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Interaction of *Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949 Race 3 with *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949 Race 3 in Tomato and Pepper

Betül GÜRKAN[1], Ramazan ÇETİNTAŞ[2]
[1]Doğu Akdeniz Geçit Kuşağı Tarımsal Araştırma Enstitüsü Müdürlüğü, Bitki Koruma Bölümü, Kahramanmaraş, [2]Kahramanmaraş Sütçü İmam Üniversitesi, Ziraat Fakültesi, Bitki Koruma Bölümü, Kahramanmaraş
[1]https://orcid.org/0000-0003-0195-4562, [2]https://orcid.org/0000-0002-5738-6915
✉: betulgurkan86@gmail.com

ABSTRACT
More than one species of root-knot nematodes can attack field vegetables and they can interact with each other. In this study, the interaction of *Meloidogyne incognita* race 3 and *M. javanica* race 3 on susceptible host plants (Falkon and Sena) were investigated in a growth chamber under controlled conditions. Experiments were arranged as a randomized plots design with four replications. The incidence of two *Meloidogyne* species in tomato and pepper hosts were determined by esterase phenotypes. No interaction was observed between the species after the mixed inoculation of 1000 J2 *M. incognita* race 3 and 1000 J2 *M. javanica* race 3 on the susceptible tomato plant (P≤0.05). Among mixed inoculation of the two species in the susceptible pepper, only the incidence of *M. incognita* race 3 was increased, while *M. javanica* race 3 was not detected in host plants.

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Domates ve Biber Bitkisinde *Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949 Irk 3'ün *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949 Irk 3 ile Etkileşimi

ÖZET
Sebze alanlarında bir bitki köküne birden fazla kök-ur nematodu türü birlikte saldırabilir ve birbirleriyle etkileşim halinde olabilirler. Bu çalışmada, *Meloidogyne incognita* ırk 3 ve *Meloidogyne javanica* ırk 3'ün hassas domates (Falkon) ve hassas biber (Sena) bitkileri üzerindeki karşılıklı etkileşimi kontrollü iklim odası koşullarında incelenmiştir. Tesadüf parselleri deneme desenine göre denemeler 4 tekerrürlü olarak kurulmuştur. İki *Meloidogyne* türünün domates ve biber bitkilerinde bulunma durumu esteraz fenotiplerine göre belirlenmiştir. Hassas domates bitkisine 1000 adet *Meloidogyne incognita* ırk 3 ve 1000 adet *M. javanica* ırk 3 ikinci dönem larvasının karışık inokulasyonu sonrasında, türler arasında herhangi bir etkileşim görülmemiştir (P≤0.05). Hassas biber bitkisinde iki türün karışık inokulasyonu sonrasında yalnızca *M. incognita* ırk 3 oranı artarken, *M. javanica* ırk 3 tespit edilmemiştir.

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INTRODUCTION

Root-knot nematodes which cause severe economic losses in vegetable crops, are known to be parasitic in a fairly high number of host plants (Mitkowski & Abawi 2003; Moens et al. 2009; Mukhtar et al. 2013). It has been reported that root-knot nematodes are in close contact with their hosts and can respond directly to their signals (Curtis 2008) and cause significant yield losses particularly in vegetables. Giant cells formed by these groups of nematodes in the roots are close to the xylem and phloem tissues, consequently, the uptake of essential nutrients and water from the soil by the plant roots is prevented (Abad et al. 2003; Siddiqui et al. 2014).

