Performance evaluation of tomato varaieties for irrigation production system in Mecha District of west Gojiam Zone, Amhara Region, Ethiopia - Masho Aklile[1*], Melkamu Alemayehu[1] and Getachew Alemayehu[1]

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Abstract

Tomato (Lycopersicon esculentum Mill*) is the most important and versatile vegetable crop in Ethiopia. Tomato production in Ethiopia as well as in Amhara Region is negligible because of lack of site specific improved varieties. Therefore the aim of this study was to evaluate the performance of 14 tomato varieties in Mecha District of West Gojjam Zone. The research was conducted trial site of Adet Agricultural Research Center under irrigation conditions. Tomato varieties were laid out in randomized complete block design (RCBD) with three replications. According to the results obtained significant differences were observed among the different tomato varieties for most of the vegetative characteristics and yield components. Sirinka-1, Mersa and Eshet varieties were the tallest varieties with the mean values of 115.5cm, 110.1cm and 102.2cm, respectively. Mersa had the highest number of primary branches (7.7) while the highest number of secondary branches was recorded in variety Eshet (17.2) followed by Sirinka-1 (16.9). Fetan, Woyno, Miya, Bishola, Metadel and Bishola flowered earliest as compared to the remaining varieties. Fetan, Woyno, Cochoro, Miya, Metadel and Bishola varieties were matured earlier than the remaining varieties. Highest fruit set percent (75.2%) was recorded in variety Mersa. Number of cluster per plant was highest (57) in variety D2. Melkashola,* Metadel, Cochoro, Oval red, *and* Miya *varieties gave the highest marketable yield with the mean values of 58.8 t ha^{-1}, 49.5 t ha^{-1}, 49.3 t ha^{-1}, 49.0 t ha^{-1}),* and *47.1 t ha^{-1}, respectively. The highest fruit length (8.05cm) was obtained from Mersa variety while variety D2 gave the highest fruit width (5.72cm) and fruit weight (120.72g). The lowest pH value was recorded in varieties Mersa (3.77) and Melkasalsa (3.78), Cochoro (3.82) and Melkashola (3.84). In terms of TSS, Sirinka -1 and Mersa (5.36 %) varieties were superior followed by Eshet (5.23%) variety. Highest value of TA was recorded in Sirink-1 and Chali varieties. Sirinka-1, Eshet and Chali varieties were superior in their juice content. According to the findings of this study the chemical quality parameters of most of the tested varieties are at standard rages for tomato fruit quality. In terms of marketable yield Melkashola, Metadel, Cochoro, Ovalred, and Miya varieties of tomato can be recommended for the study area while Sirinka-1 and Mersa in terms of fruit quality. However, it is advised to repeat the experiment on different sites of the district.*

Keywords: Acidity, fruit quality, Juice content, yield, total soluble solid

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) belongs to the Solanaceae family along with other economically important crops such as pepper, eggplant and potato. It is originated in the area extending from Ecuador to Chile in the western coastal plain of South America. It was first domesticated in Mexico where various plants with a variety of fruit sizes and colors were selected (Jones, 2008; Kelley and Boyhan, 2010).

Tomato is not only one of the world's most important vegetables, but it is also the most versatile vegetable crop. It is consumed fresh as well as used to manufacture a wide range of processed products. It is an excellent source of nutrients and secondary metabolites which are important for human health including minerals, vitamins C and E, *β*-carotene, lycopene, fla- vonoids, organic acids, phenolics and chlorophyll (Naika, 2005). Tomato has medicinal values and being used for blood purification and curing digestive ailments (Kaushik *et al.*, 2011). Thus, the scientific community has recently becoming interested in the analysis of nutrients in tomato.

It is widely cultivated in the tropical, sub-tropical and temperate climates and ranks third next to potato and sweet potato in terms of world vegetable production. According to FAOSTAT, (2014) the world

tomato production in 2012 was 161.8 million tons harvested from 4.8 million hectares of land. The leading tomato producing countries are china followed by India and United state with the productivity of 13.2, 17.5 and 50 t/ha, respectively. However in terms of productivity the Netherlands is the leading country in the world with the productivity of 130 t ha^{-1}.

