

Growing Tomato (*Lycopersicon esculentum* L.) in Nematode Infested Soil and the Pest Implications in Poorly Managed Post-harvested Fields During the Dry Season in Tanzania

*F. M. Bagarama¹, E. J. Mrema² and E. A. Lazaro³

¹Special Program Department, Tumbi Agricultural Research Institute,
P. O. Box 306, Tabora, Tanzania

²Crop Research Department, Tumbi Agricultural Research Institute,
P. O. Box 306, Tabora, Tanzania

³Sokoine University of Agriculture, Tanzania,
P. O. Box 3007, Morogoro, Tanzania

Corresponding author Email: bagaramaf@gmail.com

Abstract

Tomato (*Lycopersicon esculentum* L.) is an important income generating crop in the semi-arid areas in the Miombo ecosystem in Tabora, Tanzania. Dry season tomato growing is limited by water resource availability and it is therefore cultivated continuously in the same areas with access to water for irrigating the crop. Parasitic root-knot nematodes are a threat to tomato production. In this study, the effect of Procarvian carpensis manure at a rate of 5tons/ha and the balanced NPK inorganic fertilizer at a rate of 100kg/ha on the growth performance of the tomato genotype "Duluti" on a highly root-knot nematode soil was evaluated. The field experiment was laid in a randomized complete block with three replications. More studies were carried out in farmers' fields to assess the influence of poor management of post-harvested tomato fields as host to crop pest. In the field experiment tomato plants' vegetative and reproductive parameter data were collected. They were then subjected to analysis of variance using the GENSTAT 14th Edition at a difference declared significance of 5% level. Least significance difference (LSD) was used in means separation. Results show that, the average of 9 fruits/plant harvested in the plots applied with of 5stones/ha of *P. carpensis* manure is highly significantly ($p < 0.001$) her than 4 fruits per plants in plot with NPK YaraMira cereal. This may reveal that *P. carpensis* manure improved the growth performance of tomato and increased its tolerance to parasitic nematodes. Substantial infestation of the tomato plants by root-knot nematode grown in the control plots may be the reasons for their failure to flower. Results from the field survey show that red spider mites (*Tetranychus evansi*: Acaricidae) and mealbugs (*Phenacoccus manihot*: Cydnidae: Hemiptera) and downy mildew were surviving the dry season using tomato plant residues and associated weed species. Tomato production using organic *P. carpensis* and field sanitation after harvesting may assist in substantial reduction of the root-knot nematode and other crop pest incidences. Furthermore studies involving several rates and sources of organic and inorganic fertilizers and tomato varieties should be conducted in areas with high nematode infestation to come up with better genotype and fertilizer type and combination that will reduce nematode incidences and at the same time improve tomato yield.

Key words: Dry season, root-knot nematodes, post-harvest sanitation, tomato; and Tanzania.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is an important food and income generating crop in Africa and indeed in Tanzania. Dry season tomato growing is an important economic activity which contributes significant household

incomes to smallholder farmers in Tanzania (Bagarama *et al.*, 2012). Dry season tomato is considered to be less attacked by fungal diseases and use free household labour after harvest and processing crops produced during the main rainy season. Water scarcity is the main limiting factor

to tomato growing by smallholder farmers in the semi-arid environments in Miombo ecosystem during the dry season. In semi-arid environments, use of underground water for vegetable production is an adaptation strategy by farmers to improve household food security (World Bank, 2006; Kortasi, 1994; Ayibotele, 1985; Amuzu, 1978). In Tabora region in Tanzania tomato is grown mostly under semi-irrigation systems using shallow hand dug water wells whose water supply depends mostly on seasonal rainfall distribution. The production of tomato is therefore determined by proximity to adequate water supply during the dry season. Irrigation water is limiting and has been declining due to climate change and particularly seasonal rainfall distribution variability (Mongi *et al.*, 2010). Tomato growing in the dry season has assumed the climate change adaptive strategy in the Miombo woodland ecosystem (Bagarama, 2013b). Soil nematodes are composed of five major functional groups: plant parasites, bacterial feeders, fungal feeders, predators and omnivores (Cares and Huang, 2008). Plant parasitic nematodes are of economic importance because they reduce crop yields therefore they are assessed in soil using plant parasitic index (PPI) (Bongers, 1990). Continuous growing of root-knot nematodes host crops allows their population buildup in soil and an increase in crop losses (Netscher and Sikora, 1990). Farmers' cultural practices for control of parasitic nematodes include the application of organic materials into the soil (Sikora *et al.*, 1973a; Muller and Gooch, 1982; Bagarama, 2013a; Otieno *et al.*, 2013). In some cases root-knot nematodes are controlled by chemical fumigation (Rich *et al.*, 1982). Chemical fumigants include Aldicarb, Carbofuran and Benfurocarb (Dethe and Pawar, 1987). However, chemical fumigation is not economically feasible and is not safe in a semi-arid environment where protection of water resources and water quality is a priority for human survival. The nature and composition of organic manure has a different influence on parasitic nematodes. Some manure strongly suppresses parasitic nematodes in soil than others (Netscher and Sikora, 1990). Little information is known on the influence *P. carpensis* in comparison with NPK YaraMira cereal in tomato fields infested with root-knot nematode in Tabora environmental condition.