Vegetable varieties are being infected by more than one *Meloidogyne* species at once (Barros et al. 2018) causing damage on plant together. Because the feeding sites are similar, two or more coexisting *Meloidogyne* species may interact and probably pressure the population density of other species. It has been stated that nematodes compete each other for present feeding sites and cause similar histopathological and physiological changes in the host (Khan & Haider 1991). It has been reported that interactions can occur between *Meloidogyne-Meloidogyne*, *Heterodera-Meloidogyne*, *Rotylenchulus reniformis-Meloidogyne*, *R. reniformis-Tylenchulus semipenetrans* nematode species (Eisenback 1985). The relationships between nematode species may be beneficial for one or two species, may have no effect (neutral), or there may be serious competition between species with similar feeding habits (Eisenback 1985; Eisenback and Griffin 1987). Species diversity in the field increases with widespread dispersal and competition of nematodes with weak species (Oostenbrink 1966). Competition between species can occur when the reproductive capacity of one species is greater than that of other species (Brewer 1978). It has been stated that host damage and nematode reproduction depend on factors such as initial population density (Ferris 1974), nematode species (Barker et al. 1976), plant variety (Barker 1978), and environmental conditions (Lucas 1975). It has been reported that one of the critical environmental conditions is temperature. The interactions between *Meloidogyne incognita* and *M. hapla* are greatly affected by temperature (Johnson & Nusbaum 1970). As the temperature increases, *Meloidogyne hapla* and *M. javanica* are suppressed by *M. incognita*, and as the temperature decreases, *M. incognita* and *M. hapla* are suppressed by *M. javanica*. Factors other than temperature may also be important in the dominance of a particular *Meloidogyne* species. Even though *Meloidogyne hapla* generally prefers low temperatures, *M. hapla* suppressed by *M. javanica* at 20 °C. It is also known that the intensity of competition between species is important for the dominance of *M. hapla* (Kinloch & Allen 1972).

Many studies on nematodes have examined the effects of a single nematode species on a particular host plant, but plant parasitic nematodes are usually seen in polyspecific populations rather than being seen in a single-species community (Ostenbrink 1966; Eisenback 1985). These nematode communities are dynamic and nematode individuals are in consistent interaction with each other as well as with plants, the environment, and other organisms (Eisenback 1985). Therefore, in this study, in order to determine the interaction between root-knot nematode species that can be found in a vegetable field and can enter vegetable roots together, the interaction of *Meloidogyne incognita* race 3 and *Meloidogyne javanica* race 3 on susceptible tomato and pepper plants was investigated.

MATERIAL and METHOD

Material

In this study, the second-stage juveniles of race 3 of both *Meloidogyne incognita* and *M. javanica* species were used. As host plants, susceptible tomato, *Solanum lycopersicum* var. Falcon and susceptible pepper *Capsicum annuum* var. Sena was grown from seeds and were used as 3-4 leaf stage seedlings. Polyacrylamide gel electrophoresis was used as the separation method by using *M. javanica* species as markers.

Method

Growing susceptible tomato and pepper seedlings

The experiment was conducted in a fully controlled climate chamber with 16/8 hours of light and darkness, 60±10% relative humidity, 25±2 °C temperature. The seeds of susceptible tomato (Falcon) and susceptible (Sena) pepper were sown in plastic seed viol trays containing 80% peat and 20% perlite. Due to fast growth rate of tomato plant, tomato seeds were sown 2 weeks after pepper plant. When the tomato and pepper seedlings in the trays reached the 3-4 leaf stage, they were transplanted into 1.5 L volume pots containing 80% autoclaved (at 120 °C) sand and 20% peat. Trials were assembled as a randomized plots design with 4 replications. Aphicide (Platin chemistry-Effore/Acetamiprid) was applied once for aphid management. Plants fertilization and irrigation were done as necessary.

Extraction of the second-stage juvenile from *M. incognita* race 3 and *M. javanica* race 3

Egg masses were collected from susceptible tomato roots under a stereo microscope (2x) (Nikon SMZ-2B) to assemble the second-stage juveniles of *Meloidogyne incognita* race 3 and *M. javanica* race 3, which were obtained and reproduced from pure culture. Obtained egg masses were incubated for two days at 28 °C based on the modified Baermann-funnel method (Hooper 1986). At the end of incubation, the second-stage juveniles (J2 s) from hatched eggs were collected in the water (distilled) under the binocular microscope and the number of J2 s ml^{-1} was determined.

