Root-knot Nematodes on Vegetable Crops in Central and Western Ethiopia

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Abstract

A survey for root-knot nematodes (*Meloidogyne* spp.) was undertaken in the central and western parts of Ethiopia during the 1998-2000 cropping seasons. Eight hundred twenty eight samples were collected from different vegetable crops during both the rainy and off-seasons. The major crops grown in the areas are tomato, pepper and onion while other vegetables assessed included snap bean, cabbage, beetroot, carrot and potato. Three root-knot nematode species namely *Meloidogyne incognita, M. javanica* and *M. ethiopica* were found. Out of 192 field samples in all vegetables, 119 (62%) were found to be infested with *Meloidogyne* species. *M. incognita* was the dominant species with total incidence of 55.3% and 57.7% in 1998-99 and 1999-2000 seasons, respectively. Mixed infection of *M. incognita* and *M. ethiopica* was higher in 1999-2000 season next to *M. incognita* with an incidence of 32.7%. Pepper and tomato were the most seriously affected crops and should receive precedence in future research endeavors.

Introduction

Ethiopia is endowed with a suitable climate where many different kinds of vegetables can successfully be grown with tomato, pepper and onion being the most important crops. Because of their importance in the daily diet as well as being high cash crops for the small and large-scale growers (Lemma et al. 1992), the production of vegetables have become very important.

Significant crop yield losses due to various diseases such as those caused by nematodes are experienced annually. However, the extent of the nematode problems is not yet known, as the nematode fauna has not yet been extensively studied. Stewart & Dagnachew (1967) reported root-knot nematodes from cabbage, carrot, celery, sweet corn, cucurbits, garlic, lettuce, onion, shallot, pepper and tomato but no species were mentioned. In a subsequent survey (O'Bannon 1975); three different root-knot nematode species were identified from twenty two economically important crops including tomato, onion and lettuce. A survey was also conducted in major tomato, pepper and cabbage growing areas of eastern Ethiopia during the 1997 cropping season to study the distribution of root-knot nematodes in relation to altitude, soil texture and pH (Tadele & Mengistu 2000). From the 150 soil samples and infected roots collected from six areas, it was found that 90% of the samples contained *M. incognita*. Similarly, studies made by random sampling for root-knot nematodes in various parts of the country, revealed three root-knot nematodes to be widely spread (Wondirad & Kifle 2000). *M. incognita* was the most frequently found species with 58% incidence followed by *M. ethiopica* (24%) and *M. javanica* (18%). Frequently, large numbers of root-knot nematode infested fields were observed on vegetable farms especially in the warmer parts of the country.

Information on the abundance and distribution of these nematodes is extremely important for the development of control strategies especially for the use of resistant cultivars and in crop rotation practices. Hence, this study was undertaken.

Materials and Methods

A survey in vegetable fields in the Bako, Ambo, Guder, Butajira and Alaba areas was conducted during rainy seasons and in the Koka, Meki, Zway, Melgaewondo, Melkassa, Upper Awash, Melkasedi and Melkawerer areas during the dry season on privately and state owned farms in both 1998-99 and 1999-2000. Fifteen to twenty root samples of crops per hectare were collected randomly walking in a zig zag fashion and carefully uprooted using a hand auger. The samples were labeled and put in plastic bags and taken to the laboratory within two to three days. Root-knot galling index of 0-5 scale was used, where: 0 = no galls; 1 = 1-10% of the root system galled; 2 = 11-25% of the root system galled; 3 = 26-75% of the root system galled; 4 = 76-90% of the root system galled; 5 = 91-100% of the root system galled (Barker 1985).

Roots were thoroughly washed of soil particles and adult globose females were teased out of roots using dissecting needles under stereomicroscope. Perineal patterns of ten to twenty females from each sample were prepared and mounted (Hartman & Sasser 1985). The patterns were examined under a compound microscope for species identification according to Jepson (1987).

Polyacrylamide gel electrophoresis was performed for detection of esterase isozyme on some collections which was cultured in the greenhouse using the Phast system (Karsen 1994). Two females from a population cultured from a single egg mass were used to verify the species. Previously identified *M. javanica* was used as a reference.

Results

Three different *Meloidogyne* spp. were identified from tomato, pepper, onion, snap bean, cabbage, beet root, carrot and potato during the main and off seasons in 1998-99 and 1999-2000 (Tables 6, 7) (Fig. 1). Tomato, pepper and onion were the major vegetables grown from which large numbers of samples were taken followed by snap bean, cabbage, beetroot, carrot and potato (Table 1, 2).

