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Research Article

Response of eight melon cultivars to *Meloidogyne javanica*

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Abstract

Introduction: The Root-knot nematodes (*Meloidogyne* spp.) are one of the most damaging plant pathogens with a wide host range and cause major losses to agricultural crops. The use of resistant cultivars is considered a safe, economical, and effective method to control these nematodes. **Materials and Methods:** In the present study, eight melon cultivars namely Ahlam, 105, Tracey, Ronak, Deltagrin, Mac, Holar, and Veno were evaluated for their response to *M. javanica*. The seeds were planted in 2 kg pots and maintained under natural conditions in Khormuj city, Bushehr province. Seedlings at the four-leaf stage were inoculated with 5000 eggs and second-stage juveniles. The factorial experiment was conducted in a completely randomized design with five replicates. Sixty days after nematode inoculation, the plants were harvested and the plant growth and nematode population indices were evaluated. **Results:** The results showed that the nematode reproduction factor was significantly lower in Ronak, Deltagrin, and Veno than in the other cultivars. No significant difference was observed in shoot fresh weight of nematode inoculated and non-inoculated plants of Ronak cultivar. **Conclusion:** Ronak, Delta-green and Veno cultivars are less susceptible to *M. javanica*.

Keywords: Gall index, Reproduction factor, Susceptibility, Root-knot nematode

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مقاله پژوهشی

واکنش هشت رقم خربزه به نماتد ***Meloidogyne javanica***

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وهابی س، چاره‌گانی ح، عبداللهی م، رضایی ر (۱۴۰۰) واکنش هشت رقم خربزه به نماتد *Meloidogyne javanica* . دانش بیماری‌شناسی گیاهی ۱۰(۲): ۷۳-۶۵.

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چکیده

مقدمه: نماتدهای غده ریشه (*Meloidogyne* spp.) از زیان‌بارترین بیمارگرهای گیاهی با دامنه میزبانی وسیع می‌باشند که خسارت زیادی به محصولات کشاورزی وارد می‌نمایند. استفاده از رقمهای مقاوم به عنوان یک روش ایمن، کم هزینه و مؤثر برای مدیریت این نماتدها است. **مواد و روش‌ها:** واکنش هشت رقم خربزه احلام، ۱۰۵، تریسی، روناک، دلتاگرین، مک، هولار و ونو به گونه *M. javanica* در شرایط میکروپلات مورد ارزیابی قرار گرفت. بذرها در گلدان‌های دو کیلوگرمی کشت و در شرایط میکروپلات در شهر خورموج، استان بوشهر نگهداری شدند. گیاهچه‌ها در مرحله چهار برگی با ۵۰۰۰ تخم و لارو سن دوم نماتد *M. javanica* مایه‌زنی شدند. آزمایش بر پایه طرح کاملاً تصادفی در پنج تکرار انجام گرفت. شصت روز پس از مایه‌زنی نماتد گیاهان برداشت و شاخص‌های رویشی گیاه و جمعیتی نماتد تعیین شدند. **یافته‌ها:** فاکتور تولیدمثل نماتد در رقمهای روناک، دلتاگرین و ونو به طور معنی‌داری از سایر رقمها کمتر بود. وزن‌تر شاخساره در رقم روناک آلوده به نماتد اختلاف معنی‌داری با گیاهان سالم نداشت. **نتیجه‌گیری:** رقمهای روناک، دلتاگرین و ونو حساسیت کمتری به نماتد *M. javanica* دارند.

