Yield and Adaptability Evaluation of Newly Introduced Tomato (*Solanum lycopersicum*) Varieties in Tabora Region

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Abstract

Tomato (Solanum lycopersicum L.) is an important food and income generating crop among small holder farmers in Tabora Region. High yield is a major ambition to tomato plant breeders and farmers. The purpose of the study was to determine the influence of environmental conditions in Tabora Region on the growth and yield of newly introduced tomato varieties. The tested varieties were Duluti (LBR6), Meru (LBR 50 - 2) and Kiboko collected from AVRDC Arusha, Tanzania. The experiment was conducted both in the screen house to see the performance of the varieties under the controlled environment and the field at Tumbi Agricultural Research Institute. A screen house experiment was laid out in a Completely Randomized Design (CRD) while Randomized Complete Block Design (RCBD) was used in the field both had three replications. Yield, vegetative and reproductive data were collected and subjected to analysis of variance using the GENSTAT programme. Yield and yielding components varied among tomato varieties in both experiments. The variety, Meru, with 92 ton/ha was significantly (p<0.001) higher than Duluti and Kiboko with 74 and 69 ton/ha respectively under field conditions. The forty tone/ha observed from Duluti was significant (p<0.05) higher than the 32 ton/ha harvested from each of the other varieties. Variation in yield and yielding components among tomato varieties in both experiments may be attributed to genetic and environmental differences. Regardless, of such variations both varieties showed better production in Tabora. Their good performance was attributed largely to their apparent better adaptation, which enabled them to grow more vigorously. They will therefore be suggested for adoption by Tabora growers.

Key words: Tomato, Tanzania, varieties; yield and yielding components.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most widely cultivated crop in the world (de Putter *et al.,* 2007). It was reported to improve test and add nutritive essential elements for human health such as carbohydrates, minerals, and vitamins (Jett, 2002). Tomato can be produced at a wide range of climatic conditions including temperate, sub-tropical and tropical areas (Tindall, 1983). The crop yields better when grown in well aerated soil with pH ranges of 5.5 to 6.6 (Tindall, 1983). In Tanzania, vegetables, including tomato, covered 2.18 % of the total cultivated area in 2005-06 (de Putter H *et al.,* 2007). Total annual production is 129,578 t, representing 51% of the total vegetable produced in the country (Mwasha, 2000; de Putter *et al.,* 2007). An annual productivity of 8.4 t/ha (FAO, 2009) is relatively low in comparison with that produced in developed countries.

Despite of the social economic importance of tomato in Tanzania, yields particularly in Tabora Region are low. Factors contributing to low tomato yields include; both biotic and abiotic factors (Jett, 2002). Among biotic factors, growing of low yielding and susceptible varieties has greatly contribution to yield losses in Tabora. Tengeru 97, a commonly grown variety in Tabora Region, for example, was reported to yield less than 22 tones/ha. Such a yield is relatively low in comparison with other developed varieties produced in other areas. Moreover, yield losses of 70 – 80 % in Tabora regions were reported to result from blight. Tomato varieties, Duluti (LBR6), Meru (LBR

50 - 2) and Kiboko released by AVRDC- Arusha Tanzania were reported to perform better in different areas. Little, however, is known on the performance of these varieties under Tabora soil and water conditions. This study was therefore conducted to investigate if the varieties would have good yielding ability under the Tabora soil and water conditions.

Materials and Methods

Study areas

Screen house and field experiments were conducted at ARI-Tumbi and Ipuli areas within Tabora municipal. The region is located in western part on the central plateau between latitude 4°-7° South and longitude 31º - 34º East. During the season, the area was characterized by monthly cumulative rainfall of 24mm, 16ºC and 29ºC mean minimum and maximum monthly temperatures respectively.

