

PROMISING IMPROVED TOMATO VARIETIES FOR EASTERN TANZANIA

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Abstract

Tomato (*Solanum lycopersicum* L.) productivity in eastern Tanzania, mainly in the coastal belt, is low due to drought, excessive heat, declining soil fertility, pests and diseases, and low genetic potential of available varieties. Stress-tolerant cultivars adapted to environmental conditions in the region can increase productivity. Field experiments were conducted at Mikocheni Agricultural Research Institute and five on-farm sites in Kinondoni and Bagamoyo districts during the 2008/2009 and 2009/2010 seasons to evaluate performance and adaptability of tomato varieties. ‘Tengeru 97’ and ‘Meru’ were the most promising varieties based on tolerance to nematodes, good fruit characteristics, and high market acceptability, but were susceptible to early blight. ‘LBR-6’ and ‘LBR-11,’ which are early blight resistant, were rated excellent for taste and had high market acceptability, but were susceptible to nematodes. Further testing of these varieties in disease hot spots along with integrated pest management strategies that focus on nematodes and early blight should be pursued. To increase production and quality of tomatoes in eastern Tanzania, plant breeders must develop and introduce varieties that are heat tolerant, resistant to nematodes, fusarium wilt, early blight, bacterial wilt and *Tomato yellow leaf curl virus*.

Keywords: *Solanum lycopersicum*, abiotic, biotic, coastal, stress, vegetable production

Introduction

Vegetables are a good source of carbohydrates, minerals, and vitamins (Tindall, 1983). Tomato (*Solanum lycopersicum* L.) production is higher than other vegetable crops in Tanzania, with a total annual production of 129,578 t, representing 51% of the total vegetable production (Mwasha, 2000; de Putter *et al.*, 2007).

Vegetable production in eastern Tanzania, covering mainly the coastal belt, has increased due to growing demand. Average tomato yield is from 2.2 to 3.3 t/ha (URT, 2003) which is far below the world average of 27.5 t/ha (FAO, 2005). Low productivity is caused by a combination of factors including abiotic stress problems such as salinity, drought, excessive heat, declining soil fertility, biotic stress from pests and

diseases, poor crop management, and a lack of well-adapted, high yielding varieties.

To increase productivity, there is a need to develop and introduce stress-tolerant cultivars adaptable to the coastal areas. Breeding material and varieties are available with resistance to diseases such as *Tomato yellow leaf curl virus* (TYLCV), bacterial wilt (BW), fusarium wilt, gray leaf spot, early blight and nematodes (Cornell University, 2006). However, there are no varieties with resistance or tolerance to these stresses adapted to eastern Tanzania’s agroecologies with largely coastal climatic conditions. This project was undertaken to evaluate yield performance and adaptability of tomato varieties and lines in eastern Tanzania.

Materials and Methods

Field experiments were conducted during the 2008/2009 and 2009/2010 seasons. During the first season experiments were established at Chambezi substation of Mikocheni Agricultural Research Institute (MARI), located 6° 30' S and 38° 55' E at an altitude of 12 m asl. In the coastal belt of Tanzania, the soils area are predominantly sandy loam with pH of 6.6, and suitable for drought-tolerant annuals and perennials.

Evaluation at Chambezi involved tomato varieties originating from AVRDC's Regional Center for Africa (Table 1). During

the 2009/2010 season the varieties 'Tengeru 97,' 'Meru,' and lines LBR-6 and LBR-11 were evaluated in farmers' fields at two sites in Bagamoyo and three in Kinondoni districts. The experiment at Chambezi was arranged in a randomized complete block design with three replications. For the on-farm trials, each site served as a replicate. Seedlings were raised on nursery seedbeds in each location and transplanted in the field after four weeks. In each plot plants were arranged in two rows spaced at 60 cm between rows and 40 cm within rows.