Inoculation of *M. incognita* race 3 and *M. javanica* race 3

By the time of susceptible tomato and pepper seedlings reached approximately 14-15 cm in height, four holes with 2 cm in depth were formed and a mixture of 1000 *Meloidogyne incognita* J2 race 3 and 1000 *M. javanica* J2 race 3 combined were inoculated into each pot. After inoculation, the holes were closed, and 50 ml of distilled water was added to soil to provide the nematodes homogeneously. In order to determine the inoculum viability of *Meloidogyne incognita race* 3 and *M. javanica* race 3, 1000 second-stage juvenile from each species were inoculated into control plants. The irrigation, fertilization and other maintenance of the plants were provided as needed.

Determining of *Meloidogyne* species

During the study, 65 days following of plant inoculation by a mixture of two different root-knot nematodes, all plants were removed from the soil and the roots were carefully washed. The egg masses and galls in the roots of tomato and pepper plants were counted and evaluated according to the index of Hartman & Sasser (Hartman & Sasser 1985). In addition, the roots were dissected, and (milky white color) and transparent females were counted under a binocular microscope. Because the protein content is low in transparent females, only females with high protein content were used for the diagnosis. Single female was placed in an Eppendorf tube containing 5 µl of distilled water. Females were kept at -20 °C for further PAGE (Polyacrylamide Gel Electrophoresis) studies.

Species identification of mixed population in the plant by PAGE

Rad mini-PROTEIN II (Bio-Rad, Philadelphia, PA) electrophoresis unit was used. Before electrophoresis, the females were thawed and homogenized individually in a micro hematocrit plastic tube in 10 µl of extraction buffer. Each sample was loaded into each well of 10 wells containing gels. The standard *Meloidogyne javanica* female extract was placed into wells number 1 and 10. The remaining 8 wells were loaded with the protein extract of test sample females. Electrophoresis was carried out in a discontinuous buffer system with 8% acrylamide running gel with pH 8.8 and 4% acrylamide stacking gel with pH 6.8. Running voltage was maintained at 80 volts for the first 15 minutes and increased to 200 volts for the remainder of the running period. Following electrophoresis, the gels were removed plates and placed in an enzyme reaction mixture to determine esterase (Harris & Hopkinson 1976). Bands on the gel were evaluated based on phenotype designations of Esbenshade and Triantaphyllou, 1985.

RESULTS

Interaction of *Meloidogyne incognita* race 3 with *Meloidogyne javanica* race 3

The diagnosis of nematode populations in susceptible pepper and tomato roots was made based on the Polyacrylamide Gel Electrophoresis method and it was determined which species caused more damage to the root. As a result of the first trial, the egg mass and galling index in the susceptible Falcon tomato, which was inoculated with root-knot nematode mixture (combination of 1000 J2 of *M. incognita* race 3 and 1000 J2 of *M. javanica* race 3) was found to be 4.75. The total number of females was 65.75 and the total number of transparent females was counted as 11.25. In order to determine the viability of the inoculum, the number of egg masses and galls in the roots of the Falcon tomato inoculated by *Meloidogyne incognita* race 3 and *M. javanica* race 3 were found as 4.00 based on the scale of 0 to 5. A total of 27 females and a total of 9 transparent females were determined on the tomato plant where 1000 second stage juvenile (J2) of *Meloidogyne incognita* race 3 was inoculated. After inoculation of 1000 J2 of *Meloidogyne javanica* race 3, a total of 27 females and a total of 6 transparent females were obtained. Both nematode species multiplied on the susceptible tomato plant (Falcon). According to the type diagnosis of the root-knot nematodes mixture, 21.00±4.63a *Meloidogyne incognita* race 3 and 13.00±2.79a *M. javanica* race 3 were found in plant roots (Figure 1). As a result of the first trial, since there was no difference between the data of two nematodes according to the Duncan multiple comparison test, it was determined that there was no interaction between *Meloidogyne incognita* race 3 and *M. javanica* race 3 on the roots of the susceptible Falcon tomatoes ($P \leq 0.05$) (Table 1).