Furthermore scant study has been done on post-harvest management of fields to control tomato plant pest in dry season agriculture in Tanzania. Therefore, study was undertaken to evaluate the effect of organic manure and balanced NPK application on the tolerance of tomato genotype Duluti to parasitic root-knot nematode on highly nematode infested soil.

Materials and Method

Experimental material and plant establishment

This study was conducted through field experimentation. The experiment was laid out in a completely randomized block design with three replications on the sandy textured soil with high parasitic infestation based on previous growth performance of tomato (*Lycopersicon esculentum* L.) at Bwawani, the farm belonging to Tumbi Agricultural Training Institute during the dry season in the month of May through September 2013. Tomato variety Duluti was grown on raised beds at the space of 45 cm by 60 cm. The treatments were; (a) Beds with no application of *P. carpensis* and NPK YaraMira cereal was use as control (b) *P. carpensis* manure 5tons/ha (c) NPK YaraMira cereal fertilizer 100kg/ha. Tomato seedlings were transplanted in mid May 2013 after the rainy season. Watering of seedlings was done after every 24 hours. Insect pest were controlled using the application of Profecron 720 EC insecticide using the recommended rate for tomato at the rate of 20 ml per 20 litres of water. Two insecticide applications were carried out during the three months of tomato plants growth period. Three months after transplanting, data on the vegetative growth, yield and incidences of root-knot nematode infestation was done. Using a destructive sampling method, five tomato plants were uprooted and root-knot nematode assessment was done according to the rating scheme for evaluation of root-knot infestation method described by Zeck (1971).

Data Collection

Plant growth parameters: Twenty plants were selected randomly at each plot and tagged for data collection at the beginning of fruit harvesting. The length of the main stem was measured from the root collar level to the tip with the help of a tape measure, while that of branches was

measured from the base of the node on which the branch was formed to their tips. The numbers of nodes on the main stems and branches were counted. The length of the middle inter-nodes of the main and primary stem were determined by identifying the middle inter-node through dividing the length of the vines by two and then measuring the identified internode using a ruler. Yield Data: The number of fruit per plant and cluster was counted and recorded at fruit maturity on each selected plant in each plot.

Pest assessment on post harvested tomato fields: Field survey on post-harvested tomato fields was carried out at Tumbi Relini, Tumbi Mapula and Farm Mnyamwezi. Studies were carried out to identify crop pests which were feeding on post-harvested tomato plants. Farmers gave additional information on the importance of identified pests. Weed species which were alternative pests to tomato pests were identified by farmers. Collected weed plants were identified using a handbook for West African weeds (Akobundu and Agyakwa, 1987).

Climatic conditions: Weather data during the growing season were collected from the Agricultural Research Institute Tumbi's Meteorological station. During the season, the area was characterized by monthly cumulative rainfall of 12mm, 19°C and 32°C mean minimum and maximum monthly temperatures respectively.

Data Analysis

Collected data were subjected to analysis of variance (ANOVA) using GENSTAT 14th

Edition and the difference declared significance at 5 % level of probability. Correlation was done to compare the relationship between variables. Least significance difference (LSD) was used in means separation.

Results

Vegetative plant growth parameters

Field results showed that, the length of main stem, internode length, were very highly significantly different (p<0.001) between the treatments. The application of *P. carpensis* manure increased these two vegetative parameters. The number of nodes per branch and the total number of nodes per plant were significant (p<0.005) differently among treatments. However, there was no difference between treatments for the total number of braches (Table 1).