Table 1. Tolerance of indeterminate and semi-determinate tomato entries to various diseases

Entry	Disease tolerance
<i>Indeterminate</i>	
Tengeru 97	Nematodes, tomato mosaic virus, fusarium wilt
Meru	Late blight, nematodes, tomato mosaic virus
LBR 44-2	Late blight, nematodes, tomato mosaic virus, fusarium wilt race 1
LBR 50-2	Nematodes, late blight
LBR 19-3	Late blight, nematodes, tomato mosaic virus
<i>Semi-determinate</i>	
LBR -11	Late blight, early blight, tomato mosaic virus
LBR- 6	Late blight, early blight
LBR- 16	Late blight, early blight
Marglobe (check)	Old variety/Susceptible to many diseases

Management included weeding, irrigation, and fertilizer application. The pesticides Lambda cyaalothrin and Imidacloprid 100 g·L⁻¹ +Beta-cyfluthrin 45 g·L⁻¹ were used to control American bollworm and red spider mites. Dithane M-45 was used to control fungal diseases at the seedling stage. Fresh fruit yield, number of fruit, and occurrence of pests and diseases were collected. Percent defoliation of plants due to diseases was recorded. Field diagnosis for the presence and severity of root-knot nematodes was by visual examination of uprooted plant root systems for galls (Noling, 2008) at harvest.

Matrix ranking was used during evaluation of varieties. Varieties were assessed based on farmer-agreed criteria that included earliness, plant height, pest and

disease tolerance, number of fruit, fruit size, fruit taste, fruit firmness, and potential marketability (de Boef and Thijssen, 2007). A scale of 1 to 5 was used where 1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent. Total scores were used to rank varieties. Yield data was analyzed using the MSTAT-C statistical package (Michigan State University, 1991). Data for nematode incidence and severity was square-root transformed (Gomez and Gomez, 1984). Analysis of variance (ANOVA) procedures were applied and Duncan's Multiple Range Test was used to separate means.

Results and Discussion

There was no significant difference between varieties in fruit yield in the first and second season averages (Table 2). Season (year) had a highly significant effect on the

number of fruits produced per plant ($F=0.001$). There were lower fruit numbers during the first season compared with the second season and a significant interaction between year and varieties on the number of fruits produced per plant ($F=0.041$) (Table 3). This can be attributed to extremely high temperatures that prevailed during the first season, causing flower abortion and poor fruit-set, and in extreme cases, fruit abscission. Temperatures recorded during fruit setting and harvesting period (December 2008 to April 2009) ranged from 27 to 33 °C, higher than optimum temperatures (18.5–26

°C) for proper fruit set (LeBoeuf, 2004). The second crop was in the field between August and October when temperatures were lower (20–25 °C night and 21–29 °C day). Under extreme temperatures, tomato flowers typically drop off without setting fruit, and high temperatures affect male gametophyte development (Pressman *et al.*, 2002). In the second season ‘Tengeru 97’ produced significantly higher number of fruit compared with the check ‘Marglobe’ and other varieties. This may indicate a higher level of heat tolerance.

Table 2. Yield (t/ha) performance of indeterminate and semi-determinate tomato lines/varieties at Chambezi Substation, Mikocheni Agricultural Research Institute in 2008/2009 (1st season) and 2009/2010 (2nd season)

Growth habit/entry	Total yield (Mt·ha ⁻¹)		Number of fruit/plot	
	1st season	2nd season	1st season	2nd season
<i>Indeterminate</i>				
Tengeru 97	0.9	21.1	12	196a ^a
Meru	2.2	15.0	40	123cde
LBR 44-2	1.2	17.6	28	160b
LBR 50-2	1.4	19.4	31	108de
LBR 19-3	1.3	19.8	25	137bcd
Mean	1.4	18.6	27	145
<i>Semi determinate</i>				
LBR 11	1.7	16.5	27	101e
LBR 6	1.1	18.5	17	97e
LBR 16	1.6	21.4	20	132bcd
Marglobe (check)	1.2	23.9	13	143bc
Mean	1.4	20.1	19	118
Grand mean	1.4	19.3	24	133
CV (%)	49.9	24.7	48.5	21.4

^a Means in a column followed by the same letter are not significantly different, $P \leq 0.05$, Duncan's Multiple Range Test.

Table 3: Number of fruits as influenced by variety and year in trials at Chambezi Substation, Mikocheni Agricultural Research Institute

Change	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	8	9942.0	1242.8	1.48	0.199
Year	1	161376.0	161376.0	192.07	<.001
Variety x Year	8	15518.7	1939.8	2.31	0.041
Residual	36	30246.7	840.2		
Total	53	217083.3	4095.9		

Varieties at on-farm sites differed significantly on total yield (Table 4). 'Meru' had the highest fruit yield (36.23 Mt/ha) followed by 'Tengeru 97' (32.13 Mt/ha). Lines LBR 11 and LBR 6 did not differ significantly. There were differences between yields from different sites. Yields from the

Njowe site were lowest, and may be attributed to high incidence of nematodes (Tables 5, 6). However, 'Meru' and 'Tengeru 97' performed better than other varieties across all sites, probably due to tolerance to nematodes.