Experimental material and crop establishment

Three newly introduced tomato varieties, Meru, Duluti and Kiboko available in Tanzania were used in the study. Screen house experiment was laid in a complete randomized design (CRD) while the field experiment was established in a randomized complete block design (RCBD) both with three replications. Tomato seeds were sown in raised bed nursery in rows, 15 cm apart in a soil well incorporated with decomposed farmyard manure. Seedlings, 12 to 15 cm tall, were transplanted 4 weeks from sowing. Holes, 50 cm apart, were dug in raised beds 1.5 m wide and 9 m long in the field. For the screen house experiment, ridges, 75 cm apart were used. Top soil, mixed with well decomposed farmyard manure at a rate of 25tonnes/ha and Di-ammonium phosphate at 200 kg per ha were put in into the hole prior transplanting. Calcium ammonium nitrate (CAN) was used as top-dressing fertilizer four weeks after transplanting at a rate of 150 kg per ha. These were repeated two weeks later. Furthermore, NPK foliar fertilizer 19: 19:19 (Poly feed starter) was applied twice during flowering at the rate of 200 L per 15L at an interval of 10 days to supplement both macro and micro nutrients (Rice *et al.,* 1986; Schippers, 2000). Attakan C344SE and Hexaconazole 5 EC systemic insecticide and fungicide respectively were applied at a rate of 30 ml per 20 l of water at an interval of 10 days to control insect pests and fungal diseases.

Mulching and watering was done to conserve and add soil moisture respectively. De-suckering was done during early stage of sucker formation and only two stem (Double stem) were allowed to develop. Two stakes were inserted beside each stem to support heavy weight of fruits at the beginning of fruit set. Earthling up was done once to improve roots penetration, aeration and water movement.

Data collection

Plant growth parameters: Twenty sample plants were selected randomly from each plot and tagged for data collection at the beginning of fruits harvesting. The height of the stem was measured from the root collar level to the tip using 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 middle inter-nodal length of the main stem and branch were measured by a ruler in centimeter.

Reproductive and yield data: Numbers of flowers per sampled plants were counted when 50 % of the plant flowered. The number of fruit per plant was recorded at fruit maturity as the average of the cumulative number of fruit in all pickings of each tagged plant. Each fruit harvested from the tagged plants was weighed in gram separately at each picking and their average was calculated per each plant.

Data analysis

Data were subjected to one way analysis of variance technique using GENSTAT 14th Edition and the difference was declared significance at 5 % level of probability. Correlations analysis was done to compare the relationship between variables. Least significance difference (LSD) was used in means separation.

Results

Vegetative growth parameters

Kiboko and Meru had significantly ($p<0.001$) longer stem than Duluti measuring 106 cm, 112 cm and 58.08 cm, respectively in the field. Contrary to field results, Kiboko, had significantly (p<0.001) longer stem of 129 cm compared to Meru and Duluti with 118 and 69 cm respectively (Table 1).

had shorter internodes both on the stems and branches than the other varieties (Table 1).

Table 1: Vegetative growth data on the field and screen house experiments

	Field results							Screen house results						
Treat-ment	N B	H S	I B	I S	Nd B	Nd S	H B	N B	H S	1 B	1 S	Nd B	Nd S	H B
Duluti	1	58.1	3.2	7.5	4	13	17.3	1	69	4.6	6.85	5	10	39.8
Kiboko	1	106.1	3.6	7.8	91	18	43.9	1	129	6.9	10.9	8	16	67.1
Meru	1	112.5	4.4	7.8	13	21	75.6	1	118	7b	10.3	4	6	66.1
LSD	0.3	11.5	1.3	0.8	4.6	2.2	75.6	0.76	8	3.95	1.35	1.14	1.63	7.9
F-Test	0.3	<.001	0.2	0.7	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
CV (%)	10.9	11.7	23	4.1	20.8	12.9	41	19.4	0.8	4.1	0	14.4	4.8	3.1
SE+	0.1	5.8	0.6	0.4	6.16	1.09	6.8	0.377	3.97	0.56	0.67	0.57	0.815	3.95

NB: N = Number, B = Branch, H = Height, I = Internodes length and Nd = number of nodes and S = stem

Height of the branches were significantly different (p<0.001) among all varieties in the field. Contrary to Duluti with a branch of 17.25 cm long, Meru had significantly (p<0.001) longer branch of 75 cm. Kiboko had average branch length of 43.89 cm. In screen house Dulut had significantly (p<0.001) shorter branches of 40 cm while Kiboko and Meru had average branch length of 67 and 66 cm, respectively (Table 1).

