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Distribution and Occurrence of Plant-Parasitic Nematode on Tomato (*Lycopersicon esculentum* Mill.) in Raya Valley, Southern Tigray

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Abstract

In Sub-Saharan Africa, plant-parasitic nematodes have received little research attention, particularly in our country Ethiopia. Despite the fact that millions of people in Ethiopia and other countries use and consume daily tomato, little is known about the associated plant-parasitic nematodes. As a result, this survey was launched to investigate the occurrence and distribution of plant-parasitic nematodes in Southern Tigray zone. An exhaustive sampling of plant parasitic nematodes was undertaken during the 2018/19 growing season total of 180 composite soil sample were collected from two major tomato-growing districts in the study areas. The study revealed that, eight genera of plant parasitic nematodes: Pratylunchus, Radopholus, Tylenchorynchus, Hemicriconemoides, Rotylenchulus, Ditylenchus, Longidonus and Tylenchus were detected. The highest occurrence and distribution were recorded by the Lesion nematode (*Pratylenchus* spp.) and Burrowing nematode (*Radopholus* spp.) having a population density of 187 and 136, respectively. This diversity could be attributed to raya valley farmers' intercropping of tomato with solanaceous and other vegetables. These findings suggest that producers should carefully monitor and select their cropping pattern. Furthermore, research should focus on the impact of these plant parasitic nematode species on tomato crop performance in order to determine the economic threshold level and estimate a cost-benefit analysis of management practices.

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Keywords

Distribution, Genera, Nematode, Plant parasitic, Species, Tomato.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important edibles and nutritious widely grown vegetable crops in the world. It is widely cultivated in tropical, subtropical and temperate climates and thus ranks third in terms of world vegetable production (FAO, 2006). It originated from tropical Mexico to Peru (Maerere, 2006). The introduction of cultivated tomato in to Ethiopian agriculture dates back to the period between 1935 and 1940 (Gemechis *et al.*, 2012). Tomato is a popular and widely grown vegetable crop in Ethiopia, ranking 8th in terms of annual national production (Amina *et al.*, 2012). In Ethiopia, the crop is grown between 700 and 2000 meters above sea level, with about 700 to 1400 mm annual rainfall, in different areas and seasons, in different soils, under different weather conditions, with different levels of technology (Birhanu and Ketema, 2010).

Globally, tomato is cultivated on over 4.73 million hectares of land with a production of about 170.8 million metric tonnes (FAO, 2014). In 2017/2018 cropping season, tomato production in Ethiopia was about 27,774.54 tons harvested from 5235.19 ha of land (CSA, 2018). However, average yield of tomato in Ethiopia is low 5.3 ton/ha (CSA, 2018). This is incomparable with the average yield of other countries such as China, USA, Turkey, India, Egypt, Italy and Spain with average yield of 22.67, 80.61, 35.81, 18.61, 40.00 and 76.35 ton/ha, respectively (FAO, 2010).

Despite the importance of this crop, the production and productivity are constrained by different biotic and abiotic factors that resulted into low yield and quality. Among biotic constraints, nematodes are among the most serious constraints to crop productivity and caused 12% annual yield loss of food and fibre crops worldwide (Eyualem and Etienne, 1995). Plant parasitic nematodes are associated with nearly every important agricultural crop and represent a significant constraint on global food security (Coyne *et al.*, 2018; Feyisa, 2021). Plant parasitic nematodes are microscopic animals that attack crops. Every species of plant has at least one species of nematodes that parasitizes it (O'Bannon, 1975). The consequence of plant-parasitic nematodes (PPN) on agricultural productivity is immense. Almost every crop is affected by PPN (Sasser, 1989). The global average estimate of annual damage caused by nematodes, based on 37 life sustaining crops, is US$ 358.24 billion, which is about 12.6% (9-15%) of total crop production (Abd-Elgawad, 2014; Martin and Fleming, 2014).