Correlation of vegetative and reproductive showed a significantly (p<0.005) positive correlation while root-knot nematode infestation (gall index) showed a negative insignificant correlation with the number of fruits per clusters (Table 2).

Yield Performance

There were very highly significantly different (p<0.001) in reproductive parameters, total number of fruits per plant, number of clusters and number of fruits per cluster between treatments. The application of *P. carpensis* manure improved the formation of fruits and gave tomato plants tolerance to the high level of nematode infestation compared to either the control or the plants which received NPK fertilizer (Table 1). There was a weak negative correlation between

Table 1: The effect of *P. carpensis* manure application on yield and vegetative components of tomato variety Duluti on a highly root-knot nematode infested soil at Tumbi, Tabora

Treatment	Nd/B	N. Nd	N F	NCL	NB	IL	H	GI	F/CI
Control	3.133	9.4	0	1.2	1.6	2	21.6	9.4	0
Procavian	3.600	17.4	9	4.6	2.8	4.4	47.2	8.8	1.96
NPK	5.400	16.8	3.8	2.8a	3.2	4	29.8	9.2	0.76
LSD	1.2	4.0	2.66	1.306	1.496	1.014	8.56	1.404	0.58
F-Test	0.005	0.003	<.001	<.001	0.126	0.001	<.001	0.693	<.001
CV (%)	22.9	21.7	49.2	36	46.7	23.1	20.6	12.2	50
SE±	0.6	1.993	1.33	0.653	0.748	0.507	4.28	0.702	0.29

Key: Nd = nodes, N= number, F = fruits, CL = clusters, B = branches, and IL= internodes length

Table 2: Correlation of tomato plant vegetative, reproductive and nematode infestation

	Nd/B	N.Nd	N.F	N.CL	N.B	IL	H	GI	F/CL
Nd/B	-								
N. Nd	0.6*	-							
N.F	0.1	0.7*	-						
N.CL	0.2	0.6*	0.8*	-					
N.B	0.7*	0.8*	0.3	0.3	-				
IL	0.3	0.6*	0.8*	0.7*	0.3	-			
H	-0.1	0.4	0.9*	0.8*	0	0.7*	-		
GI	0.2	-0.1	-0.3	-0.1	-0.1	-0.1	-0.3	-	
F/CL	0.1	0.7*	1	0.8*	0.2	0.8*	0.9*	-0.3	-

Key: Nd = nodes, N = number, F = fruits, CL= clusters, B = branches, IL= internodes length, * highly significant. GI gall index

the number of nodes per branch and plant height, total number of nodes, total number of fruits, number of fruit clusters, number of branches, internodes length, and plant height with gall index. This reflects that root-knot nematodes negatively affect the general physiology of the plant growth (Netscher and Sikora, 1990).

Tomato plant pests on post-harvested tomato plants in surveyed fields

Management of fields after harvest is important for breaking pest reproductive cycles and reducing the pest pressure on planted crops. Farmers seldom pay attention in destroying plant residues and growing tomato plants left in fields. There was a significant difference of root-knot nematode infection, red spider mites and meal bugs ($p < 0.05$) between tomato varieties (sites) left in field after harvest in June (2013). Root-knot nematode infestation was found on three

tomato genotypes; Tanya from Kibo, Grifford and Tanya Mkulima but not on Calgill. These four tomato varieties were grown by farmers in four different ecological sites. The results show that 75% of the sites were infested with root-knot nematodes (Table 3). There was a weak correlation between gall index and red spider mite and white grubs infection. The two tomato pests increase their population and damage to crops in dry environment thus an increase of one pest appears to influence the increase of the second pest but this might be strongly influenced by the dry climate (Table 4). Red spider mites (*T.evansi*) were found on *N. physaloides* and on living and dying tomato plants (*L. esculentum*); while mealbugs (*P. manihot*) were found on weed species such as (*A. conyzoides*, *B. pilosa*, and *Hibiscus* sp.), and living tomato plants and dying tomato plants (*L. esculentum*); downey mildew fungi was found on *B. pilosa* and *Cassia*

Table 3: Pest incidences on tomato plants left in field after harvest during the dry season at Tumbi, Tabora

Tomato variety	Gall Index	Red SI	Mealy bugs
Calgill	4.3	4.4	51.8
Tanya kibo	6.6	2.3	21
Grifford	8.1	3.3	73.5
Tanya Mkulima	8.5	3.2	7.2
F-Test	0.005	0.005	0.034
CV (%)	39.1	36.5	137.6
SE+	1.202	0.539	23.62
LSD	2.437	1.092	47.89

Key: SI = Spider mites infection

Table 4: Correlation of pest and nematode infestation

	Gall Index	Red spider mites infestation	Meal bugs
Gall index	-		
Red spider mites infestation	-0.06	-	
White grab	-0.21	0.21	-

obtusifolia L. Studies show that red spider mites infections on crops increased in dry season in different environments). Red spider mites attack green leaf before moving to stems but mealy bugs were found most on stems and roots.