Number of nodes on the stem and branches: The number of nodes on the stem and branches were significantly different (p<0.001) among the tomato varieties in both trials. Meru and Duluti had significantly (p<0.001) fewer nodes on branches than Kiboko. As opposed to screen house experiments, 21 nodes on the stem possessed by Meru were significantly (p<0.001) higher than the other varieties. Duluti had 13 nodes which were significantly (p<0.001) fewer than the other varieties in the field. Sixteen nodes in Kiboko were significantly (p<0.001) larger than other varieties in the screen house (Table 1).

Length of the middle internodes on the stem and branches: Length of the middle internodes on the stem and branches were not different among the tomato varieties in the field. They had a mean range of 3 to 4 cm and 7 cm to 9 cm long on the stem and branches, respectively. Their lengths were however significantly (p<0.001) different in the screen house where Duluti

Reproductive growth and yield performance: There were significant differences (p<0.001) in reproductive and yield parameters between the tomato varieties in the field. Mean weight of a single fruits ranged from 135 to 162 g and 93 to 103 g in the field and screen house respectively. Duluti with a mean of 162 g was significantly (p<0.001) heavier than the other varieties. It was, however, not different from Meru with 154 g. Kiboko fruit weighing up to 135 g, these was significantly (p<0.01) less intense than other varieties. No difference in weight was observed in the screen house (Table 2).

Number of clusters varies significantly (p<0.001) among tomato varieties. They were ranging from 5 to 7 and 7 to 13 in the field and screen house respectively. Meru with 7 and 12 clusters per plant in the field and screen house, respectively were significantly (p<0.001) larger than the other varieties (Table 2).

Kiboko and Meru had significantly (p<0.05) larger number of flowers, fruits per plant and fruits per cluster than Duluti in the field. Sixty six flowers in Meru were significantly (p<0.001) large than the other varieties. Duluti had a mean of 15 fruits per plant, which was significantly (p<0.001) larger than other varieties. This was however not different from Kiboko with 12 fruits per plant (Table 2).

Table 2: Data on reproductive and growth variables on the field and screen house experiments

	Field results					Screen house results				
Treatment	N Cl	N F	N Fr	N Fr/Cl	W(g)	N Cl	N F	N Fr	Fr/Cl	Frw
Duluti	5	25	16	3	162	10	47	15	3	92.7
Kiboko	5	49	18	3	135	7	37	12	3	94.25
Meru	7	55	21	4	154	13	66	11	4	102.5
LSD	0.8	4.6	2.4	0.36	17.6	1.97	11.5	3.0	0.8	20.3
F-Test	<.001	<.001	<.001	<.001	0.009	<.001	<.001	0.018	0.38	0.588
CV (%)	8.5	6	5.8	0.4	6.3	1.9	6.3	1.1	11.1	0.7
SE+	0.402	2.327	1.192	0.1816	8.93	0.983	5.75	1.505	0.402	10.15

NB: N = Number, Cl = Cluster, F = Flower, Fr = Fruit, W = weight and g = gram

Correlation analysis for the field experiment

Significantly ($p<0.05$) positive and negative correlation had been shown between some of vegetative and reproductive growth parameters in the field experiment. Number of nodes on the stem were significantly ($p<0.05$) positively correlated with the number of flowers, length of the middle internodes and height of the branches. Furthermore, it was highly significantly ($p<0.05$) positive correlated to the height of stem. Number of flowers were significant ($p<0.05$) and positively correlated with the height of the stem and branches. Heights of the branches were also significant ($p<0.05$) and positively correlated with the length of the middle internodes of the branches and height of the stem (Table 3).

Numbers of clusters were negative correlated with the number of nodes on the branches and length of the middle internodes. Nodes on the branches were negative correlated with the length of the middle internodes of the stem and branches and height of the branches. Fruit weight was negative correlated with number of nodes on the branches, fruits, flowers, branches, fruits per cluster and length of the middle internodes (Table 3).