According to De Lannoy (2001) the average productivity of tomato in Africa ranged from 8 t ha^{-1} to 25 t ha^{-1}, the highest in South Africa and the least in Benin and Nigeria. Tomatoes in Ethiopia are produced mainly in northern and central rift valley areas. According to FAOSTAT (2014) commercial tomato production in Ethiopia has significantly expanded as the national agriculture strategies gave the highest priority for the production of high value cash crops like tomato. In the year of 2011/12 the total production of tomato in Ethiopia was about 81,970 ton harvested from 7,255 hectare of land, with the productivity of about 11.3 t ha^{-1} which was very low compared to other countries. Several production constraints identified for this low level of productivity. Inappropriate agronomic practices and high incidence of diseases and insect pests are among other the major constrains of tomato production in Ethiopia (Lemma, 2002).

Tomato offers better economic returns to many farmers in Ethiopia especially when it is grown during the wet season. However, productivity of tomato varies upon the cultural, and management practices employed as well as upon and the variety used for production. The application of appropriate field cultural management practices and the choice of cultivars specific for the area are the main factors that affect the productivity of tomato. The main aim of the present study was therefore to evaluate different released tomato varieties which are suitable for Mecha Districts of Amhara Region under irrigation farming system.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at Koga Irrigation Scheme during dry season of 2014/15 under irrigation. Koga Irrigation Scheme is located between 11^{o} 10' and 11^{o} 25' North latitude and 37^{o} 2' and 37^{o} 17' East longitude in Mecha District of Amhara region, Ethiopia. The mean annual rainfall recorded at the station of Merawi, the main town of Mecha District, is 1480 mm, of which 90 % falls in the months ranging from May to October. Altitude of the trial site is about 1850 meter above sea level with the mean monthly temperature of 25.8^{o}C and its slope ranges from nearly flat to 5 %. The area is characterized as tepid moist mild agro-ecology. The soil of the experimental site is Nitosol with strong acidity (pH 5.1-5.3). It has medium to high organic matter (2.34-4.44 %) content has low available phosphorus and medium total nitrogen contents with the values of 3.51-8.69 ppm and 0.18-0.24 %, respectively (Adet Agricultural Research center, 2003).