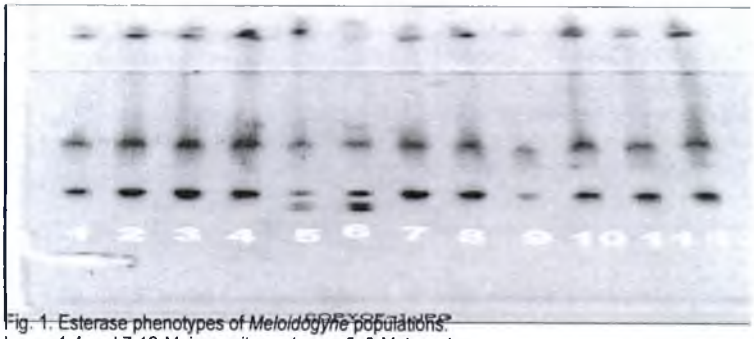

Fig. 1. Esterase phenotypes of *Meloidogyne* populations.
Lanes 1-4 and 7-12 *M. incognita*, Lanes 5, 6 *M. javanica*

Among the major vegetables, pepper was highly infected with an occurrence of 62.1% followed by tomato and onion with 60.9% and 33.3%, respectively, in 1998-99 season. Similarly, in 1999-2000 season pepper had the highest incidence of 80%, while tomato and onion had an

equal incidence of 47.1% (Table 1, 2). The highest incidence of 100%, however, was obtained in beetroot and carrot in 1998-99 and in beetroot, carrot and potato in 1999-2000 season. In both years, onion had the lowest occurrence with 33.3% in 1998-99 and 47.1% in 1999-2000. Total occurrence of root-knot infection in vegetable fields was higher in 1999-2000 than in 1998-99 with 66.6% and 57.8%, respectively, indicating that the cropping system in the season was favorable for build up of nematode population.

Table 1. Percentage occurrence of root-knot nematodes and mean root-knot index on different vegetables in 1998-99 crop season.

Vegetables	No. of fields visited	No. of fields with root-knot nematode	% occurrence	Total samples collected	Mean root-knot index
Tomato	46	28	60.9	148	2.5
Pepper	29	18	62.1	89	2.8
Onion	15	5	33.3	46	1.6
Snap bean	5	3	60	16	2.4
Cabbage	3	2	66.7	14	1.8
Beet root	1	1	100	5	1
Carrot	1	1	100	5	1
Potato	2	1	50	2	2
Total	102	59	57.8	384	

Table 2. Percentage occurrence of root-knot nematodes and mean root-knot index on different vegetables in 1999-2000 crop season.

Vegetables	No. of fields Visited	No. of fields with root-knot nematode	% Occurrence	Total samples collected	Mean root-knot index
Tomato	17	8	47.1	78	1.5
Pepper	45	36	80	232	1.6
Onion	17	8	47.1	83	0.9
Snap bean	3	2	66.7	16	0.8
Cabbage	4	2	50	15	0.9
Beet root	2	2	100	11	4.2
Carrot	1	1	100	4	1.8
Potato	1	1	100	5	1.8
Total	90	60	66.6	444	

The most dominant species in major vegetables was *M. incognita* with 55.3% and 57.7% incidences in the 1998-99 and 1999-2000 seasons, respectively (Table 4, 5). *M. ethiopica* was the second dominant species in both years with 14.9% and 3.9% incidences followed by *M. javanica* with 12.8% and 1.9%. All major vegetables were found to be infected with three species singly and in mixture.

Mixed infection of *M. incognita* with either *M. ethiopica* or *M. javanica* was found in tomato, pepper, onion, snap bean and beetroot. *M. ethiopica* was mixed with *M. incognita* more frequently than with *M. javanica* in both years (Table 4, 5). No infection of either the three *Meloidogyne* spp. in mixture or the two species, *M. javanica* and *M. ethiopica,* was found on the same field during the survey (Table 6, 7).

Table 3. Occurrence of root-knot nematodes on different vegetables in 1998-99 and 1 999-2000 crop seasons.

Vegetables	Total number of fields visited	Total number of fields with root-knot infection	Total % occurrence
Tomato	63	36	57.1
Pepper	74	54	73.0
Onion	32	13	40.6
Snap bean	8	5	62.5
Cabbage	7	4	57.1
Beet root	3	3	100
Carrot	2	2	100
Potato	3	2	66.7
Total	192	119	62.0

Table 4. Percentage occurrence of root-knot nematode species on major vegetables in 1998-99.