Table 3: Correlation between yield and yielding components among tomato varieties for the field experiment

	N Cl	Nd S	Nd B	N. Fr	N F	N B	I S	IB	H S	H B	Fr/Cl	Frw
N Cl	-											
Nd S	0.2	-										
Nd B	-0.1	0	-									
N Fr	0.3	0.2	0	-								
N F	0.2	0.5*	0.2	0.6*	-							
N B	0.1	0.4	-0.1	0.2	0.3	-						
I S	-0.1	0.5*	-0.1	0	0.1	0.4	-					
IB	0.1	0.2	-0.3	0.2	0.3	0.4	0.1	-				
H S	0.1	0.7**	0.1	0.2	0.6**	0.2	0.4	0.2	-			
H B	0.2	0.5*	-0.4	0.3	0.7**	0.4	0.3	0.5*	0.5*	-		
Fr/Cl	0.2	0.3	0.1	0.1	0.3	0	-0.1	-0.1	0.3	0.2	-	
Frw	0.2	0	-0.2	-0.2	-0.3	-0.1	-0.1	0.1	-0.2	0	-0.1	-

Key: N = Number, ** = highly significant, * = significant, B = branch, H = height, I = internodes length, Nd = number of nodes, Cl = cluster, F = flower, Fr = fruit, W = weight, g = gram and S = stem

Table 4: Correlation between yield and yielding components among tomato varieties for the screen house experiment

	l S	l B	Nd S	Nd B	N F	N F	N Cl	N B	HB	HS	Fr/cl	Frw
l S	-											
l B	0.6**	-										
Nd S	0	0	-									
Nd B	0.1	0	0.7**	-								
N F	-0.3	-0	0.1	0	-							
N F	-0.1	-0	-0.4	-0	-0	-						
N Cl	-0.1	-0	-0.5*	-0	-0	0.7**	-					
N B	0	0.1	-0.4	-0	-0	0.6**	0.6**	-				
H B	0.5*	0.4	0	0.1	-0	0	0	0.1	-			
H S	0.7**	0.5*	0.2	0.3	-0	0.1	0	0.2	0.8**	-		
Fr/cl	0	0.1	-0.1	0	0.3	0.3	-0.1	0	0.1	0.1	-	
Frw	-0.1	-0	0.1	0.1	0	0.1	0.1	0.2	-0.2	-0	-0.1	-

Key: N = Number, ** highly significant, * significant, B = branch, H = height, I = internodes length, Nd = nodes, Cl = cluster, F = flower, Fr = fruit, W = weight, g = gram and S = stem

Correlation analysis for screen house experiment

Significantly ($p<0.05$) positive and negative correlations were observed between some of vegetative, reproductive and yield parameters in the screen house experiments. Stem internodes length was highly significantly ($p<0.05$) and positively correlated with height of the stem and branches. Number of nodes on the stem were significant ($p<0.05$) and positively correlated with number of nodes on the branches and number of clusters. Furthermore, the number of flowers were significant ($p<0.05$) and positively correlated with the number of clusters and branches. Number of clusters were also significant ($p<0.05$) and positively correlated with number of branches while heights of the branches were positively correlated with that of the stem (Table 4).

Internodes lengths on stem and branches were negatively correlated with number of flowers, fruits and clusters. Number of nodes on the stem and branches were negatively correlated with number of flowers, clusters and branches. Furthermore, number of fruits was negatively correlated with the number of flowers, clusters, branches and height of the stem and branches. Number of fruits per cluster was also negatively correlated with number of clusters and nodes on the stem. In addition, fruit weight was negatively correlated with length of the middle internodes, height of the stem and branches and number of fruits per clusters.

Discussion

Variations in heights of the stem and branches among tomato varieties both in field and screen house were observed. Khokhar *et al*. (1988) and Hussain *et al.* (2001) reported plant height ranging from 81.8 to103.4 cm and 62 to 126 cm in different tomato varieties, respectively. Differences in plant vigour and growth may depend on variety and environmental conditions. Variation in vigour and growth among varieties may be the source of variation in yield and yielding components. With the exception of height of Duluti in screen house, all varieties in all experiment included in this study were within the range reported by Khokhar *et al.* (1988) and Hussain *et al.* (2001). Such an observation may be the results of continuous breeding and use of improved agronomic practices that leads to improvements in plant performance. Shorter height in Duluti may be the attribute of its genetic composition as it was observed to have shorter stem, branches and middle internodes.

