

Checklist of Host Range of Root-Knot Nematodes (*Meloidogyne* species and races) in Jordan

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ABSTRACT

Root-knot nematodes, RKNs (*Meloidogyne* species and races) are widely distributed throughout the irrigated agricultural areas in Jordan which differ in their environmental conditions. In this study, host plant range of local populations of RKNs was revised in Jordan and new host samples were collected from some agricultural areas. Thirty one plant species belonging to 19 different plant families were reported as hosts for RKNs in Jordan. Some plant species were recorded for the first time as new natural hosts including: rosemary (*Rosmarinus officinalis*) to *M. incognita* race 1, jungle rice (*Echinochloa colona*), and Mallow (*Malva sylvestris*) and wild barley (*Hordeum spontaneum*) to *M. javanica*. Some of the studied areas e.g. Al-Eina, Karak was recorded as a new site for RKNs. The results of this study may provide useful information for the management of RKNs in Jordan.

Keywords: Economic crops, Jordan, root-knot nematodes, survey, weeds.

INTRODUCTION

In Jordan, about 189 thousand hectares were cultivated in 2012 with field crops, vegetable crops and fruit trees (Anonymous, 2012). A great diversity of climatic conditions is common in Jordan; ranging from a semi-temperate climate on the elevated highlands to semi-tropical in the Jordan Valley, and from arid regions along the desert periphery to semi-humid on the tops of high mountains close to the Jordan Valley (Abu-Gharbieh, 1987).

Root-knot Nematodes (RKNs) belonging to the genus *Meloidogyne* are considered the most important group of plant-parasitic nematodes worldwide attacking nearly every crop. These nematodes inflict great losses

to various vegetable crops and fruit trees (Sasser and Freckman, 1987). About 5% of the total world crop yield is destroyed due to RKNs (Sasser *et al.*, 1983; Barker *et al.*, 1985; Sasser, 1987). Over 80 species of *Meloidogyne* have been described worldwide, three of them are extremely polyphagous apomictic species namely; *M. incognita* (Kofoid and White) Chitwood, *M. javanica* (Treub) Chitwood, and *M. arenaria* (Neal) Chitwood, widely distributed with a wide host range and cause most of crop losses due to RKNs worldwide (Nickle, 1991; Karssen, 2002).

Several surveys were conducted in Jordan to identify local populations of RKNs (Abu-Gharbieh and Hammou, 1970; Hashim, 1979; Abu-Gharbieh, 1982a; Abu-Gharbieh, 1982b; Karajeh, 2004). The two species: *M. javanica* and *M. incognita* were recovered and identified from soil and galled root samples collected from the irrigated areas in Jordan. Nearly 84% of the collected RKN populations were identified as *M. javanica*, 6% as *M. incognita* race 1, 4% as *M. incognita*

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race 2, and 6% as *M. arenaria* race 2. Among the collected samples, three populations of *M. javanica* were found virulent to the *Mi* gene of tomato resistance as indicated by their ability to infect the roots of resistant tomato cultivar Better Boy (Karajeh *et al.*, 2005). Therefore, the objectives of this study were to provide a checklist of the hosts of root-knot nematodes from previously published paper and to search for new host-plant species for *Meloidogyne* species and races in Jordan.

MATERIALS AND METHODS

1- Sample collection

About one hundred galled roots of about thirty plant species (5 plants/ site) and their rhizospheric soil samples were taken over two years (March 2011-March 2013), placed in plastic bags and brought to plant pathology laboratory of Department of Plant Protection and IPM, Faculty of Agriculture, Mutah University in Karak Province of Jordan. Most RKN populations were collected from the open fields, plastic houses, fruit tree orchards and home gardens suspected to be infected with RKNs during surveys covered some of the irrigated areas in Jordan especially the southern part of Jordan.

2- Nematode extraction and identification

A: Nematode extraction from plant roots

Galled root samples were washed thoroughly under tap water for 5 minutes. Small-galled roots were excised and examined under a dissecting microscope to extract the RKN females.

B: Nematode extraction from soil

Second-stage juveniles were extracted from the collected soil samples using Baermann tray method (Whitehead and Hemming, 1965).

C: Nematode identification

Identification of RKNs was performed by observing female perineal patterns (10 patterns/ sample),

measuring length of 10 second-stage juveniles/ sample (Taylor and Sasser, 1978; Hartman and Sasser, 1985; Barker *et al.* 1985) at the *Meloidogyne* species level and testing their host preference using North Carolina differential host test (Barker *et al.* 1985) at the race level (Karajeh, 2004). The morphological identification was then confirmed by species-specific sequence characterized amplified region-polymerase chain reaction (SCARPCR) based test (Zijlstra *et al.*, 2000; Karajeh, 2004).