As a result of the first trial of the susceptible Sena pepper plant, based on the average of 4 replications, the egg mass and root galling index value was 5.00, the total number of females in the roots was 167.50, the total number of transparent females was 40.75. After inoculation of 1000 J2 of *Meloidogyne incognita* race 3 to pepper plant both egg mass and root galling index was found to be 5.00, the total number of females was 135.00 and the number of transparent females was 6. Overall, 65 days after the inoculation of 1000 J2 of *Meloidogyne javanica* race 3 to the pepper plant, no egg mass and root galling were observed in the plant roots (0.00). Therefore, the reproduction of *M. javanica* race 3 on pepper (Sena) was not occurred. According to the PAGE results, it was determined that 167.50 females and 40.75 transparent females belonged to a single species were found (*M. incognita* race 3) in the pepper plant inoculated by mixed population (Figure 1, (Table 2).

According to the results of the second trial to determine the interaction of two mixed species in the Falcon tomatoes, the egg mass and root galling index was found to be 5.00 in tomato plant where mixture of both root nematode species were inoculated. A total of 105.50 females and 69.25 transparent females were found in the tomatoes roots inoculated by mixed nematode populations. To determine the viability of the inoculation, galling and root mass index of 5.00 was found in susceptible tomato inoculated by 1000 J2 of each species. A total of 362.00 females and 45.00 transparent females were counted on the tomato plant inoculated by *Meloidogyne incognita* race 3.

Table 1. First trial results of the interaction of *Meloidogyne incognita* race 3 and *Meloidogyne javanica* race 3 on tomato

Çizelge 1. Domates bitkisinde Meloidogyne incognita ırk 3 ve Meloidogyne javanica ırk 3 etkileşiminin birinci deneme sonuçları

RKN Species	*FALCON (Susceptible tomato variety)*					
	Starting population (Pi)	Egg mass index (0-5)	Gall index (0-5)	Number of females	Number of transparent females	PAGE result
M. incognita race 3 + *M. javanica* race 3	1000+1000	4.75	4.75	65.75	11.25	21.00±4.63 a *M. incognita* / 13.00±2.79 a *M. javanica*
Control *M. incognita* race 3	1000	4.00	4.00	27.00	9.00	*M. incognita*
Control *M. javanica* race 3	1000	4.00	4.00	27.00	6.00	*M. javanica*

0-5 egg mass and galling index, 0: no egg mass and galling, 1: 1-2 egg mass and galls, 2: 3-10 egg mass and galls, 3: 11-30 egg mass and galls 4: 31-100 egg mass and galls, 5: >100 egg mass and gall formation (Hartman and Sasser 1985). The different letters in the same column differ from each other according to Duncan multiple comparison test ($P \leq 0.05$)

Table 2. First trial results of the interaction of *Meloidogyne incognita* race 3 and *Meloidogyne javanica* race 3 in pepper plant

Çizelge 2. Biber bitkisinde Meloidogyne incognita ırk 3 ve Meloidogyne javanica ırk 3 etkileşiminin birinci deneme sonuçları

RKN Species	SENA (Susceptible pepper variety)					
	Starting population (Pi)	Egg mass index (0-5)	Gall index (0-5)	Number of females	Number of transparent females	PAGE result
M. incognita race 3 + M. javanica race 3	1000+1000	5.00	5.00	167.50	40.75	*M. incognita*
Control M. incognita race 3	1000	5.00	5.00	135.00	6.00	*M. incognita*
Control M. javanica race 3	1000	0.00	0.00	0.00	0.00	-

0-5 egg mass and galling index, 0: no egg mass and galling, 1: 1-2 egg mass and galls, 2: 3-10 egg mass and galls, 3: 11-30 egg mass and galls 4: 31-100 egg mass and galls, 5: >100 egg mass and gall formation (Hartman and Sasser 1985). The different letters in the same column differ from each other according to Duncan multiple comparison test ($P \leq 0.05$)

A total of 173.00 females and 85.00 transparent females were formed by the second-stage juvenile of 1000 *Meloidogyne javanica* race 3 inoculated susceptible tomato. Overall, 65 days after inoculation of 1000 second-stage *Meloidogyne incognita* race 3 juveniles and 1000 second-stage *M. javanica* 3 juvenile mixture in susceptible tomato plant, 33.00±8.59a *M. incognita* race 3, 26.50 ± 8.18a *M. javanica* race 3 was determined based on the results of Polyacrylamide Gel Electrophoresis. Duncan multiple comparison test indicated that there was no interaction between these two species in tomatoes roots ($P \leq 0.05$) (Table 3).

