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Distribution and Identification of Nematodes in Tomato Farmers' Fields in the Selected Semi-Arid Climates of Central and Northern Tanzania

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Authors' contributions

This work was carried out in collaboration between both authors. Author JSM designed the study, performed the statistical analysis, managed the discussion and wrote the first draft of the manuscript. Author CDR managed the designed study, analysis and literature searches. Both authors read and approved the final manuscript

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ABSTRACT

Aims: On farm assessment of nematode infestation in tomato farmers' fields was carried out by scoring their incidence and severity in the selected semi-arid climates of central and northern Tanzania. Out of 25 plants assessed from each farmer's field, 5 plants were uprooted and scored using a 1-5 galling index. Uprooted disease plant and soil samples were collected for laboratory assessment. This study revealed a degree of variation in the mean incidence and severity of nematode infestation along the study areas. *Meloidogyne*, *Scutellonema* and *Helicotylenchus* were identified nematodes of economic importance. *Meloidogyne* was the most predominant nematode across all the production areas. It was therefore advised that farmers' management practices be improved alongside an establishment of varieties that could withstand pressure of nematodes as revealed from present study.

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Study Design: Study was cross-sectional assessment survey.
Place and Duration of Study: This study was conducted in farmers' fields in 22 villages from peri-urban areas of Dodoma Municipality, Kongwa, Babati and Kiteto districts as the main tomato growing areas in the central and northern districts of Tanzania in 2013/14 and 2015/16 production seasons.
Methodology: On farm assessment of nematode was taken by scoring incidence and severity of their infestation. From each village, four tomato farmers' fields were randomly selected for an assessment. Out of 25 plants selected from each field, 5 plants were uprooted to 15-30 cm soil depth for nematode scoring. Gall score for severity determination of nematodes was a 1-5 galling index i.e. 1 (no galling) to 5 (severe galling). Incidence % of nematodes was analyzed to low, medium, or high, if (≤25%), (25% < to 50%), and (50% < to 100%) of tomato roots were infested with nematodes respectively.
Results: The average mean incidence of nematodes along the selected semi-arid climates of central and northern Tanzania was 36.1% with the highest mean incidence (48%) discovered in Kongwa district. Kiteto and Babati districts had the next highest mean incidence by 38.3 and 34.3% respectively. The lowest mean incidence (23.8%) was discovered in peri-urban areas of Dodoma Municipality. The mean incidence had an impact on the average mean severity (2.7) of nematode infestation and the mean severity in the specific district along the study areas. Kongwa district that had the greatest incidence along the study areas was noted with the highest mean severity by 3.8. Closely, was Kiteto by 3.0 which had greater mean incidence than two other districts; Babati and Dodoma Municipality whose mean severity were the lowest by 2.3 and 2.2 respectively. Furthermore, *Meloidogyne* was discovered the most predominant nematode along the selected study areas by 99.3%. *Tylenchulus, Pratylenchus, Helicotylenchus, Aphelenchoides* and *Rotylenchus* were revealed less common nematodes by 0.7% in total.
Conclusion: It was advised that farmers' management practices be improved alongside an establishment of more varieties that could withstand dry climates and doing well in pressure of nematodes within surveyed areas.

Keywords: Lycopersicon esculentum; helicotylenchus; meloidogyne; scutellonema; incidence; severity.