Root-knot	Percentage occurrence on different hosts						Total	
	Tomato		Pepper		Onion			
	No.	%	No.	%	No.	%	No.	%
M. incognita	11	45.8	15	83.3	-	-	26	55.3
M. ethiopica	4	16.7	-	-	3	60	7	14.9
M. javanica	4	16.7	-	-	2	40	6	12.8
M. incognita & M. ethiopica	2	8.3	2	11.1	-	-	4	8.5
M. incognita & M. javanica	3	12.5	1	5.6	-	-	4	8.5
Total	24	100	18	100	5	100	47	100

Table 5. Percentage occurrence of root-knot nematode species on major vegetables in 1999-2000.

Root-knot nematode species	Percentage occurrence on different hosts						Total occurrence	
	Tomato		Pepper		Onion			
	No.	%	No.	%	No.	%	No.	%
M. incognita	2	25	24	66.7	4	50	30	57.7
M. ethiopica	1	12.5	1	2.8	-	-	2	3.9
M. javanica	-	-	1	2.8	-	-	1	1.9
M. incognita & M. ethiopica	4	50	10	27.7	3	37.5	17	32.7
M. incognita & M. javanica	1	12.5	-	-	1	12.5	2	3.9
Total	8	100	36	100	8	100	52	100

Mean root-knot index was generally higher in 1998-99 than 1999-2000 seasons (Table 1, 2). The general trend, however, was similar in both years on all vegetables. The highest infection was found at Zway farmer's field on beetroot with an average root-knot index of 4.2 in 1999-2000 on a 0-5 root knot-index scale (Table 7). Among the major vegetables, pepper roots were the most severely infected with an average index of 2.8 in 1998-99 season (Table 1). Tomato was the second most severely infected crop with an average root-knot index of 2.5 followed by onion with 1.6.

From the total of 192 fields sampled in both years, 119 (62%) were infested with root-knot nematodes, of which pepper fields were the most infested among major vegetables. It is dominantly main season crop while tomato and onion are off season crops grown on irrigated fields. The other vegetables were less cultivated and thus were less represented in this study. The variation in number of samples per crop and area in both years was due to random sampling method followed and availability of vegetable farms.

Table 6. Vegetable growing areas surveyed, number of fields infested and root-knot nematode species identified in 1998-99 season.

Area	Altitude (m)	Crop	No of fields	Species identified	Mean RKI*
Rainy season					
Bako	1750	Pepper	8	*M. incognita, M. javanica*	2.7
Alaba	1820	Pepper	4	*M. incognita, M. ethiopica*	3.6
Butajira/Mareko	1835	Pepper	5	*M. incognita*	3.2
Meki	1660	Pepper	4	*M. incognita, M. ethiopica*	2.6
Off season					
Meki	1660	Tomato	4	*M. incognita, M. ethiopica*	2.8
Meki	1660	Snap bean	1	*M. incognita, M. ethiopica*	4
Meki	1660	Potato	1	*M. incognita*	2
Meki	1660	Carrot	1	*M. javanica*	1
Meki	1660	Cabbage	1	*M. javanica*	3.5
Meki	1660	Beetroot	1	*M. incognita, M. ethiopica*	4
Wonji	1680	Pepper	4	*M. incognita, M. ethiopica*	0.6
Melgaewondo	1750	Tomato	3	*M. incognita, M. ethiopica, M. javanica*	0.5
Zway	1660	Pepper	1	*M. incognita, M. ethiopica*	2.2
Zway	1660	Snap bean	1	*M. incognita*	3
Zway	1660	Onion	3	*M. ethiopica, M. javanica*	2
Tibila	1250	Snap bean	3	*M. incognita*	3
Merti	1100	Pepper	1	*M. incognita*	0.6
Nuraera	1100	Pepper	1	*M. incognita*	1.0

** RKI – Root-knot index (0 – 5 scale)*

Table 7. Vegetable growing areas surveyed, number of fields infested and root-knot nematode species identified in 1999-2000 season.