In the interaction of *Meloidogyne incognita* race 3 and *M. javanica* race 3 species on pepper host, the scale value of 0-5 egg mass formed in the roots by the mixture of two species was determined as 4.50 and the galling index was 4.25. In order to determine the viability of the inoculum, the egg mass index was determined as 5. And galling index was 4 on the control susceptible pepper plants inoculated with 1000 *Meloidogyne incognita* race 3. In the control plant, the total number of *Meloidogyne incognita* race 3 females was 135.00 and the number of transparent females was 9.00. It was observed that *Meloidogyne javanica* race 3 did not form any egg mass and galls on pepper roots. In the second experiment, no egg mass and galls formed on roots of pepper. Thus, it was confirmed that this species could not reproduce in pepper plants. It was determined that a total of 185.00 females and 11.00 transparent females formed in the roots of the pepper plant where the two species mixtures were inoculated based on the PAGE diagnosis method and no mutual interaction of these two species was observed in pepper host (Table 4).

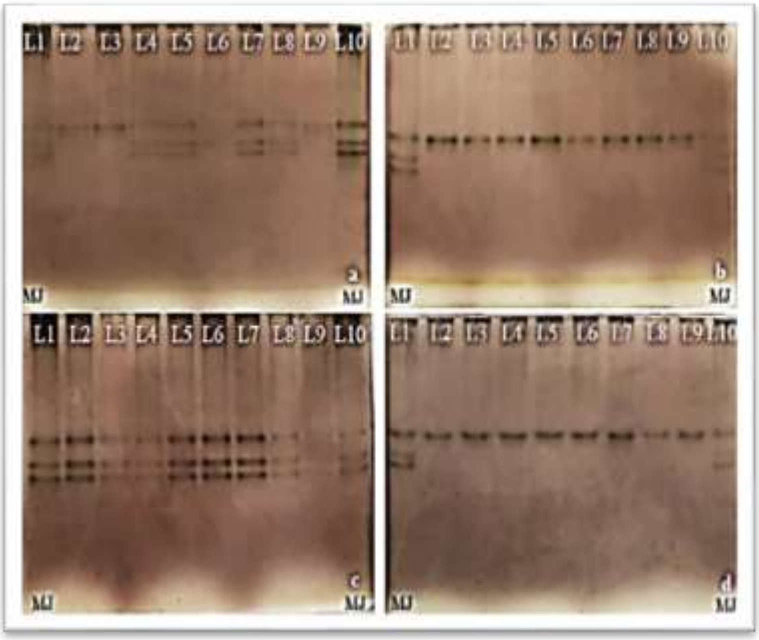

Figure 1. Esterase isoenzyme phenotypes formed on polyacrylamide gel; standard control *Meloidogyne javanica* (MJ) (L1 and L10) a) *M. incognita* race 3+*M. javanica* race 3 populations on tomato host; *M. incognita* race 3 (L2, L3, L9), *M. javanica* race 3 (L4, L5, L7, L8), b) *M. incognita* race 3+*M. javanica* race 3 populations on pepper; *M. incognita* race 3 (L2 and L9), c) *M. javanica* race 3 populations on control tomato (L2 and L9), d) *M. incognita* race 3 population on control pepper (L2 and L9).