واژگان کلیدی: حساسیت، شاخص غده، فاکتور تولیدمثل، نماتد غده ریشه

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Introduction مقدمه

Melon (*Cucumis melo* L.) is one of the important cucurbitaceous plants worldwide (Diniz et al. 2016). It is grown in tropical and subtropical countries but has also grown extensively in temperate regions (Schmidt et al. 2016). Melon is attacked by root-knot nematodes, *Meloidogyne* spp., (Diniz et al. 2016). Root-knot nematodes are sedentary endoparasites and are among the most dangerous plant parasites worldwide due to the broad host range and high reproduction rate (Jones et al. 2013). These nematodes cause general weakness, leaf necrosis, arrest plant growth, and form galls in the plant root system (Mukhtar and Kayani 2020). Using resistant cultivars and applying nematicides are the main strategies to reduce yield losses caused by root-knot nematodes. The use of nematicides is limited due to their high cost and hazardous effects. Using resistant cultivars is environmentally friendly and economically viable for managing these nematodes (Mukhtar et al. 2013).

Limited studies have been conducted to identify root-knot nematode resistance in melon cultivars. The aim of this research was to evaluate the response of eight melon cultivars namely Ahlam, 105, Tracey, Rounak, Delta green, Mac, Holar, and Veno to *M. javanica* under natural conditions.

Materials and Methods مواد و روش‌ها

M. javanica isolate was obtained from an infected greenhouse in Boyer-Ahmad County, Iran, and then propagated on tomato cv. "Early-Urbana Y" using a single egg mass of nematode. (Hussy and Barker 1973).

The experiment was conducted in 2020 under natural conditions in the city of Khormuj, Bushehr Province, Iran (with an altitude of 60 m, latitude 51°23' and longitude 28°39' E.). The factorial experiment with two factors (cultivars and nematode inoculation) was conducted in a completely randomized design with five replicates. Eight melon cultivars namely Ahlam, 105, Tracey, Rounak, Delta green, Mac, Holar, and Veno were planted in 2 kg pots containing steam-sterilize soil (1 part cow manure; 1 part steam-sterilized sandy loam soil; 2 parts sand). Seedlings at the four-leaf stage were divided into two groups. One group was used as uninoculated control and the other group was inoculated with 5000 eggs and second-stage juveniles (J2s) of *M. javanica*. For this purpose, nematode inoculum was pipetted into three holes around the stalk of the melon seedlings. The pots were maintained and watered under natural conditions. Sixty days after inoculation with the nematode, plants were harvested and the indices of plant growth (plant height, fresh and dry shoot weight, and fresh root weight) and nematode population (the number of eggs as described by Hussey and Barker (1973), the number of galls and egg masses on the root system as described by Hussey and Jansen (2002), number of J2 in soil as described by Whitehead and Hemming (1965) and nematode reproduction factor (Rf)) were evaluated. Gall index (GI) was estimated on a scale of 0 to 5, where 0 = no galls; 1 = 1 to 2 galls; 2 = 3 to 10 galls; 3 = 11 to 30 galls; 4 = 31 to 100 galls; and 5 = more than 100 galls in the root system (Taylor and Sasser 1978). The degree of resistance of the tested melon varieties was assigned according to the modified Canto-Saenz scheme (Sasser et al. 1984). According to that, degree of resistance is based on gall index (GI) and reproduction factor (RF) as follow: resistant (GI ≤ 2, RF ≤ 1); tolerant (GI ≤ 2, RF > 1); hyper susceptible (GI > 2, RF ≤ 1); susceptible (GI > 2, RF > 1).

Data were subjected to factorial analysis of variance (ANOVA) by using SAS statistical software ver. 9.4 (SAS Institute, Cary, NC). The parametric data (plant growth indices) were analyzed by using the general linear model (GLM) procedure and the differences among groups were determined by the Tukey-Kramer HSD test at $P<0.01$. The non-parametric data (nematode population indices) were analyzed by using the Friedman rank test and the differences among groups were determined by Bonferroni means comparison test at $P<0.01$.