RESULTS AND DISCUSSION

Meloidogyne javanica was found to be the most frequently recovered species from plant and soil samples collected from irrigated agricultural areas in Jordan. *Meloidogyne incognita* race 1 was detected more frequently in samples collected from the central part of the Jordan Valley (Dier Alla) and the eastern desert plain (Qwerah), while *M. incognita* race 2 was recovered in samples collected from the northern part of Jordan Valley (Al-Qarin) and the elevated upland (Al-Qastall) and *M. arenaria* race 2 was recovered only in Deir Alla in the central part of Jordan Valley (Abu-Gharbieh *et al.* 2005).

Most of the listed plant species in Table 1 were previously reported as hosts RKNs in Jordan. However, to our knowledge, some new plant species including Rosemary (*Rosmarinus officinalis* L.) to *M. incognita* race 1, and jungle rice (*Echinochloa colona* L.), Mallow (*Malva sylvestris* L.), and wild barley (*Hordeum spontaneum* L.) were recorded to *M. javanica* (Table 1). Also, new sites were recorded e.g. Madaba for *M. javanica* on cucumber (*Cucumis sativus* L.) and Al-Eina region/ Karak for the same nematode species on tomato (*Solanum lycopersicum* L.). Thirty one plant species belonging to 19 families were reported as hosts for RKNs in open fields, plastic houses and home gardens of

Jordan (Table 1). Some plant species were previously reported as hosts for Jordanian populations of RKNs under laboratory and artificial inoculation conditions including wheat, oat and barley as cereal crops (Karajeh

et al., 2011), corn, onion, lettuce, spinach, turnip and melon (Abu-Gharbieh and Karajeh, 2006), and peach (Al-Qasim *et al.*, 2009).

Table 1. Host plant species that were found infested with root-knot-nematodes (*Meloidogyne* species and races) under the field conditions of Jordan:

Host-plant species	Scientific Name	Family	Plant type	<i>Meloidogyne</i> species	Locality*	Researchers Survey reports
Alfalfa	<i>Medicago sativa</i> L.	Leguminosae	Forage crop	<i>Meloidogyne</i> sp.	UL	Abu-Gharbieh (1987)
Black nightshade	<i>Solanum nigrum</i> L.	Solanaceae	Weed	<i>M. incognita</i> (Kofoid <i>et</i> White) Chitwood	J	Hashim (1979)
				<i>M. javanica</i> (Treub) Chitwood	J	Hashim (1979)
Cabbage	<i>Brassica oleracea</i> var. <i>capitata</i>	Brassicaceae	Vegetable crop	<i>M. incognita</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. javanica</i>	NS	Hashim (1979)
				<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
Cavendish Banana	<i>Musa cavendishii</i> Lambert and Paxton	Musaceae	Fruit tree	<i>M. javanica</i>	JV	Yousef and Jacob (1994)
				<i>M. javanica</i>	NS, GS	Karajeh (2004)
Common bean	<i>Phaseolus vulgaris</i> L.	Leguminosae	Field crop	<i>M. arenaria</i> (Neal) Chitwood race 2	DA	Karajeh (2004)
				<i>M. incognita</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. javanica</i>	JV	Yousef and Jacob (1994)
				<i>M. javanica</i>	GS	Karajeh and Al-Ameiri (2010)
Cowpea	<i>Vigna sinensis</i> L.	Leguminosae	Field crop	<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. javanica</i>	SS, GS	Karajeh (2004)
				<i>M. incognita</i>	SK	Karajeh and Al-Ameiri (2010)
Cucumber	<i>Cucumis sativus</i> L.	Cucurbitaceae	Vegetable crop	<i>M. incognita</i> race 1	DA	Karajeh (2004)
				<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. javanica</i>	DA	Hashim (1979)