Şekil 1. Poliakrilamid jel üzerinde oluşan esteraz izoenzim fenotipleri; standart kontrol Meloidogyne javanica (MJ) (L1 ve L10) a) Domates bitkisindeki M. incognita ırk 3+M. javanica ırk 3 popülasyonları; M. incognita ırk 3 (L2,L3,L9), M. javanica ırk 3 (L4,L5,L7,L8), b) Biber bitkisindeki M. incognita ırk 3+M. javanica ırk 3 popülasyonları; M. incognita ırk 3 (L2 ve L9), c) Kontrol domates bitkisindeki M. javanica ırk 3 popülasyonu (L2 ve L9), d) Kontrol biber bitkisindeki M. incognita ırk 3 popülasyonu (L2 ve L9).

Table 3. Second trial results of the interaction of *Meloidogyne incognita* race 3 and *Meloidogyne javanica* race 3 in tomato plant

Çizelge 3. Domates bitkisinde Meloidogyne incognita ırk 3 ve Meloidogyne javanica ırk 3 etkileşiminin ikinci deneme sonuçları

RKN Species	FALCON (Susceptible tomato variety)					
	Starting population (Pi)	Egg mass index (0-5)	Gall index (0-5)	Number of females	Number of transparent females	PAGE result
M. incognita race 3 + *M. javanica* race 3	1000+1000	5.00	5.00	105.50	69.25	33.00±8.59 a *M. incognita*
						26.50±8.18 a *M. javanica*
Control *M. incognita* race 3	1000	5.00	5.00	362.00	45.00	*M. incognita*
Control *M. javanica* race 3	1000	5.00	5.00	173.00	85.00	*M. javanica*

0-5 egg mass and galling index, 0: no egg mass and galling, 1: 1-2 egg mass and galls, 2: 3-10 egg mass and galls, 3: 11-30 egg mass and galls 4: 31-100 egg mass and galls, 5: >100 egg mass and gall formation (Hartman and Sasser 1985). The different letters in the same column differ from each other according to Duncan multiple comparison test (P≤0.05)

Table 4. Second trial results of the interaction of *Meloidogyne incognita* race 3 and *Meloidogyne javanica* race 3 in pepper plant

Çizelge 4. Biber bitkisinde Meloidogyne incognita ırk 3 ve Meloidogyne javanica ırk 3 etkileşiminin ikinci deneme sonuçları

	SENA (Susceptible pepper variety)					
RKN Species	**Starting population (Pi)**	**Egg mass index (0-5)**	**Gall index (0-5)**	**Number of females**	**Number of transparent females**	**PAGE result**
M. incognita race 3 + *M. javanica* race 3	1000+1000	4.50	4.25	185.00	11.00	*M. incognita*
Control *M. incognita* race 3	1000	5.00	4.00	135.00	9.00	*M. incognita*
Control *M. javanica* race 3	1000	0.00	0.00	0.00	0.00	-

0-5 egg mass and galling index, 0: no egg mass and galling, 1: 1-2 egg mass and galls, 2: 3-10 egg mass and galls, 3: 11-30 egg mass and galls 4: 31-100 egg mass and galls, 5: >100 egg mass and gall formation (Hartman and Sasser 1985). The different letters in the same column differ from each other according to Duncan multiple comparison test ($P \leq 0.05$)

DISCUSSION and CONCLUSION

It has been reported in various studies that *Meloidogyne javanica* did not infect pepper varieties. All pepper lines and cultivars tested by Peixoto et al. (1995) against *Meloidogyne javanica* were found resistant. Özarslandan & Elekçioğlu (2003) determined that all 16 varieties of pepper plant were resistant to *Meloidogyne javanica* race 1. Pinheiro et al. (2020) examined the reaction of 37 pepper genotypes (*Capsicum annuum, C. chinense and C. frutescens*) against *Meloidogyne javanica* and found all pepper genotypes were resistant or immune to *M. javanica*. In this study, it was observed that *Meloidogyne javanica* did not compete life cycle or did not multiply in the pepper inoculated by mixed population and nevertheless only *M. incognita* race 3 increased in numbers.