Table 4: Yields (t/ha) of indeterminate and semi-determinate tomato lines/varieties in on-farm trial sites in 2009/2010 season

Growth habit/entry	On-farm sites					Average
	Ramadhani	Njowe	Kibesa	Muungano	Mabwe	
Indeterminate						
Tengeru 97	42.1	7.3	31.7	58.2	21.4	32.1 ab*
Meru	43.1	3.6	45.4	66.1	22.9	36.2 a
Semi-determinate						
LBR 11	40.2	0.2	31.3	56.5	14.1	28.4 b
LBR 6	39.4	3.3	31.7	56.5	14.1	29.0 b

* Means in a column followed by the same letter are not significantly different, $P \leq 0.05$, Duncan's Multiple Range Test. CV of the study is 9.8%.

Early blight and plant wilting caused by nematodes affected plants at Chambezi (Table 5). Occurrence and severity of nematodes might be influenced by weather and soil type (Cerkauskas, 2004). During the first season, which had high air temperatures, all varieties including those resistant to nematodes were infested. Resistance to root-knot nematodes (*Meloidogyne* spp.) in tomato has been reported to break down at soil temperatures higher than 28 °C (Abdul-Baki et al., 1996). This can be further supported by zero infestation during the second season trial when temperatures were cooler (21-29 °C). Varieties and lines without nematode resistance, including 'Marglobe' (check), LBR-6, LBR-11 and LBR-16, were most affected. 'Meru' and LBR 19-3 were least affected. During the first season all varieties were infested by nematodes although the resistant lines were affected at lower levels, which may be a result of higher temperatures. The high coefficient of variation (45.39%) on nematode incidence might be caused by uneven distribution of inoculum in the field.

Although LBR 6, LBR 11 and LBR 16 are known to be resistant to early blight,

during this study the disease was observed, probably because of plant stress resulting from high temperatures and nematode damage. Early blight is most severe on plants with a heavy fruit load, nematode attack, or low nitrogen fertility (CIFAD, 1995). Plants affected by root-knot nematodes are more easily infected by soil-borne diseases such as bacterial wilt (*Ralstonia solanacearum*), southern blight (*Sclerotium rolfsii*), fusarium wilt (*Fusarium oxysporum*), and damping off (*Pythium* spp. or *Rhizoctonia* spp.). Secondary infection may lead to extensive discoloration of internal stem and root tissue, and rapid plant death (Cerkauskas, 2004). Plants attacked by nematodes displayed symptoms of Fusarium wilt. Interaction between root-knot nematodes and Fusarium wilt has been reported (Mai and Abawi, 1987). Early blight and leaf mold (*Cercospora* spp.) diseases occurred at Kibesa and Muungano on-farm sites (Table 6). The diseases did not occur at other on-farm sites. 'Meru' was tolerant to leaf mold while LBR 6 and LBR 11 appeared to display resistance to early blight.

Table 5: Occurrence and severity of early blight and nematodes on tomato varieties at Chambezi substation, Mikocheni Agricultural Research Institute

Variety/season	Nematode incidence (%)		Nematode severity (%)	
	1st	2nd	1st	2nd
<i>Indeterminate</i>				
LBR 44-2	100	29.8a	60.0abc	46.7ab*
LBR 50-2	100	0.0c	66.7abc	0.0c
LBR 19-3	51	0.0c	26.7c	0.0c
Tengeru 97	100	0.0c	46.7bc	0.0c
Meru	94	0.0c	46.7bc	0.0c
<i>Semideterminate</i>				
LBR 11	100	31.0a	93.3a	60.0a
LBR 6	100	27.4ab	86.7ab	53.3ab
Marglobe	100	20.2ab	86.7ab	53.3ab
LBR 16	100	11.9b	93.3a	46.7ab
CV (%)	18.1	45.4	24.9	24.1

* Means in a column followed by the same letter are not significantly different, $P \leq 0.05$, Duncan's Multiple Range Test.

