PLANT PARASITIC NEMATODES ASSOCIATED WITH TOMATO IN GHANA

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Summary. A survey was conducted during 2011 in the Ashanti, Brong Ahafo and Upper East regions of Ghana, West Africa, to identify the nematode taxa associated with tomato (*Solanum lycopersicum* L.). Eight nematode genera or species were encountered. They were: *Helicotylenchus* spp., *Hoplolaimus indicus*, *Meloidogyne incognita*, *Pratylenchus brachyurus*, *Rotylenculus reniformis*, *Scutellonema* spp., *Tylenchulus* spp. and *Xiphinema elongatum*. The Upper East Region (UER) had all eight nematode species, while the Ashanti and Brong Ahafo regions each had six nematode species only. *Meloidogyne incognita* was found in all the 21 farms sampled with a relative abundance of 36.8%, whilst *Hoplolaimus indicus* was the least abundant. Akomadan and Agogo, in the Ashanti region, were the greatest and least populated localities, respectively. Three species, *M. incognita, P. brachyurus* and *R. reniformis* were also extracted from tomato roots, with *M. incognita* being the most abundant and *R. reniformis* the least. Tomato cv. Petomech did not show galls in the three localities of the UER, but was severely galled at Akomadan in the Ashanti region.

Key words: Abundance, distribution, phytoparasitic nematodes, *Solanum lycopersicum*.

Tomato (*Solanum lycopersicum* L.) is the second most cultivated vegetable in the world, with China, USA and Turkey being the leading producers (FAO, 2004). In Ghana, the total land area under tomato cultivation was 37,000 ha in 2000 with an average yield of 7.5 t/ha (GIPC, 2000). Plant parasitic nematodes (PPN) have been implicated as a major constraint to agricultural production all over the world (Luc *et al.*, 2005). In the West African sub-region, the severity of PPN has been documented. In Ghana, Osei *et al.* (2011) observed populations of PPN on tomatoes larger than on *Mucuna pruriens* L. and *Tithonia diversifolia* Hemsl. *et* Gray. Losses in the range 20-94% due to nematodes were recorded in Nigeria (Olowe, 1978). Duponnois *et al.* (1995) reported that in Senegal *Meloidogyne* species parasitized tomatoes. For sustainable tomato production, efforts must be made to obtain insights on the presence and distribution of pests and diseases associated with major crops. Therefore, a survey was conducted in Ghana in 2011 to identify the nematode taxa associated with tomato production in the regions where tomato is intensively produced, in order to design integrated pest management strategies to curb the nematode menace.

MATERIALS AND METHODS

Study sites. The survey was conducted in three main tomato producing regions of Ghana having different rainfall patterns, soil and vegetation types (Table I). The surveyed regions were: Ashanti, Brong Ahafo and Upper East. Two localities were selected in the Ashanti (Agogo and Akomadan) and the Brong Ahafo (Tanoso and Tuobodom) regions, whilst three localities (Pwalugu, Vea and Tono) were selected in the UER. Tomato cultivars observed in the study areas were: Petomech at harvesting stage and a local cultivar at flowering stage at Akomadan and Agogo, respectively, in the Ashanti region; a local cultivar at fruiting stage in both localities (Tanoso and Tuobodom) in the Brong Ahafo region; and Petomech at harvesting stage in all three localities in the UER. Petomech is not marketed as a resistant cultivar.