1. INTRODUCTION

The tomato (*Lycopersicon esculentum* Mill.) is one of the most significant vegetable crops grown throughout the world [1]. Presently, tomato is classified as the most commonly grown vegetable crop in the world [2] that forms an essential part of human diet. It is an important source of vitamins, micronutrients and other food supplements [3]. Tomato production is a significant income generating activity among many small scale farmers in Africa. According to FAO [2], 14% of world vegetable production which is about 100 million metric tons per annum comes from tomato production. The tomato productivity is worth of $ 1.6 billion. Nematode infestation is one of the main factors that influence tomato production in the world. Opeña and Kyomo [4] have reported nematode as an economic important pest throughout tropical and sub-tropical countries. Nematodes consist of five major functional groups namely; plant parasites, bacterial and fungal feeders, predators and omnivores [5]. Plant parasitic nematodes are of economic importance because they reduce crop yields [6]. They interact with infectious pathogens to produce disease complexes which breakdown plant resistance against disease pathogens [7, 8]. For many years, parasitic nematodes have been responsible for annual losses in vegetable crops which pose a serious threat to the production. According to Sasser and Carter [9], parasitic nematodes have been causing up to 22% of crop losses in farmers' fields every year. Plant-parasitic nematodes feed either ecto- or endoparasitically. Ectoparasites that feed from outside of a root include *Xiphinema* (dagger nematodes), *Longidorus* (needle nematodes), and *Trichodorus* (stubby-root nematodes). In contrast, endoparasites enter root to feed within the plant. They can be sedentary, establishing specialised feeding sites and remaining there until they die. Examples of sedentary endoparasites are *Heterodera* and *Globodera* (cyst nematodes), *Rotylenchulus reniformis* (reniform nematodes) and *Meloidogyne* (root-knot nematode) [10]. Root Knot Nematodes (RKN) with four major species; *M. arenaria, M. hapla, M. incognita,* and *M. javanica* have been reported to have great impact on tomato

production in many parts of the world [11]. These species cause galls or root-knots on infected plants with other symptoms such as stunted growth, wilting, and poor fruit yield. Root weight increase with decrease in shoot weight is observed in plants infected with *M. incognita* [12]. Infestation of RKN on tomato production depends mainly on varieties used, growth stage, mode of transmission, and farmers' management practices. RKN is a serious problem in tomato production in Tanzania [13]. Continuous growing of RKN host crops allows their population build up in soil and an increase in crop losses [14,15]. Central and Northern districts are the region potential in vegetable production in Tanzania whose tomato production is mainly practiced by smallholder farmers. However, less information is known about the prevalence of nematode on tomato farmers' fields of the selected areas of this study. Therefore epidemiology study for nematode infestation on tomato is a significant step towards sustainable management practices which lack among many tomato farmers in Tanzania.

2. MATERIALS AND METHODS

2.1 Description of the Areas of Study

The area covered in this study was the central zone of Tanzania lies roughly between latitudes 4° and 8°S and longitudes 32° and 39°E. The study was carried out in selected administrative wards and villages of peri-urban areas of Dodoma Municipality, Kongwa, Babati and Kiteto districts as the main tomato growing areas in the central and northern districts of Tanzania (Fig. 1 and Table 1).

2.2 Field Data Collection

To obtain baseline data, on farm assessment of nematodes infestation was carried out by scoring mean incidence and severity of their infestation from selected villages. From each village, four fields of tomato were randomly selected for an assessment. Out of 25 plants selected from each field in a zigzag pattern, 5 plants were uprooted to 15-30 cm soil depth using a trowel. The soil adhering to the root system was gently removed and roots were observed for incidence (presence or absence of galls). This was followed by gall scoring for determination of severity of nematodes using a 1-5 galling index i.e. 1 (no galling) to 5 (severe galling) as developed by Bridge and Page [16]. This is considered gall index indicating damage caused by RKN. The infected roots and soil samples were preserved into properly labelled polythene bags and brought to the laboratory for further species identification. The incidence of nematodes in a tomato field was determined as a number of samples containing a given nematode genus (n) on the total number of the surveyed samples (N) in terms of frequency. Incidence % of nematodes was recorded low, medium, or high, if (≤25%), (25% < to 50%), and (50% < to 100%) of tomato roots were infested with nematode