				<i>M. javanica</i>	JV	Mamluk <i>et al.</i> , 1984; Yousef and Jacob (1994)
				<i>M. javanica</i>	SS, DA, J, B	Karajeh, (2004)
				<i>M. javanica</i>	SG	Karajeh and Al-Ameiri (2010)
				<i>M. javanica</i>	M**	New
Date palm	<i>Phoenix dactylifera</i> L.	Palmae	Fruit tree	<i>M. incognita</i> race 1	Q	Karajeh (2004) Rubeya (1999)
Eggplant	<i>Solanum melongena</i> L.	Solanaceae	Vegetable crop	<i>M. arenaria</i> (suspected)	WS	Hashim (1979)
				<i>M. arenaria</i> race 2	DA	Karajeh (2004)
				<i>M. incognita</i>	JV and UL	Abu-Gharbieh (1982)
				<i>M. incognita</i>	JV and UL	Abu-Gharbieh (1979)
				<i>M. incognita</i> race 1	NS	Karajeh (2004)
				<i>M. incognita</i> race 2	NS	Karajeh (2004)
				<i>M. javanica</i>		Abu-Gharbieh (1979)
				<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. javanica</i>	JV	Yousef and Jacob (1994)
				<i>M. javanica</i>	GS, T	Karajeh and Al-Ameiri (2010)
				<i>M. javanica</i>	AB, SS, DA,	Karajeh (2004)
				<i>M. javanica</i>	DA, J, SG, SS, WS	Hashim (1979)
Faba bean	<i>Vicia faba</i> L.	Leguminosae	Field crop	<i>M. javanica</i>	JV and SW	Abu-Gharbieh (1987)
Fig	<i>Ficus carica</i> L.	Moraceae	Fruit tree	<i>M. incognita</i> race 1	Q	Karajeh (2004)
Garlic	<i>Allium sativum</i> L.	liliaceae	Vegetable crop	<i>M. incognita</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. javanica</i>	GS	Karajeh (2004)
Grapevine	<i>Vitis vinifera</i> L.	Vitaceae	Fruit tree	<i>M. incognita</i> race 1	Q	Karajeh, (2004)
				<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
Guava	<i>Psidium guajava</i> L.	Myrtaceae	Fruit tree	<i>M. javanica</i>	JV	Yousef and Jacob (1994)
Jew's Mallow	<i>Corchorus olitorius</i> L.	Tiliaceae	Vegetable crop	<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
Jungle Rice	<i>Echinochloa colona</i> L.	Poaceae	Weed	<i>M. javanica</i>	GS	New

Mallow	<i>Malva sylvestris</i> L.	Malvaceae	Weed	<i>M. javanica</i>	GS	New
Okra	<i>Hibiscus esculentus</i> L.	Malvaceae	Vegetable crop	<i>M. incognita</i>	JV and UL	Abu-Gharbieh (1982)
				<i>M. javanica</i>	J, SS	Hashim (1979)
Olive	<i>Olea europaea</i> L.	Oleaceae	Fruit tree	<i>M. incognita</i>	SG	Hashim (1979)
				<i>M. javanica</i>	J, SG	Hashim (1979)
				<i>M. javanica</i>	UL and JV	Hashim (1983b)
				<i>Meloidogyne</i> sp.	UL	Hashim (1983b)
Peach	<i>Prunus persica</i> (L.) Batsch	Rosaceae	Fruit tree	<i>M. javanica</i>	JV	Yousef and Jacob (1994)
Peas	<i>Pisum sativum</i> L.		Field crop	<i>M. javanica</i>	B	Karajeh (2004)
Pepper	<i>Capsicum anuum</i> L.	Solanaceae	Vegetable crop	<i>M. incognita</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. incognita</i> race 1	DA	Karajeh (2004)
Pomegranate	<i>Punica granatum</i> L.	Punicaceae	Fruit tree	<i>M. incognita</i>	WD	Hashim (1983a)
				<i>M. javanica</i>	WD	Hashim (1983a)
Rosemary	<i>Rosmarinus officinalis</i> L.	Lamiaceae	Ornamental	<i>M. incognita</i> race 1	Q	New***
Squash	<i>Cucurbita pepo</i> L.	Cucurbitaceae	Vegetable crop	<i>M. arenaria</i> race 2	DA	Karajeh (2004)
				<i>M. incognita</i>	JV	Yousef and Jacob (1994)
				<i>M. javanica</i>	JV	Yousef and Jacob (1994)
				<i>M. javanica</i>	SS	Hashim (1979)
				<i>M. javanica</i>	SS	Karajeh (2004)
Snake cucumber	<i>Cucumis melo</i> var. <i>flexuosus</i> (L.) Naudin	Cucurbitaceae	Vegetable crop	<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
Tomato	<i>Solanum lycopersicum</i> L.	Solanaceae	Vegetable crop	<i>M. arenaria</i> race 2	DA	Karajeh (2004)
				<i>M. incognita</i>	J, NS	Hashim (1979)
				<i>M. incognita</i>	WBH	Karajeh and Al-Ameiri (2010)
				<i>M. incognita</i> race 1	DA	Karajeh (2004)

				<i>M. incognita</i> race 2	NS	Karajeh (2004)
				<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1979)
				<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
				<i>M. javanica</i>	DA, NS, SG, SS	Hashim (1979)
				<i>M. javanica</i>	JV	Mamluk <i>et al.</i> , 1984; Yousef and Jacob (1994)
				<i>M. javanica</i>	GS, GM, GH, AB, SK, WBH, T	Karajeh and Al-Ameiri (2010)
				<i>M. javanica</i>	GS, AB, NS, DA, SS, A, J, B, M, SK	Karajeh, (2004)
				<i>M. javanica</i>	AE**	New
Yellow Dock	<i>Rumex crispus</i> L.	Polygonaceae	Weed	<i>M. javanica</i>	SK	New
Watermelon	<i>Citrullus lanatus</i> L.	Cucurbitaceae	Vegetable crop	<i>M. javanica</i>	JV and UL	Abu-Gharbieh (1982b)
White Mulberry	<i>Morus alba</i> L.	Moraceae	Fruit tree	<i>M. javanica</i>	A	Karajeh (2004)
Wild Barley	<i>Hordeum spontaneum</i> L.	Gramineae	Weed	<i>M. javanica</i>	SK	New