Sampling and extraction of nematodes. Three farms, each of one acre, were randomly selected at Akomadan, Pwalugu, Vea and Tono, and four farms were selected at Agogo, Tuobodom and Tanoso. Three soil samples per farm were collected from the rhizosphere of tomatoes, with a 5 cm diameter soil auger, to a depth of 20 cm. Each soil sample (200 cm^3) was collected in a polythene bag and labeled. Samples were kept in iced chests to prevent excessive heating. In the laboratory, nematodes were extracted from the soil samples using the modified Baermann funnel method (Whitehead and Hemming, 1965). Root samples collected from tomatoes whose rhizosphere soil was sampled (three samples per farm) were rated for gall index according to Zeck's 0-10 scale (Sikora and Fernandez, 2005). Motile stages of the nematodes were also extracted from 5 g of tomato root samples (three samples/farm) by the same method used to extract nematodes from the soil. After 24 h of extraction, nematodes were fixed in TAF (37% formaldehyde 7.6 ml, Tri-ethylamine 2 ml and distilled water 90.4 ml) and third and fourth stage nematodes were mounted on aluminium double-coverglass slides. Nematode specimens were then identified on the basis of morphological characteristics.

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Table I. Geo-ecological description of study sites.

Locality	Region	Location	Rainfall type	Soil series	Vegetation
Vea	Upper East	0° 45'N 10° 40'W	Unimodal	Yorogo/Zorko	Sudan savanna
Pwalugu	Upper East	10° 36'N 0° 51'S	Unimodal	Pwalugu	Guinea savanna
Tono	Upper East	10° 45'N 01° 54'W	Unimodal	Savanna agrisols	Guinea savanna
Akomadan	Ashanti	01° 60'W 01° 45'E	Bimodal	Kumasi/Offinso	Moist semideciduous forest
Agogo	Ashanti	06° 69'N 01° 22'W	Bimodal	Phylite	Semideciduous forest
Tuobodom	Brong Ahafo	07° 38'N 01° 54'W	Bimodal	Sandstone	Forest savanna transition
Tanoso	Brong Ahafo	07° 27'N 01 58'W	Bimodal	Sandstone	Forest savanna transition

However, *Meloidogyne incognita* was identified by examining the perineal patterns of adult females (CIH, 1978). Nematode counts and index based data were log [ln (x +1)] and square root [√(x + 0.5)] transformed, respectively, to improve homogeneity of variance before analysis which was performed using GenStat 8.1. (Lawes Agricultural Trust, VSN International). Means were compared using Duncan's multiple range test.

RESULTS

Eight plant parasitic nematodes were encountered in the three regions surveyed (Table II). They were: *Helicotylenchus* spp., *Hoplolaimus indicus* (Sher), *Meloidogyne incognita* (Kofoid *et* White) Chitw., *Pratylenchus brachyurus* Godfrey, *Rotylenculus reniformis* Linford *et* Oliveira, *Scutellonema* spp., *Tylenchulus* spp. and *Xiphinema elongatum* Schuurmans Stekhoven *et* Teunissen. The UER had all eight genera of nematodes encountered. However, this region recorded the least total nematode density (5,376/200 cm^3) soil (Table II). The Ashanti and Brong Ahafo regions, in the middle belt of Ghana, had the same number of genera each (6) and the same diversity of nematodes. *Hoplolaimus indicus* and *X. elongatum* were not found in these regions.

A total of 21,638 nematode specimens were encountered during the survey (Table III). *Meloidogyne incognita* was the most frequent (found in all the 21 farms sampled) and abundant nematode (relative abundance of 36.8%), followed by *P. brachyurus* recorded in twenty farms with an abundance of 27.1%, *Helichotylencus* spp. occurring in fifteen farms with an abundance of 10.2%, *Scutellonema* spp. present in thirteen farms but with a low abundance (3.8%), and *R. reniformis* recovered from eleven farms with an abundance of 10.5%. The other genera were less frequent and abundant with *H. indicus* being the least frequent (present in only two

Table II. Diversity and density/200 cm^3 soil of plant parasitic nematodes from the Ashanti, Brong Ahafo and Upper East regions of Ghana during 2011.