Moreover, this amount is certain to increase when additional loss studies on crops of regional importance are included. Species of the root-knot nematode genus, Meloidogyne, are estimated to cause a global loss of US$ 157 billion (Abad *et al.*, 2008) with a 30-100% reported crop loss within Africa, it is not difficult to recognize that the 20 species of this genus recorded from Africa alone are undermining the continent's agriculture (Murungi and Torto, 2014). Staple crop productivity is small scale in Ethiopian agriculture and is impacted by a number of factors, among which crop diseases are the most critical. The limited studies conducted so far on crop diseases shows that problems caused by PPN in Ethiopia have a serious impact on crop productivity (Bogale *et al.*, 2004; Yusuf *et al.*, 2009). Keeping in view of these *immense* effects of plant-parasitic nematodes (PPN) on global agriculture, the study has been conducted with the objectives: to identify the type of nematodes available, to determine and aware the impact of nematodes on tomato production in the areas. To assess the distribution and occurrence of plant-parasitic nematodes on tomato in the study areas.

Materials and Methods

Study Areas and Sampling

A total of 180 composite soil were collected from two major tomato growing districts in southern zone Tigray region of Ethiopia during the 2018/19 growing season. Sample numbers were evenly distributed and 10 fields were randomly sampled per kebeles. Soil samples of 1.5 kg consisting of 15 to 20 soil cores were taken in a zigzag pattern from 0 to 30 cm deep. The cores were combined per field to form a single composite sample. For each sampling site, cropping history, cropping patterns, crops grown, frequency of tomato production, and irrigation system employed were recorded. Samples were sealed in plastic bags and transported in a cooled insulated container to plant nematology laboratory at Mekelle University, for extraction and further characterization of the nematodes. The samples were kept in a cold room at 5-8 °C until they were processed for nematode extraction within a week.

Extraction and Counting of Nematodes

Each soil sample was thoroughly mixed, and a subsample of 200g of soil was assayed for nematodes using the modified Baermann funnel technique (Southey, 1970). Two hundred grams of soils were placed in the funnel and water was added slowly to moist the soil and left for 24 hours for extraction. After 24 hours, the sieve containing soil was removed, water was collected into a measuring beaker and the volume of water was recorded. Each sample was mixed well and 2 ml suspension was transferred into a counting chamber.

The population density of the plant-parasitic nematode genera was enumerated from a subsample of the extracted nematode suspension using a stereomicroscope. Subsamples with equal volume (2ml) were counted three times, and the average was used to describe the population densities.

The number of nematodes were counted and recorded. Individual nematodes were picked up from extraction and transferred on a temporary. Characterization of the plant-parasitic nematodes was done using identification keys developed by Mai and Mullin (1996) and Mekete *et al.*, (2012).

Data Collected

Nematode numbers were expressed as the number of nematodes per 200g soil. The prominence value (PV) was calculated as: absolute density × √absolute frequency of occurrence/10 (De Waele and Jowaan, 1988). Frequency is expressed as the number of sites where a genus occurred. Percentage frequency of occurrence (FO), population densities (PD) and abundance (A) of the extracted nematodes were determined.

Results and Discussion

Genera of Nematodes Detected in the Study Areas

A total of eight genera of plant parasitic nematodes were detected where, Pratylunchus, Radopholus, Tylenchorynchus, Hemicriconemoides, Rotylenchulus, Ditylenchus, Longidonus and Tylenchus, Plant parasitic nematode were identified. In line with previous studies, the highest occurrence was recorded by the Lesion nematode (*Pratylenchus spp*.) and Burrowing nematode (*Radopholus spp*.) having a population density of 187 and 136, respectively. This was followed by false-sheath nematode (Hemicriconemoides) having a population of 6 in the samples extracted. The reniform nematode (Rotylenches) was in the third rank which was attained a population of 15 and Needle nematode (Longidorus), were 12 in the samples extracted. Other nematodes encountered were, stylet -stunt nematode (Tylenchorynchus), stem and bulb nematode (Ditylenchus) and citrus root nematode (Tylenchus) which were recorded having the lowest population density in the area. From the survey study, the *Pratylenchus spp*. and *Radopholus spp*. might have a great importance because of their wide distribution. This finding is in agreement with O'Bannon (1975) survey revealed the frequent occurrence of *Pratylenchus spp*. in Enset, coffee and potato in Ethiopia. Similar observation was reported by Seid *et al*., (2015) as they find out eight PPN genera (*Criconema spp*., *Helicotylenchus spp*., *Hemicyclophora spp*., *Longidorus spp*., *Meloidogyne spp*., *Paratylenchus spp*., *Pratylenchus spp*. and *Rotylenchulus spp*.) associated with khat crop.