Current study results indicated, there was no difference between the interaction of *Meloidogyne incognita* race 3 and *M. javanica* race 3 species on tomato plant. In previous studies, it was reported that the competition among *Meloidogyne* species, especially between *M. javanica* and *M. incognita* was fairly low (Eisenback 1985). Although the antagonistic interactions between *Meloidogyne javanica* and *M. incognita* are not intense, it has been reported that such interactions can occur in nature, which will affect the reproductive efficiency and population growth of nematodes (Khan & Haider 1991). It has been determined that the interaction between two nematodes may be hostile (antagonistic) for one or both species, may have no effect (neutral), or may be beneficial (mutualistic) for one or both species (Eisenback 1985; Khan & Haider 1991). In the interactions between *Meloidogyne javanica* and *M. incognita* species, it was stated that these species can live together closely, affect each other directly or indirectly (Norton 1978) and that one population may not also exclude the other (Gause 1934).

In a mixed population, *Meloidogyne javanica* was found to be able to survive more effectively than *M. incognita*, adapt or compete with *M. incognita*. Also, it has been reported that races 1 and 2 of *M. incognita* can compete life cycle more aggressively than races 3 and 4 (Khan & Haider 1991). Mixed populations of *Meloidogyne incognita* all four races and *M. javanica* did not have intense species interactions in tomato; however, it was determined that there was an intensive interaction between *M. incognita* races 2 and other remaining 3 races (Khan & Haider 1991). In this study, aggression of *Meloidogyne incognita* race 3 against *M. javanica* race 3 was not observed.

It can be thought that the fact that the two species in the experiment did not show a dominant feature to each other and that could be due to the fact of the environmental conditions (25±2 °C temperature, 60±10% proportional humidity, 16/8 hours of light and darkness) which were remained steady for 65 days. In some studies, it was stated that *Meloidogyne incognita* was dominant in tomato plants at high temperatures and *M. javanica* as so at low temperatures in mixed populations. In addition, it has been determined that *Meloidogyne javanica* suppresses *M. incognita* and *M. hapla* as the temperature decreases, and *M. incognita* suppresses *M. javanica* and *M. hapla* as the temperature increase (Minz & Strich-Harari 1959). It has been reported that the entrance of *Meloidogyne hapla* and *H. schachtii* into the roots of tomato were maximized at 30°C and 26°C, respectively (Griffin 1985). From the plants inoculated with mix of *Meloidogyne incognita* and *M. hapla*, 90% of extracted females was *M. incognita* and 10% was *M. hapla* at high temperatures, and only 57% that was *M. incognita* at low temperatures (Chapman 1965).

Haider (1989) reported that there is dominant interspecies interaction between *Meloidogyne* species and the races. It has been stated that two nematode species can co-exist when competition among individuals in a species is greater than competition between species (Brewer 1978). In this study, the neutrality of the interaction of *Meloidogyne incognita* race 3 and *M. javanica* race 3 may be thought to be due to the high competition between individuals within the species' own populations.

In nature, plant parasitic nematodes are rarely found as mono-specific populations. Instead, nematodes constantly interact with the plant, the environment, and other organisms. Mixed infections of the species on plants are common. In this study, trials for the invasion and development of *Meloidogyne incognita* race 3 and *M. javanica* race 3 species community on susceptible tomato and pepper plants were equally applied and carried out at appropriate climatic conditions. A certain degree of temperature in the climate chamber did not affect the dominance of the two species against each other and did not cause an interaction between these two root-knot nematode species. Therefore, it can be considered that environmental conditions are important in the competition of a nematode with other species. In addition, since only *Meloidogyne incognita* race 3 was found in the pepper host, the coexistence of *M. javanica* race 3 with a second species in the soil did not cause *M. javanica* to enter the roots of a non-host plant by competing with the other species. It can be concluded that the damage to the plant can be reduced by using pepper varieties in the crop rotation to manage the *Meloidogyne incognita* and *M. javanica* species found together in the field.

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Author's Contributions

The contribution of the authors is equal.

Statement of Conflict of Interest

The authors declare no conflict of interest.

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