Nematode genus	Ashanti	Brong Ahafo	Upper East
Helicotylenchus	1,121	829	225
Hoplolaimus	0	0	51
Meloidogyne (juveniles)	2,889	3,110	1,959
Pratylenchus	2,455	2,269	1,147
Rotylenchulus	1,808	420	40
Scutellonema	139	180	540
Tylenchulus	212	830	672
Xiphinema	0	0	742
Total	8,624	7,638	5,376
Number of genera	6	6	8

Table III. Frequency of occurrence and relative abundance of plant parasitic nematodes associated with all the 21 farms in the three regions of Ghana during 2011.

Nematode genus	Population/200 cm^3 soil	Frequency of occurrence*	Relative abundance (%)[1]
Helicotylenchus	2,205	15	10.2
Hoplolaimus	51	2	0.2
Meloidogyne (juveniles)	7,958	21	36.8
Pratylenchus	5,871	20	27.1
Rotylenchulus	2,268	11	10.5
Scutellonema	829	13	3.8
Tylenchulus	1,714	7	7.9
Xiphinema	742	5	3.4
Total	21,638	–	–

*No. of farms in which a particular nematode was found.
[1]The ratio of a particular nematode over the total nematode population × 100.

farms) and least abundant (0.2%) in the UER.

Akomadan, in the Ashanti region, had the greatest nematode density in the soil, followed by Tuobodom in the Brong Ahafo region (Table IV). Agogo, also in the Ashanti region, was the locality less populated by nematodes. *Xiphinema elongatum* was found only in the three locations of the UER.

Three species, namely *M. incognita*, *P. brachyurus* and *R. reniformis* were also extracted from the roots of tomato and their densities were larger in the middle belt of Ghana than in the UER. *Meloidogyne incognita* was the most abundant and *R. reniformis* was the least as this nematode was not extracted from tomato roots in the UER. Vea had the lowest density of *M. incognita* whilst the significantly largest densities of *M. incognita* occurred in Akomadan and Tuobodom ($P < 0.05$). There were almost no differences in the numbers of *P. brachyurus* found in the roots of tomato in the different localities (Table V).

Galling was not observed on the root of cv. Petomech in the three localities in the UER (Table V), while in Akomadan, which recorded the largest density of *M. incognita* both in soil and root, this cultivar showed the most severe root galling (3.9).

DISCUSSION

In West Africa, tomato production has been reported to be adversely affected by plant parasitic nematodes. In Ghana for instance, Hemeng (1981) reported 73-100% yield loss in tomato in the Guinea savanna zone of the country. Populations of *M. incognita* from the Ivory Coast overcame the resistance of tomato cv. Rossol (Fargette and Braaksma, 1990). Nematode densities in the UER were comparatively low partly due to the extremely high temperatures and long drought spells in those areas. In Ghana, where most farmers are unaware of the

Table IV. Density of nematodes/200 cm^3 soil from the seven localities surveyed in 2011.

Locality	Meloi	Praty	Heli	Roty	T'chus	Scut	Xiph
Pwalugu	93 (1.9)[1]	293 (2.5)	80 (1.6)	0*	159 (2.2)	94 (1.9)	80 (1.6)
Vea	111(2.0)	173 (2.1)	141(2.1)	40 (1.5)	188 (2.2)	146 (2.0)	94 (1.7)
Tono	96 (1.9)	286 (2.4)	27 (1.3)	12 (1.0)	26 (1.3)	135 (2.1)	67 (1.6)
Agogo	141 (2.1)	98 (2.1)	50 (1.5)	74 (1.6)	71 (1.6)	0	0
Akomadan	775 (2.9)	630 (2.8)	300 (2.6)	529 (2.7)	0	46 (1.5)	0
Tuobodom	516 (2.7)	340 (2.6)	140 (2.1)	23 (1.3)	160 (2.2)	37 (1.5)	0
Tanoso	317 (2.5)	137 (2.1)	0	47 (1.5)	116 (2.1)	0	0
LSD ($P<0.05$	(0.4)	(0.5)	(0.6)	(0.2)	(0.6)	(0.3)	(0.4)
CV (%)	(1.1)	(6.9)	(2.6)	(6.0)	(3.2)	(11.6)	(8.7)

Data are means of three replicates.
[1]In brackets are transformed data [ln (x + 1)] used in ANOVA
*Data not used in analysis
Meloi = *Meloidogyne incognita*, Praty = *Pratylenchus brachyurus*, Heli = *Helicotylenchus* spp., Roty = *Rotylenchulus reniformis*, T'chus = *Tylenchulus* spp., Scut = *Scutellonema* spp., Xiph = *Xiphinema elongatum*.