The current study found eight plant parasitic nematode genera from the tomato farm in southern Tigray. Pratylenchus and Radopholus genera appeared to be the most prevalent plant parasitic nematode among the eight-plant parasitic nematode genera, occurring at rates of 187 and 136 times, with percent occurrences of 47.70% and 34.69%, respectively. Furthermore, the nematode genera Longidorus, Tylenchorynchus and Hemicriconemoides had modest distributions, occurring at rates of 26, 15 and 12 times, with percent occurrences of 6.63%, 3.83% and 3.06%, respectively, whereas Ditylenchus, Tylenchorynchus and Tylenchus had a less frequent distribution. In our country, nematodes have been reported as production constraints of cereal, pulse and oil crop.

Several species of Pratylenchus and Radopholus genera were found to be widely distributed on tomato. However, the economic importance of these nematodes in relation to yield loss and their impact on national production of these crops still remains unknown. Higher occurrence and density of major nematode pests such as Pratylenchus and Radopholus may constrain tomato production in the study areas. The economic importance of the reported nematodes in Ethiopia must be determined, as well as the continuous search for an effective plant parasitic nematode management strategy in horticultural crops especially tomato and potato-based cropping systems.

Summary

Plant-parasitic nematodes are a significant constraint to crop production and productivity. Plant parasitic nematodes are found in nearly every important agricultural crop and pose a significant threat to global food security. Because of their intricate relationship with host plants, wide host range, and the level of damage caused by infection, plant parasitic nematode such as Pratylunchus, Radopholus, Tylenchorynchus and Hemicriconemoides genera at the top of the list of the most economically and scientifically important species at the study area on tomato crop. A large number of cultivated tomatoes suffer severe damage and yield loss as a result of the plant parasitic nematode. The most prevalent nematode genera were Pratylenchus (47.70%) and Radopholus (34.69%), respectively, in average percentage.

The lowest nematode genera assessed during the study were Tylenchus and Tylenchorynchus, respectively. Furthermore, our lack of concern given for this plant parasitic nematode cost us many yield reductions and penalties. Therefore, as a recommendation and conclusion every year the assessment should be performed to determine the most dangerous plant parasitic nematode, and an integrated management strategy should be developed.

Table.1 Distribution of plant-parasitic nematode genera from two major tomato growing districts in southern zone of Tigray region, during the 2018/19 growing season

Zones	Districts	Kebeles	Number farms	Nematode type	Ss1	Ss2	Ss3	Total population
Southern	Raya Azebo	Kara Adisho	1	Pratylenchus	4	2	3	9
				Radopholus	3	2	2	7
				Tylenchorynchus	3	0	2	5
			2	Pratylenchus	2	2	2	6
				Radopholus	3	1	2	6
				Roytlenchulus	0	0	1	1
				Hemicriconemoides	0	1	1	2
			3	Pratylenchus	1	1	2	4
				Radopholus	3	2	1	6
				Roytlenchulus	2	0	1	3
				Hemicriconemoides	1	0	1	2
			4	Hemicriconemoides	2	1	1	4
				Pratylenchus	2	2	3	7
				Radopholus	1	1	2	4
				Ditylenchus	1	2	2	5
			5	Hemicriconemoides	3	1	2	6
				Pratylenchus	3	2	4	9
				Longidonus	0	0	1	1
			6	Hemicriconemoides	2	2	1	5
				Pratylenchus	2	1	2	5
				Radopholus	3	2	2	7
			7	Hemicriconemoides	1	1	1	3
				Pratylenchus	1	4	3	8
				Radopholus	2	3	1	6
				Tylenchus	1	2	1	4
				Ditylenchus	0	1	1	2
			8	Hemicriconemoides	1	1	2	4
				Pratylenchus	4	2	2	8
				Radopholus	1	0	1	2
				Roytlenchulus	1	2	2	5
			9	Pratylenchus	3	2	3	8
			10	Radopholus	1	2	1	4
		Warabaye	1	Longidorus	1	0	0	1
			2	Pratylenchus	1	0	0	1