Table 6: Occurrence and severity of early blight, leaf mold and nematodes at on-farm sites

Variety	Early blight (Kibesa)	Leaf mold (Muungano)	Nematodes (%) (Njowe)	Nematodes (%) (Ramadhani)
Meru	3 ^a	0	25	17
LBR 11	1.5	4	96	33
LBR 6	1	4	83	25
Tengeru 97	2.5	3	45	17

^a comparison scale: 0 = no disease symptoms, 5 = plant severely infected

It was discovered that most farmers were unaware of the nematode infestation in their tomato crop, but for some farmers the problem was severe enough to cause them to stop production of tomato. In addition to introducing resistant varieties, it is important to train farmers on other recommended technologies such as rotation with non-solanaceous crops such as cereals or sun hemp, ploughing of land during the hot season to expose nematodes to heat and light, choosing unaffected sites for seedbeds, intercropping with African or French marigolds, addition of organic matter, and soil solarization to effectively control nematodes (Cerkauskas, 2004).

All entries were acceptable considering individual field and organoleptic traits and market acceptability (Table 7).

However, entries differed in degree of acceptability for a number of traits. At Chambezi 'Tengeru 97' and 'Meru' were the preferred varieties for fruit number and tolerance to pests while LBR 11, LBR 6 and 'Marglobe' were the most preferred for fruit size. Early fruiting varieties were preferred. Based on pooled data of field traits, the average degree of acceptability ranged from 3.8 (very good) to 5 (excellent). Sensory evaluation indicated that 'Tengeru 97' and 'Meru' were the best for fruit firmness, reflecting good shelf-life. LBR 11, LBR 6 and 'Marglobe' scored highest for taste, which could be due to lesser acid content than other varieties. 'Tengeru 97,' 'Meru,' LBR 11 and LBR 6 received the highest market acceptability. Results of evaluation in Muungano were generally similar to those

at Chambezi. Farmers indicated that ‘Tengeru 97’ and ‘Meru’ could be marketed for cooking purposes and LBR 11 and LBR 6 for fresh consumption.

Table 7: Mean scores of tomato varieties and lines in participatory varietal selection¹ (PVS) conducted at Chambezi Substation, Mikocheni Agricultural Research Institute and a farmer's field in Muungano

Growth habit/entry	Field traits					Organoleptic traits			Market acceptability
	Plant height	Fruit no.	Fruit size	Earliness	Tolerance to pests	Mean	Fruit firmness	Taste	
PVS at Chambezi Substation									
<i>Indeterminate</i>									
Tengeru 97	5 ²	5	3	3	5	4.2	5	4	5
Meru	5	5	4	5	5	4.8	5	4	5
LBR 44-2	5	4	4	4	3	4.0	4	4	4
LBR 50-2	5	4	4	4	5	4.4	4	4	4
LBR 19-3	5	4	4	3	5	4.2	4	4	4
<i>Semi-determinate</i>									
LBR 11	4	3	5	4	3	3.8	3	5	5
LBR 6	4	3	5	4	3	3.8	3	5	5
LBR 16	4	4	4	4	4	4.0	4	4	4
Marglobe	4	3	5	5	3	4.0	3	5	4
PVS at Muungano Farm									
<i>Indeterminate</i>									
Tengeru 97	-	5	3	3	4	3.8	5	-	5
Meru	-	5	4	5	4	4.5	4	-	5
<i>Semi-determinate</i>									
LBR 11	-	4	5	4	2	3.8	3	-	5
LBR 6	-	3	5	4	2	3.5	3	-	5

¹ 20 and 18 stakeholders in Chambezi Substation and Muungano Farm, respectively.

² comparison scale: 1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = excellent.

Conclusion

Tomato production in eastern Tanzania is affected by both abiotic and biotic stresses. Field performance of the tomato varieties tested indicated that no variety has all desirable traits. ‘Tengeru 97’ and ‘Meru’ have tolerance to nematodes, good fruit characteristics, and high market acceptability. However, they are susceptible to early blight, an important disease in the area. LBR-6 and LBR-11, early and late blight resistant candidate lines with high market acceptability and excellent taste, have potential in the region but are highly affected by nematodes. Further testing of these

promising varieties in disease hot spots together with the introduction of integrated pest management strategies to control major biotic stresses should be pursued to increase tomato productivity in eastern Tanzania. Development and introduction of varieties that combine tolerance to heat, resistance to nematodes, fusarium wilt, early blight, bacterial wilt, and TYLCV is necessary.

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