Results یافته‌ها

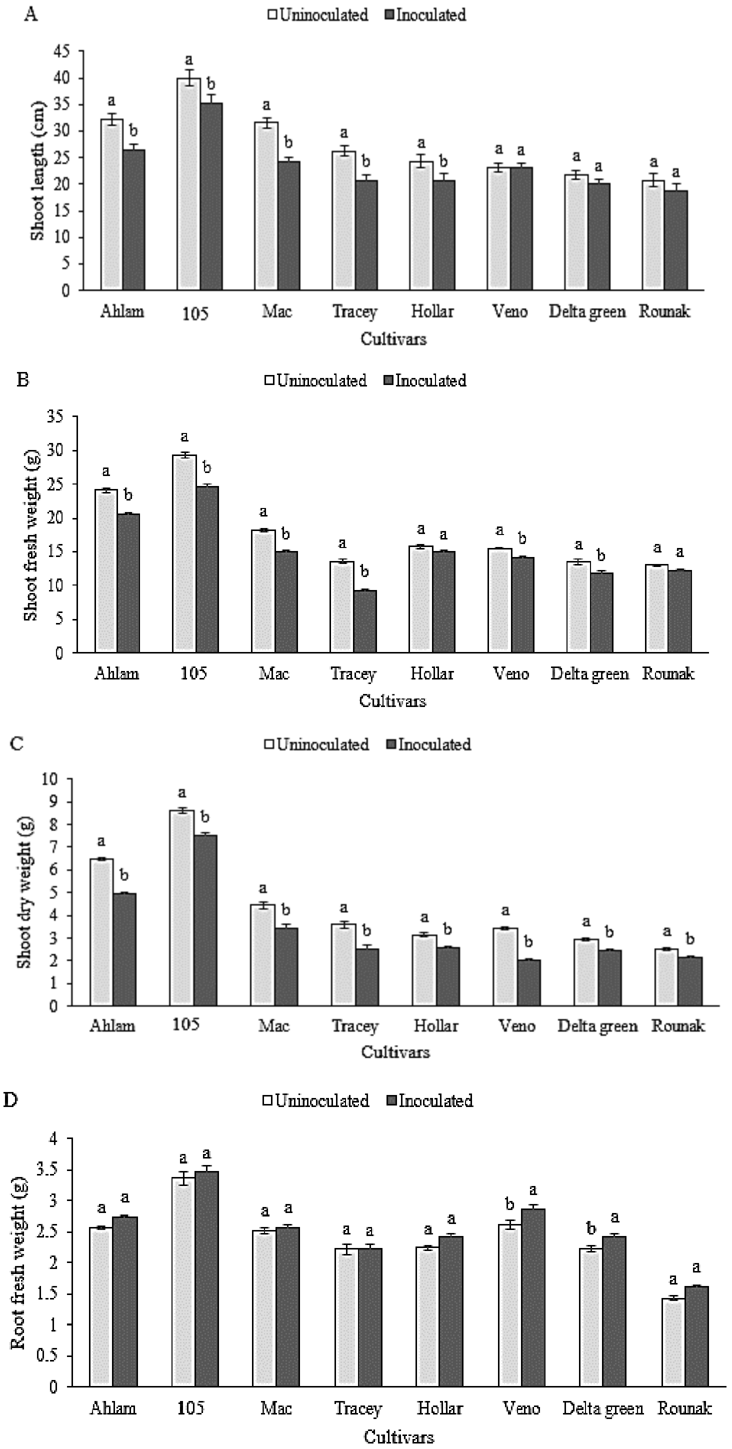
The Mac and Ahlam cultivars had a significantly higher number of eggs per root system and also a higher RF than the other cultivars. The number of galls per root system in the roots of cultivars Mac and Ahlam was significantly higher than the other cultivars, but there was no significant difference between the number of galls per root system of cultivars Mac and Ahlam. the Mac cultivar had a significantly higher number of egg masses per root system than the other cultivars. The Rounak, Delta Green and Veno cultivars had significantly lower numbers of eggs, galls, and egg masses per root system and also RF than the other cultivars. There was no significant difference between the number of J2s per pot and the GI of the tested varieties. According to the Canto-Saenz scheme, all cultivars with a GI greater than 2 and an RF greater than 1 can be considered susceptible hosts to *M. javanica* (Table 1).