Weed species in post-harvested tomato fields and the associated crop pest at Tumbi, Tabora

During the dry season weed growth is restricted in irrigated areas and plays an important role in providing food for crop pest and diseases to complete their reproductive cycles before the following rainy and a new cropping season. Tomato growing niches are small in area thus continuous growing of tomatoes in the same area leads to increase in pests and diseases. The results of this study (Table 5) demonstrate the existing association of tomato pest surviving on growing alternative host weeds during the dry season. Weed species such as black jack (*Bidens pilosa* L.) and goat weed (*Ageratum conyzoides* L.), spurge weed (*Euphorbia heterophylla* (L)

and *Sida* sp., are common weeds in moist areas during the dry season. The common plant pests of socio-economic importance are red spider mites (Bagarama, 2013b) and mealbugs (*Phenacoccus manihot*). Mealbugs in post-harvested tomato fields survived the dry season on weed species such as *A. conyzoides*, *Sida* sp., *B. pilosa*, and *Sesamum alatum* Thonning, Downey mildew disease caused by fungi in the family Erysiphaceae survives the dry hot season on weed species such as *B. pilosa*, *Cassia obtusifolia* L. and *E. heterophylla* as alternative host plants. Survival of powdery mildews from season to season by active infection of volunteer plants has been documented in previous studies in Britain (Turner, 1956) and Denmark (Smeddegaard-Peterson, 1967) and Stone (1962) found that conidia of *Erysiphe cichoracearum* from Compositae family plants infected cucumbers. The knowledge on the cycle of fungal disease is important for establishing Integrated Pest Management (IPM) strategies.

Table 5: Weed species as alterate hosts to tomato pests in the dry season at Tumbi, Tabora

Common name	Botanical name	Family	Crop pests on weed
Goat weed	<i>Ageratum conyzoides</i> (L.)	Asteraceae	Mealybugs (<i>Phenacoccus manihot</i>)/Meloidoidogyne ssp.
Blackjack	<i>Bidens pilosa</i> (L.)	Asteraceae	Mealybugs (<i>Phenacoccus manihot</i>)/Powdery mildew
Garden spurge	<i>Euphorbia hirta</i> Linn	Euphorbiaceae	Mealybugs (<i>Phenacoccus manihot</i>)
Spurge weed	<i>Euphorbia heterophylla</i> (L)	Euphorbiaceae	Powdery mildew
-	<i>Nicandra physaloides</i> (L.) Gaertn	Solanaceae	Red spider mites (<i>Tetranychus evansi</i>)
-	<i>Hibiscus</i> spp.	Malvaceae	Mealybugs (<i>Phenacoccus manihot</i>)
Wire weed	<i>Sida</i> spp.	Malvaceae	Mealybugs (<i>Phenacoccus manihot</i>)
Sesame	<i>Sesamum alatum</i> Thonning	Pedaliaceae	Mealybugs (<i>Phenacoccus manihot</i>)

Source: Tomato fields survey August, 2013, Tumbi, Tabora

Conclusions

Data presented from this study demonstrated by gall indices show that using *P. carpensis* manure impact tolerance of tomato plants to nematode compared to use of balanced NPK fertilizer. Growing tomato without organic fertilizers as it is normally practiced by farmers is increasing yield loss induced by root-knot parasitic nematodes. The practice of most farmers and extension officers of neglecting field sanitation after tomato harvest may be the reason of the increase in pest in tomato fields. Weed species *A. conyzoides*, *B. pilosa*, *N. physaloides*, *E. heterophylla*, *E. hirta* and *S. alatum* and tomato plant residues are alternative host plants to mealbugs (*Phenacoccus manihot*) and the red spider mites (*Tetranychus evansi*) to survive during the dry season living and dying tomato plants in post harvested fields and *N. physaloides* weed. Monitoring and post-harvest sanitation of tomato fields in dry season agriculture is urgently needed to reduce pest pressure on crops in the following rainy season.

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