Number of nodes on the stem and branches and internodes length

Nodes on the stem and branches were significantly ($p<0.05$) different among tomato varieties in field and screen house experiments. Except for screen house, the lengths of the middle internodes were not significantly different. The results indicated that, the number of nodes increases with increase in stem and branch height. These resulted in increases in number of flowers and longer stems, branches and internodes as they are positively correlated. Except for stem in screen house, Duluti had fewer nodes than other varieties. These may be due to its shorter internodes, stem and branches. The shorter stem and branches, fewer nodes and heavier fruits observed in Duluti concur with Hussein *et al.* (2001) findings with tomato variety, Samarzano. A longer stem may be the reason for the larger number of nodes and longer middle internodes. The reason for the number of nodes in the field to differ significantly ($p<0.05$) from screen house among varieties may be due to variation in adapting to the different environmental conditions.

Reproductive growth performance

Number of flowers showed significant ($p<0.05$) variation among tomato varieties in both experiment. The number of flowers in tomato has been reported to vary depending on crop vigour, genetic factor and environmental conditions (Hussein *at el.,* 2001). Plants with longer stems, large number of nodes and clusters may produce more flowers than those with shorter stems, fewer nodes and clusters. Therefore, any increase or decrease in number of nodes, clusters and length would have great influences the number flowers due to their strong positive correlations. Similar observations were reported by Warren *et al.* (1998) and Loy (2004) in their study of the association of vegetative, reproductive and yield parameters in watermelon. Significantly ($p<0.05$) longer stem and better performance of other vegetative growth parameters in screen house may be the reason for the larger number of flowers counted in screen house than in field conditions.

Yield performance

There were significant variations in number and weight of a single fruits per plant among varieties in both experiments. Hussain *et al.* (2001) reported 15 to 36 fruits per plant weighing 48 to 88 g per fruit. Gabal *et al.,* (1985) reported variation of 66 to 99g per fruit among bush-type tomato varieties. The number and weight of fruits depend on both environmental and genetic variations and plant management. Tomato plants with longer stems, many nodes and branches may produce higher number of flower initials and heavier fruits than those with shorter stems, fewer nodes and branches. Conditions, such as increased planting density, water scarcity during flowering and fruiting, high temperatures, reduced leaf area index. Greater numbers of fruits per plant were reported to decrease fruit size and soluble solids (Wien, 1997). High temperature was reported to cause abortion of flowers and ultimately reducing number of fruits (Maynard, 2007). Weather conditions have great influence on pollinator activity and that honeybees are less active when it is hot and dry (Maynard, 2007). Fewer fruits set in screen house experiment as opposed to field one may be due to the relatively low moisture content in the screen house experienced during flowering as a result of water shorted experienced between May and August together with higher temperatures of 16°C (Min) to 29°C (Max) during flowering. Such conditions have been reported to cause flower abortion (Maynard, 2007). Failure in pollination due to limited entrance and inactiveness of pollinating agents caused by high temperature may also be the reason for poor fruit setting in the screen house experiment and thus yield reduction. Availability of irrigation water particularly during flowering enhanced fruit yields in the field.

Duluti had heavier fruits in the field and average performance in screen house as opposed to Meru and Kiboko. This may be due to its fewer fruits per plants, fruits per cluster, clusters, nodes and plant height than either of the varieties. The amount of assimilates directed into few fruits were higher in Duluti than those went into many fruits and other vegetative and reproductive parameters in other varieties. These findings agree with those of Wien (1997) who reported that the size of the mature fruit is influenced by genetics, environment, and plant conditions during development of flower and fruit. The author further reported that conditions that reduce the amount of assimilate available tend to decrease the size of individual fruits.

Conclusion and Recommendations

This study was done to determine the influence of environmental conditions in Tabora on the growth of newly introduced tomato varieties. Duluti was found to be the best performer in fruit weight but average in other yielding components in both experiments. Other varieties were observed to have average performance in all aspects. They both showed better production in Tabora. Their good performance was attributed largely to their apparent better adaptation, which enabled them to grow more vigorously. They will therefore be suggested for adoption by Tabora growers. Therefore seeds agencies should improve the supply of these variety's seeds to growers. Multi ecological studies on the performance of these varieties with addition of other introductions during different seasons are important in identifying varieties which may perform better in different agro-ecological conditions and seasons. Fruit quality and market studies on these varieties are essential in the development of a variety which will meet both farmer's and consumer's interests.

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