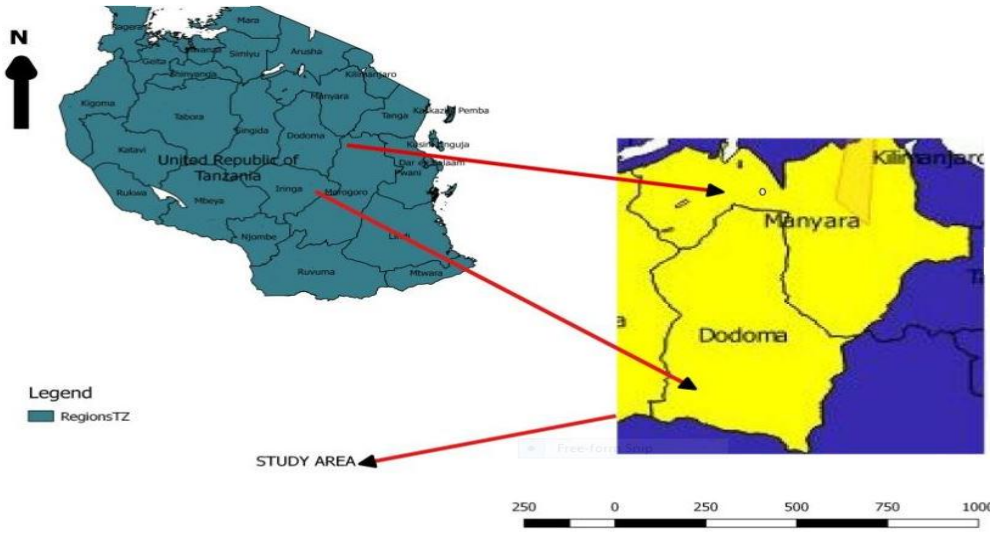

Fig. 1. Dodoma (Peri-urban and Kongwa district) and Manyara (Babati, and Kiteto districts) as study area

(Source: Field Survey 2013-16)

Table 1. Selected tomato production areas in central and northern districts of Tanzania

Region	District	Wards	Villages
Dodoma	Dodoma Municipality	Mpunguzi	Mpunguzi
			Matumbulu
		Makotopola	Veyula
			Msalato
	Kongwa	Mlali	Mlali Iyegu
			Mlali bondeni
		Pandambili	Moleti
		Chamkoroma	Chamkoroma
			Tubugwe juu
Manyara	Babati	Riroda	Sangara
		Magugu	Mawemairo
			Matufa
			Gichameda
		Mwada	Shaurimoyo
		Gallapo	Gallapo
		Quash	Endodash
	Kiteto	Kibaya	Kibaya
		Partimbo	Nalangtomony
		Matui	Matui
			Bwawani
			Chapakazi
		Sunya	Sunya

respectively. Nematode scoring survey was jointly assessed with pathologist using nematology identification guide. Uprooted and nematode scored plants were collected for further identification. Samples collected within fields of the same district were pooled as one sample.

2.3 Nematode Extraction

Nematode scored plant roots were chopped into small pieces using a blender and mixed together for 48 hr of incubation. 10 - 100 g of chopped roots were taken for further extraction using modified Baermann technique [17]. Nematode adults and juveniles extracted from soil and chopped root samples were morphologically identified and counted using a compound microscope at 20 and 40 x magnifications respectively [18].

3. RESULTS

3.1 Incidence and Severity of Root-knot Nematodes on Tomato

Mean incidence of nematodes infestation scored from 22 villages of four districts (Table 2) showed majority of farmers' fields were infested with nematode in variable degree. However, the average mean incidence of nematodes along the selected semi-arid climates of central and northern Tanzania was 36.1%.

Table 2. Mean incidence and severity of nematodes in the selected study areas

Description	Dodoma	Kongwa	Babati	Kiteto	Average
Village surveyed	4	5	7	6	5
Farmers' fields	16	20	28	24	22
Plant studied (N)	80	100	105	120	101
Infestation cases (n)	19	48	36	46	37
Mean incidence (%)	23.8 ± 1.96	48.0 ± 3.06	34.3 ± 3.46	38.3 ± 2.62	36.1 ± 2.01
Mean severity	2.2 ± 0.24	3.2 ± 0.33	2.3 ± 0.66	3.0 ± 0.59	2.7 ± 0.28

The highest mean incidence (48%) was found in Kongwa district, next to Kiteto and Babati by 38.3 and 34.3% respectively. The lowest mean incidence (23.8%) was found in peri-urban areas of Dodoma Municipality. Mean severity of nematodes infestation on tomato in areas of study (Table 2) had also variations along districts. Kongwa district had highest mean severity (3.8) with also the greatest incidence along the study areas. Closely followed, was Kiteto (3.0) which had also greater mean incidence than two other districts; Babati and Dodoma Municipality which had the lowest mean severity by 2.3 and 2.2 respectively. However, the overall mean severity was 2.7 slightly higher than the lowest mean severity along districts.

3.2 Identification of the Root Knot Nematodes (RKN)

Noted in Table 3 are the nematodes isolated from root samples along the study areas. From the results, *Meloidogyne* was the most predominant nematode along the selected semi-arid climates of central and northern Tanzania by 99.3%. *Tylenchulus, Pratylenchus, Helicotylenchus, Aphelenchoides* and *Rotylenchus* were recorded as less common nematodes in the study areas by less than 0.7% in total. Other nematodes were also very few by 0.2%.