Table V. Root gall index (RGI) (0-10 scale) of tomato and nematode density/5 g tomato root sampled during 2011.

Location	Meloi		Praty	Roty
	RGI	‡	‡	‡
Pwalugu	0*	40 (1.8)	33 (1.6)	0
Vea	0	10 (1.4)	30 (1.6)	0
Tono	0	36 (1.5)	48 (1.8)	0
Agogo	2.5 (1.5)	81 (1.9)	38 (1.7)	37 (1.7)
Akomadan	3.9 (1.7)	112 (2.0)	79 (1.9)	46 (1.8)
Tuobodom	1.3 (1.1)	112 (2.0)	94 (1.9)	49 (1.9)
Tanoso	1.5 (1.2)	82 (1.9)	0	13 (1.5)
LSD (P <0.05)	(0.8)	(0.5)	(0.5)	(1.1)
CV (%)	(9.5)	(3.0)	(0.6)	(3.9)

Data are means of three replicates

‡Nematode density/5 g root

[1]In brackets are transformed data $\sqrt{(x + 0.5)}$ and [ln (x + 1)] used in ANOVA for RGI and nematode density respectively

*Data not used in analysis.

damages caused by plant parasitic nematodes (Osei *et al.*, 2004), low nematode densities still constitute a threat to the tomato industry. The short life cycle, 20-30 days (Crow and Dunn, 2005) and high reproductive rates under favourable soil conditions (Ananhirunsalee *et al.*, 1995) could result in a rapid build-up of the nematode population during the growing season and so cause economic damage to the crop. Besides, interaction between nematodes and other pathogenic soil organisms, such as bacteria and fungi, in the development of certain disease complexes (Moura *et al.,* 1975), makes soil nematodes very important even at very low soil densities.

Of the nematodes found, *M. incognita* is certainly the most damaging on a world basis. Sasser and Freckman (1987) reported that the yield losses caused by nematodes to tomato are of about 20.6%, of which the largest proportion is caused by root-knot nematodes. Di Vito *et al.* (1991) reported a tolerance limit of tomato to *M. incognita* of 0.55 eggs and juveniles/cm^3 soil and crop failure occurring at 32 eggs and juveniles/cm^3 soil. *Rotylenchulus reniformis* is also known to affect tomato yield in several countries (Robinson *et al.*, 1997; Sikora and Fernandez, 2005). In general, all species of *Pratylenchus* extracted from the roots, including *P. brachyurus*, must be considered as potential constraints to crop yield. The other nematodes encountered are known to attack vegetables and other crops, but their economic importance has not yet been assessed. The three endoparasitic nematodes referred to above have rather large host ranges (Robinson *et al.*, 1997; Castillo and Vovlas, 2007; Rich *et al.*, 2009) and, therefore, they have potential to damage other crops rotated with tomato in Ghana. Therefore, the results of our study are useful to suggest and design integrated pest management strategies.

The cv. Petomech was not galled in the UER and severely galled at Akomadan in the Ashanti region. Host resistance has been reported as the most practical alternative to the use of nematicides (Da Conceicao *et al.*, 2003). However, more investigations are needed to obtain insights on the reaction of tomato cv. Petomech, widely cultivated in Ghana, to Ghanaian populations of the major root-knot nematodes species and to ascertain whether the populations of root-knot nematodes occurring in the Ashanti region are of *Mi* gene virulent strain of *M. incognita* or of a species of root-knot nematode against which this gene is not effective.

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