جدول ۱. واکنش هشت رقم خربزه به نماتد غده ریشه *Meloidogyne javanica* با استفاده از شاخص گال و فاکتور تولیدمثل بر اساس روش Canto-Saenz (Sasser et al. 1984)، میانگین تعداد تخم، گال و توده تخم در ریشه و تعداد لارو سن دوم در گلدان.

Table 1. Response of eight melon cultivars to the root-knot nematode *Meloidogyne javanica* based on the reproduction factor and gall index according to the modified scheme of Canto-Saenz (Sasser et al. 1984), mean numbers of eggs, galls, and egg masses per root system, and mean numbers of second-stage juveniles (J2s) per pot.

Cultivars	Number of eggs/root	Number of galls/root	Number of egg masses/ root	Number of J2s/pot	GI	RF	Response
Ahlam	23265 a	581 ab	312 b	120 a	5	4.7 a	Susceptible
105	20188 b	441 c	232 d	140 a	5	4.1 b	Susceptible
Mac	23245 a	617 a	332 a	90 a	5	4.7 a	Susceptible
Tracey	21273 b	560 b	284 c	100 a	5	4.3 b	Susceptible
Hollar	19986 b	472 c	221 d	120 a	5	4 b	Susceptible
Veno	15728 c	330 d	177 e	100 a	5	3.2 c	Susceptible
Delta green	16288 c	341 d	182 e	130 a	5	3.3 c	Susceptible
Rounak	16533 c	367 d	191 e	110 a	5	3.3 c	Susceptible

Values in the same column followed by different letters are significantly different ($P≤0.01$) based on Bonferroni means comparison test.



شکل ۱. میانگین A: طول، B: وزن‌تر و C: وزن خشک شاخساره و D: وزن‌تر ریشه هشت رقم خربزه آلوده به *Meloidogyne javanica*، ۶۰ روز پس از مایه‌زنی با نماتد در شرایط میکروپلات. داده‌ها میانگین پنج تکرار می‌باشند. حروف غیر مشابه نشان دهنده تفاوت معنی‌دار بین تیمارها در سطح احتمال ۱ درصد با استفاده از آزمون توکی-کرامر می‌باشد.

Figure 1. Mean values of A: shoot length, B: shoot fresh weight, C: shoot dry weight, and D: root fresh weight of eight melon cultivars infected with *Meloidogyne javanica*, 60 days after nematode inoculation in pots under natural conditions. Data presented are means of five replicates. Values followed by different letters differ significantly ($P \leq 0.01$) based on the Tukey-Kramer HSD test. For each variety, the data was analyzed and compared separately.

The shoot length of uninoculated Ahlam, Mac, Tracy, Hollar and 105 cultivars was significantly higher than inoculated cultivars (Fig 1A). Shoot fresh weight of inoculated and uninoculated Hollar and Rounak cultivars showed no significant differences, but shoot fresh weight of the other uninoculated cultivars was significantly higher than inoculated cultivars (Fig. 1B). The shoot dry weight of uninoculated cultivars was significantly higher than that of inoculated cultivars (Fig. 1C). Root fresh weight of uninoculated Delta Green and Veno cultivars was significantly higher than inoculated plants (Fig. 1D).

Discussion بحث

In the present study, eight melon cultivars were examined for their response to M. javanica infection. Statistical analysis of the data and comparison of inoculated cultivars with uninoculated cultivars showed that the tested cultivars showed high susceptibility to *M. javanica* based on vegetative indices. This result agrees with the study by Aboulipour et al. (2011) who showed that cucumber infections with *M. javanica* significantly reduced plant shoot length and shoot fresh weight.