Table 4 shows also distribution of Nematodes as isolated from soil samples. From the findings, *Meloidogyne* and *Scutellonema* were discovered as the most predominant nematodes along the study area by 81.4 and 11. 9% respectively. Other nematodes: *Helicotylenchus, Pratylenchus, Rotylenchus, Aphelenchoides, Tylenchulus, Xiphinema, Hemicycliophpra, Ditylenchus, Criconema and Paratylenchus* were less common by 7.0% in total.

4. DISCUSSION

Tomato is considered the most favourable host crop for nematodes [19]. The results of the

Table 3. Nematodes distribution as isolated from roots samples *(n= 405)*

Taxa	Samples tested (N)	Nematodes cases (n)	Distribution %
Meloidogyne	405	42,973	99.3
Tylenchulus	405	88	0.2
Pratylenchus	405	85	0.2
Helicotylenchus	405	65	0.2
Aphelenchoides	405	24	0.1
Rotylenchus	405	10	0.02
Other nematodes	405	10	0.02
Total	305	43,255	100.0

Table 4. Nematode distribution as isolated from soil samples *(n= 405)*

Taxa	Samples tested (N)	Nematodes cases (n)	Distribution %
Meloidogyne	405	35,485	81.4
Scutellonema	405	5,178	11.9
Helicotylenchus	405	2,395	5.5
Pratylenchus	405	170	0.4
Rotylenchus	405	148	0.3
Aphelenchoides	405	91	0.2
Tylenchulus	405	71	0.2
Xiphinema	405	30	0.1
Hemicycliophpra	405	14	0.03
Ditylenchus	405	10	0.02
Criconema	405	5	0.01
Paratylenchus	405	5	0.01
Total	305	43,602	100.0

present findings confirmed nematodes as widely spread disease in tomato fields from the selected semi-arid climates of central and northern Tanzania. Root-knot nematodes were found in all surveyed tomato growing districts. Infected tomato plants developed root-knot galls two or three times as large in diameter as the healthy roots, indicating the high population densities of the pathogens. Similar results were also reported by Nono-Womdim et al. [20] showing the prevalence of RKN *(Meloidogyne)* and their occurrence in some tomato-growing regions of Tanzania. *Meloidogyne* was reported to constitute about 47% of the total world population of nematodes [9] and considered the largest dominant nematode distributed all over the world [21,22]. Estimated production losses of tomatoes due to Meloidogyne in tropics reach as high as 50%. In this study, *Meloidogyne* was noted widely distributed in the study areas compared to other nematodes where mean incidence and severity of nematode were significant. The results of this study discovered *Meloidogyne* as the most prevailing nematode by 99.3 and 81.4% within tomato roots and soil samples respectively. However, variation and distribution of nematodes in the study areas have partially been attributed by many biotic and abiotic factors. Farmers were lacking proper management practices. According to Bagarama [23] and Otieno [24], several control strategies, such as host plant resistance, rotation with non-hosts, sanitation and avoidance, destruction of residual crop roots, and judicious use of nematicides have been reported to effectively control RKN. However, the use of resistant varieties remains the most viable option, particularly for small-scale farmers with limited resources. These were lacking to the farmers in some extents. In some cases RKN are controlled by chemical fumigation [25]. However, chemical fumigation was not economically feasible to the farmers as it is not safe in a semi-arid environment where protection of water resources and water quality is a priority for human survival [26]. According to Ijan and Mmbaga [13], RKN is a serious problem in tomato production in Tanzania due to unsustainable management practices. Lack of proper management skills usually results into late management intervention and thus crop loss. Plants affected by RKN are more easily infested by soil-borne diseases such as early and late blight, fungal and bacterial wilt [8] and therefore more crop losses [27].

5. CONCLUSION AND RECOMMENDATION

From the present findings, nematode infestation was observed in variable degrees within many farmers' fields along the selected areas in central and northern districts of Tanzania. This was contributing to the decline of tomato production among farmers whose management practices were not properly handled. Improvement in management practices was therefore advised among farmers alongside an establishment of more varieties that could perform well in the nematodes infested areas.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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