on the reaction of some *Phaseolus vulgaris* cultivars and lines to root- knot nematode *Meloidogyne javanica.* In *Proceedings of the 23rd Iranian Plant Protection Congress* (p.731). Gorgan, Iran.

Ramazani H. 2006. Effect of *Meloidogyne incognita* and *Fusarium oxysporum* f. sp. *ciceri* on chickpea. In *Proceedings of the 17th Iranian Plant Protection Congress* (p.141). Karaj, Iran.

Rasoulian R. 1970. Study of the resistance of pulse crops of root-knot- nematode. In *Proceedings of the 2nd Iranian Plant Protection Congress* (pp.249-255). Tehran, Iran.

Reen R. A., Thompson J. P., Clewett T. G., Sheedy J. G. & Bell K. L. 2014. Yield response in chickpea cultivars and wheat following crop rotations affecting population densities of *Pratylenchus thornei* and arbuscular mycorrhizal fungi. *Crop and Pasture Science* 65(5), 428–441.

Riga E., Porter L. D., Mojtahedi H. & Erickson D. 2008. *Pratylenchus neglectus*, *Pratylenchus thornei*, and *Paratylenchus hamatus*, nematodes causing yield reduction to dryland peas and Lentils in Idaho. *Plant Disease* 92(6): 979.

Saeedi A., Abdolahi M., Ghaderi R. & Charegani H. 2019. Plant parasitic nematodes of the families Merliniidae, Telotylenchidae and Pratylenchidae (Nematoda: Tylenchoidea) associated with important field crops of Gorgan region. *Plant Protection (Scientific Journal of Agriculture)* 41(4), 35-42. (In Persian with English summary).

Sasser J. N. 1989. *Plant parasitic nematodes: the farmers hidden enemy*. Raleigh North Carolina State University.

Shahabi S., Kheiri A. & Rezaee S. 2010. Evaluation of resistance in four variety of soybean to soybean cyst nematode (*Heterodera glycines*) in greenhouse. In *Proceedings of the 19th Iranian Plant Protection Congress* (p. 582). Tehran, Iran.

Sharma S.B., Smith D.H. & McDonald D. 1992. Nematode constraints of chickpea and pigeonpea production in the semiarid tropics. *Plant Disease* 76, 868–874.

Solimani T., Olia M., Heydari F. & Tadayon M. 2018. Evaluation the reaction of some soybean cultivars to root-knot nematode, *Meloidogyne javanica.* In *Proceedings of the 23rd Iranian Plant Protection Congress* (p. 730). Gorgan, Iran

Tabatabaei F.S. & Saeedizadeh A. 2017. Rhizobacteria cooperative effect against *Meloidogyne javanica* in rhizosphere of legume seedlings. *Hellenic Plant Protection Journal* 10, 25-34.

Tanha Maafi Z., Majd Taheri Z. & Subbotin S. A. 2013. First report of the giant stem nematode, *Ditylenchus gigas*, from broad bean in Iran. *Plant Disease Reporter* 97(7), 1005.

Tanha Maafi Z., Salati M. & Riggs R. D. 2008. Distribution, population density, race and type determination of soybean cyst nematode, *Heterodera glycines*, in Iran. *Nematology* 10(6), 919-924.

Thompson J.P., Greco N., Eastwood R., Sharma S.B. & Scurrah M. 2000. Integrated control of nematodes of cool season food legumes. In Knight R. (Ed.), *Linking Research and Marketing Opportunities for Pulses in the 21st Century*, 3rd edition (pp. 491-566). Australia, Kluwer Academic Publishers.

Warnke S.A., Chen S.Y., Wyse D.L., Johnson G.A. & Porter P.M. 2008. Effect of rotation crops on hatch, viability and development of *Heterodera glycines*. *Nematology* 10, 869-882.

Wrather J.A., Anderson T.R., Arsyad D.M., Gai J., Ploper L.D., Porta-Puglia A., Ram H.H. & Yorinori J.T. 1997. Soybean disease loss estimates for the top 10 soybean producing countries in 1994. *Plant Disease* 81(1), 107-110.

Zaki F.A. & Bhatti D.S. 1986. Pathogenicity of pigeon-pea cyst nematode, Heterodera cajani Koshy, 1967 on some pulse crops. *Indian Journal of Nematology* 16(1), 30–35.