* UL: Up-lands (J: Jerash, B: Al-baqaa, M: Madaba, A: Amman, OA: Om Al-Amad, WS: Wadi Shoieb, and AE: Al-Eina), DP: Desert plains (WD: Wadi Dhulail, Q: Al-Qwerah, Z: Zarqa, and AM: Al-Mafraq), JV: Jordan Valley (DA: Dier Allah, NS: North Shona, and SS: South Shona), SG: Southern Karak, GS: Ghor Safi, GM: Ghor Al-Mazra'a, GH: Ghor Haditha, AB: Al-Baqee', T: Al-Thira' and ShG: Shafa Ghors (SW: Side Wadis, SK: Sail Al-Karak, and WBH: Wadi bani Hamad).

** New site for the root-knot nematodes.

*** New record is only based on our knowledge.

Plant species infected with the Jordanian populations of RKNs were vegetable, forage and field crops, ornamentals, fruit trees and weeds. Twenty one percent of the listed plant species in Table 1 were weeds, which reflect the importance of these weeds as alternative hosts for RKNs in absence of the crop during fallow or over-seasoning periods. Other weeds were previously reported (Abu-Gharbieh, Abu-Irmaileh and Al-Banna, unpublished data cited by Abu-Gharbieh, 1994) as hosts for the root-knot

nematodes in some infested fields of the central part of Jordan valley including bishops weed (*Ammi majus* L., Apiaceae), Scarlet pimpernel (*Anagallis arvensis* L., Primulaceae), Chamomile (*Anthemis* sp., Asteraceae), Dwarf yellow milk vetch (*Astragalus hamosus* L., Leguminosae), pale star thistle (*Centaurea pallascens* Del., Asteraceae), Nettle-leaved goosefoot (*Chenopodium murale* L., Chenopodiaceae), field bindweed (*Convolvulus arvensis* L., Convolvulaceae), prickly lettuce (*Lactuca*

serriola L., Asteraceae), cheese-weed (*Malva parviflora* L., Malvaceae), knotgrass (*Polygonum aviculare* L., Polygonaceae), common purslane (*Portulaca oleracea* L., Portulacaceae), prickly dock (*Emex spinosa* L., Polygonaceae), yellow dock (*Rumex crispus* L., Polygonaceae), London rocket (*Sisymbrium irio* L., Asteraceae), night shade (*Solanum nigrum* L., Solanaceae), common sow thistle (*Sonchus oleraceus* L., Asteraceae), and narrow-leaved purple vetch (*Vicia peregrine* L., Leguminosae). Therefore, weeding and plowing could be effective for controlling weeds especially those are secondary hosts for RKNs thus preventing their contribution in increasing the initial population at the beginning of crop growing season.

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قائمة المدى العوائل لنيماتودا تعقد الجذور (*Meloidogyne species and races*) في الأردن

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ملخص

تعد نيماتودا تعقد الجذور (*Meloidogyne species and races*) ذات انتشار واسع في المناطق الزراعية المروية والتي تختلف في الظروف البيئية. في هذه الدراسة، تمت مراجعة المدى العائلي لأنواع وسلالات المجتمعات المحلية من نيماتودا تعقد الجذور في الأردن بالإضافة إلى جمع عينات جديدة من بعض المناطق الزراعية في الأردن. تم تسجيل واحد وثلاثون نوعاً نباتياً تنتمي إلى تسعة عشر عائلة كعوائل لهذه النيماتودا. بعض الأنواع النباتية سجلت لأول مرة كعوائل طبيعية وتشمل حصا اللبان (*Rosmarinus officinalis*) للسلالة الأولى من النوع *M. incognita*، وكلاً من أبو ركة (*Echinochloa colona*) والخبيزة (*Malva sylvestris*) والشعير البري (*Hordeum spontaneum*) للنوع *M. javanica*. تم تسجيل بعض مناطق الحصر كمواقع جديدة لنيماتودا تعقد الجذور في الأردن. نتائج الدراسة تحوي معلومات مفيدة في مكافحة نيماتودا تعقد الجذور والحد من انتشارها في الأردن.

الكلمات الدالة: المحاصيل الاقتصادية، الأردن، نيماتودا تعقد الجذور، حصر، الأعشاب الضارة.

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