The production of the highest egg masses at the roots of susceptible cultivars indicates that most J2s have invaded the root and successfully completed their life cycle on the host (Kayani and Mukhtar 2018). The reproduction rate of plant-parasitic nematodes is one of the most important factors in selecting cultivars for cultivation. Cultivars with the lowest reproductive rate are suitable for use in the root-knot nematode management program. If the reproductive factor on the selected host is not greater than one, it means that the nematode cannot successfully reproduce on that host and vice versa.

Host susceptibility is assessed based on the host's conditions and its responses to nematode infestation. If the plant allows the nematode to reproduce and plant growth is reduced, it is considered a sensible host, while if the host's yield does not decrease, it is considered a tolerant host. If the host does not allow the nematode to reproduce and therefore plays no role in reducing plant yield, the host will be considered resistant (Mukhtar et al. 2013). This suggests that the cultivars may have had resistant genes. In response to nematode infection, the resistant genes suppress one or more stages of pathogenicity (Hussain et al. 2016). The incompatible reaction between nematode and plant leads to reduction or non-formation of galls on the root of the plant (Roberts et al. 2008). Differences in host resistance can affect different stages of the nematode life cycle. The nematode is unable to grow or reproduce after penetrating the root of the resistant host (Mukhtar et al. 2013). Growth reduction in susceptible cultivars can be attributed to severe root damage from nematode penetration and feeding. Root-knot nematodes cause a lack of water uptake by forming galls in the roots. As a result, plant growth indices in infected plants show a significant decrease compared to healthy plants (Mukhtar and Kayani 2020). Studies have shown that, in addition to morphological changes, molecular and biochemical changes also occur in resistant plants after nematode infestation. Increased activity of phenylalanine ammonia-lyase and

peroxidase enzymes was observed in resistant plants after nematode inoculation (Brueske 1980; Zacheo et al. 1993).
Infection with *M. javanica* increased the fresh weight of infected melon roots compared to healthy plants. The highest and lowest increases in root fresh weight were observed in the Delta and Tracy cultivars, respectively. Previous studies have shown that there is a positive relationship between number of gall/root system and fresh root weight (Charegani et al. 2012; Mukhtar et al. 2013). The number of galls and the RF of nematodes are good indices for evaluating resistance (Gomes *e*t al. 2015; Mukhtar et al. 2017). Our results showed that all tested cultivars can be considered as susceptible hosts for *M. javanica*. According to the results, all cultivars had the highest GI (GI= 5); the Ahlam and Mac cultivars had the highest, and the Rounak, Delta green, and Veno cultivars had the lowest RF. Reduced RF in these strains may be due to less invasion of J2s and their growth within the root (Griffin and Elgin 1977; Mukhtar et al. 2013). A positive correlation between bile index and the number of egg masses was reported by Karuri et al. (2017). Sadegh Moosavi et al. (2006) showed that based on RF and GI, 14 cucumber cultivars/lines are susceptible to *M. incognita* race 2.
The influence of pathogen inoculation on the growth indices of the examined cultivars is an essential factor in cultivar comparison. Based on the results of the mean comparison, the least reduction in shoot length due to nematode inoculation was observed in Veno, Delta green, and Rounak cultivars, and the least reduction in shoot fresh weight in Hollar and Rounak cultivars. But shoot dry weight of all inoculated cultivars showed a statistically significant difference from uninoculated treatments. This means that none of the cultivars can be considered tolerant. In the same study, the response of ten greenhouse cucumber cultivars to root-knot nematode, *M. javanica*, was examined (Abdollahi 2015). Based on his study, the impact of nematode infection on the growth parameters of some cultivars was less than that of other cultivars, so they can be considered tolerant.

Conclusion نتیجه‌گیری

Although according to Canto-Saenz's scheme, all eight melon cultivars, namely Ahlam, 105, Tracey, Rounak, Delta-Green, Mac, Holar, and Veno, are susceptible to *M. javanica* under natural conditions, Ronak, Delta-Green, and Veno are less susceptible.

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