Area	Altitude (m)	Crop	No. of fields	Species identified	Mean RKI*
Rainy season					
Bako	1750	Pepper	12	*M. incognita, M. ethiopica*	1.7
Bako	1750	Onion	1	*M. incognita*	0.2
Alaba	1820	Pepper	5	*M. incognita, M. ethiopica*	2.1
Butajira/Mareko	1835	Pepper	10	*M. incognita, M. ethiopica, M javanica*	1.8
Shone/Boditi	2050	Pepper	5	*M. incognita, M. ethiopica*	1.2
Sheno/Boditi	2050				
Off season					
Meki	1660	Onion	2	*M. incognita, M. ethiopica*	2.8
Meki	1660	Cabbage	1	*M. javanica*	1.3
Meki	1660	Potato	1	*M. ethiopica*	1.8
Melkassa	1650	Pepper	3	*M. incognita*	0.2
Melkassa	1650	Tomato	2	*M. incognita, M. javanica*	1.3
Wonji	1680	Pepper	4	*M. incognita*	1
Wonji	1680	Onion	3	*M. incognita, M. ethiopica*	0.6
Wonji	1680	Tomato	3	*M. incognita, M. ethiopica*	0.6
Sheled	1750	Tomato	1	*M. incognita*	0.8
Zway	1660	Tomato	4	*M. incognita, M. ethiopica, M javanica*	2.4
		Onion	4	*M. incognita*	0.9
		Beetroot	2	*M. incognita, M. ethiopica*	4.2
		Snap bean	2	*M. incognita*	0.8
Tibila	1250	Pepper	2	*M. incognita, M. ethiopica*	2.4
Merti	1100	Pepper	1	*M. incognita*	0.1

** RKI – Root-knot index (0 – 5 scale)*

Discussion

The study conforms to previous reports that *M. incognita, M. javanica* and *M. ethiopica* are present in Ethiopia (Stewart & Dagnachew 1967, O'Bannon 1975). Previous studies concentrated mainly on the species found and not on the distribution of these species. In this study, *M. incognita* was the most frequently found species followed by *M. ethiopica*, while Sasser & Carter (1985) reported that, *M. incognita* was the most dominant species worldwide followed by *M. javanica, M. arenaria* and *M. hapla*. Similarly, Wondirad & Kifle (2000) found *M. ethiopica* to be more widespread than *M. javanica* in Ethiopia, while it is considered less important in the rest of the world due to limited geographic distribution (Netscher & Sikora 1990). A nematode species is considered important when it has wider geographic distribution and infecting more host plants.

Though no loss assessment data are available in the country, these nematode species are potentially damaging to susceptible vegetable crops. Damage threshold for Ethiopian isolate of *M. incognita* was found to be 1.6 Juveniles/cc of soil on susceptible tomato cv. Marmande (Tesfamariam 2000).

Plant-parasitic nematodes generally occur in polyspecific communities. Competition between two endoparasitic species is generally mutually suppressive because of the contention for available

feeding sites and physiological alterations; however, neutral and stimulatory interactions also occur (Eisenback 1985). In this study, mixed infection of *M. incognita* with the two species is common in tomato, pepper, onion, snap bean and beetroot. The interaction of these species could have synergistic effect to cause greater damage on the host plants. It is also possible that through competition for space and food, the damage due to the nematode could be less on the host plant. The reason why either the three species or *M. ethiopica* and *M. javanica* were not found mixed, however, is not clear and requires detailed study.

In most parts of the country vegetables remain the choice for irrigation farmers due to their high cash value. During the survey, all varieties of vegetables on the field were found to be susceptible to one or more of the three root-knot nematode species. The infection of onion, which was thought to be resistant or tolerant to root-knot nematodes, causes a serious problem as farmers are left without the choice of a rotation crop.

The high average incidence of nematode infection in both years shows that these nematodes are widely spread affecting both irrigated and non-irrigated fields. Once these nematodes are introduced into the soil, they can stay for several years persistently, particularly in irrigated fields, reaching high population level in short time. According to our observation and farmers opinion, there was a decline in the interest of farmers towards cultivation of vegetables and particularly tomato, due to root-knot nematodes. Recently, tomato cultivation has been withdrawn at Zway and some Upper Awash state farms. The situation would get worse as there are major plans of expanding vegetable production under irrigation.

Most farmers are not aware of nematode problems, hence, it will take long to change the situation unless strong extension and advisory service is in place in affected areas. Currently, farmers cultural practices are not up to standard and need to be addressed especially with regard to fallow and crop rotation. Unless in large farms or some areas where land is fairly available, the use of fallow will be limited. When properly designed and implemented, crop rotation was proved to be effective in controlling most plant-parasitic nematodes (Schmitt & Barker 1988). The wide host range of most root-knot nematode species, however, complicates its feasibility. Currently, there is only one root-knot nematode resistant tomato variety in production at horticulture development enterprises. It has been introduced years ago and has been planted continuously. Unless some other measures are taken to support its resistance, the variety will in short time might loss its resistance.

Hence, nematode control research should be strengthened in the country to fill the gap between research and production. It should be geared towards development of an IPM strategy focusing on cultural control practices which concentrate on the eradication of mixed infection. Pepper and tomato are the most seriously affected crops in Ethiopia and they should receive precedence in research endeavors.

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