			Radopholus	0	1	0	1
			Longidorus	1	0	0	1
			Rotylenchulus	1	1	0	2
		3	No nematode	-	-	-	-
		4	Radopholus	1	1	1	3
		5	Radopholus	1	0	0	1
		6	Pratylenchus	1	1	0	2
		7	Radopholus	1	2	2	5
		8	Pratylenchus	1	1	2	4
		9	Radopholus	1	0	0	1
		10	No nematode	-	-	-	-
	Hada alga	1	Pratylenchus	1	0	0	1
		2	Pratylenchus	2	1	1	4
			Rotylenchulus	1	1	0	2
		3	Pratylenchus	2	0	1	3
			Longidorus	0	1	0	1
			Radopholus	3	4	2	9
		4	Pratylenchus	2	1	1	4
			Radopholus	3	2	2	7
		5	Pratylenchus	3	2	2	7
		6	Pratylenchus	2	3	2	7
			Radopholus	2	1	3	6
		7	Pratylenchus	3	2	2	7
		8	Radopholus	0	1	2	3
		9	No nematode	-	-	-	-
		10	No nematode	-	-	-	-
	Wargiba	1	Pratylenchus	2	1	0	3
			Rotylenchulus	1	0	0	1
			Radopholus	3	2	2	7
		2	Pratylenchus	4	3	3	10
			Radopholus	2	1	4	7
		3	Pratylenchus	3	2	3	8
			Radopholus	4	3	2	9
		4	Pratylenchus	2	1	0	3
			Radopholus	3	2	1	6
			Rotylenchulus	1	0	0	1
		5	Pratylenchus	1	2	2	5
		6	Pratylenchus	3	2	1	6

				Radopholus	2	1	1	4
			7	Radopholus	1	1	0	2
			8	Radopholus	2	1	1	4
				Pratylenchus	2	3	3	8
			9	Radopholus	2	0	1	3
				Pratylenchus	4	1	1	6
			10	Radopholus	1	1	2	4
				Pratylenchus	4	1	1	6
	Raya Alamata	Adis kigni	1	Longidorus	1	0	0	1
			2	Pratylenchus	0	1	0	1
			3	Radopholus	1	0	0	1
				Longidorus	3	2	2	7
				Pratylenchus	2	1	0	3
			4	Pratylenchus	1	1	0	2
			5	No nematode	-	-	-	
			6	Pratylenchus	1	0	0	1
				Radopholus	1	0	0	1
			7	Pratylenchus	0	1	0	1
				Radopholus	0	0	1	1
			8	Pratylenchus	1	1	0	2
			9	Radopholus	1	0	1	2
				Pratylenchus	0	1	0	1
			10	Pratylenchus	1	0	0	1
				Radopholus	0	1	0	1
		Gerjelle	1	No nematode				-
			2	No nematode				-
			3	No nematode				-
			4	No nematode				-
			5	No nematode				-
			6	No nematode				-
			7	No nematode				-
			8	Pratylenchus	3	2	1	6
			9	Pratylenchus	1	2	3	6
				Radopholus	1	2	2	5
			10	Pratylenchus	1	1	2	4
				Radopholus	1	0	0	1
Total								

Table.2 Population densities of plant parasitic nematodes identified from soil sample during 2018/2019 in Sothern Tigray

Available nematode genera				
S/N	**Nematode**	**Common name**	Crop (Tomato)	Total Population
1	Pratylenchus	Lesion nematode	Tomato	187
2	Tylenchorynchus	Stylet -stunt nematode	Tomato	5
3	Rotylenches	Reniform nematode	Tomato	15
4	Radopholus	Burrowing nematode	Tomato	136
5	Ditylenchus	Stem and bulb nematode	Tomato	7
6	Tylenchus	Citrus root nematode	Tomato	4
7	Longidorus	Needle nematode	Tomato	12
8	Hemicriconemoides	false-sheath nematodes	Tomato	26
Total	8	-	-	392

Table.3 Occurrence of plant-parasitic nematode genera in soil samples from two major tomato growing districts in southern zone of Tigray region, during the 2018/19 growing season

Districts	Kebeles	Pratylenchus	Radopholus	Hemicriconemoides	Rotylenches	Longidorus	Tylenchorynchus	Ditylenchus	Tylenchus
Raya Azebo	Kara Adisho	*	*	*	*	*	*	*	*
	Warabaye	*	*	-	*	*	-	-	-
	Hada alga	*	*	-	*	*	-	-	-
	Wargiba	*	*	-	*		-	-	-
Raya Alamata	Adis kigni	*	*	-		*	-	-	-
	Gerjelle	*	*	-	-	-	-	-	-

‘’*’’ Presence the nematode genera, ‘’- ‘’ absence of nematode genera

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