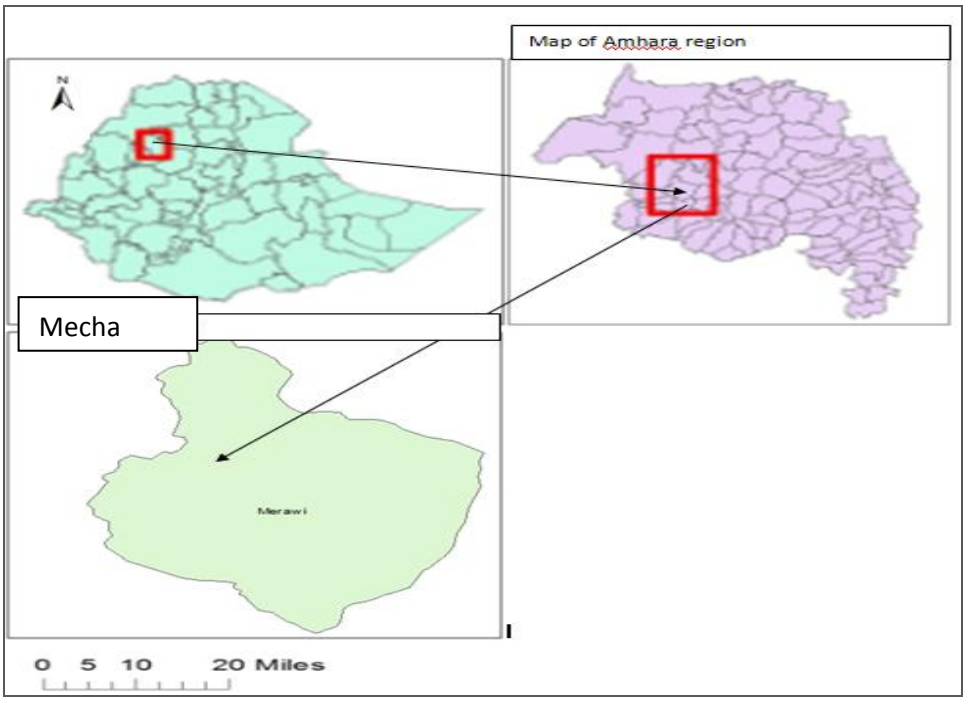

Figure 1: Map of the study area

Experimental Treatments, Design and Procedure

Fourteen improved and released tomato varieties collected from Melkassa and Sirinka Agricultural Research Centers were evaluated for their performance in the study area (Table 1). The treatments were laid out in Randomized Complete Block Design (RCBD) with three replications. The size of experimental plots was 4m x 3cm ($12m^2$) with the net plot area of 2m x 2.4m ($4.8m^2$). Seedlings were planted at the spacing 30 x 100cm between plants in the row and between rows, respectively, as indicated by Naika (2005). A free space of one meter and 1.5 m between plots with in block and between blocks was kept for cultural practices.

Table 1: Released tomato varieties used for the study and some of their descriptions.

Variety name	Year of release	Environmental requirements		Days to maturity	Yield (t/ha)		Production status
		Altitude (m)	Rainfall (mm)		Research field	Farmer`s field	
Sirinka-1	2006	800-2000	1400	95-100	38.2	14.4	Limited
Mersa	2006	800-2000	1400	100-120	27.6	15.9	Widely
Woyno	2006	800-2000	1400	85	24.9	14.4	Limited
Cochoro	2007	800-2000	1400	100-120	45	13-17	Limited
Miya	2007	500-2000	1200	82	47.1	14-19	Limited
Fetan	2005	500-2000	1200	95-100	45.4	13	Limited
Metadel	2005	700-2000	1400	75-90	34.5	13	Limited
Chali	2007	500-2000	1400	86	46.3	14-18	Limited
Eshet	2005	700-2000	1400	75-80	39.4	14	Limited
Melkasala	1998	700-2000	1400	100-110	45	13-17	Limited
Melkashola	1998	700-2000	1400	100-120	43	14-18	Widely
Bishola	2005	500-1800	1200	85-90	34	12.5-13	Limited
D2	2012	800-2000	1400	100-120	37.2	13	Limited
Oval red	2007	800-2000	1400	100-110	42	14-18	Limited

Source: Directory of released crop varieties, Ministry of Agriculture, Addis Ababa (2009)

Seeds were sown in rows of 15 cm spacing on well prepared raised ground nursery beds having the size of 2m x1m at AARC horticultural trial site of in Weramit, Bahir Dar. Sown seeds were covered lightly with fine soil and then with two-three cm thick grass mulch. Watering was done daily until germination and then with three days interval.

Transplanting of seedlings on experimental field was done at 3-5 true leave stage when seedlings attained the height of about 15-25cm. The experimental field was well prepared ahead of seedling transplanting using tractor and human labor. On each experimental plot 40 seedlings were planted at the spacing of 30 x100 cm between plants and between rows.

Watering was done using furrow irrigation at three days interval. The whole amount DAP (100kg/ha) recommended to the area was applied during transplanting while the recommended rate of urea (250kg/ha) was applied in to two equal splits. The first half of urea was applied at the time of planting while the remaining half was applied 21 day after transplanting of seedling (Adet Agricultural Research Center (2003). Experimental plots were kept free from weeds manually and other cultural practices such as disease and insect pest control were performed as per the recommendation for tomato production.

Data Collection and Analysis

Growth and phenological parameters

Plant height (cm): Heights of five randomly selected plants from the ground level to the apex grown in net plot area using rules were measured at maturity stage and the mean values were used for further analysis.

Number of primary branches per plant: **T**he primary branches of five randomly selected plants in net plot area were counted at the maturity stage and mean values were used for statistical analysis.

Number of secondary branches per plant*:* The secondary branches of five randomly selected plants in the net plot area were counted at maturity stage and the mean value was used for analysis.

Days to 50% flowering*:* the number of days elapsed from date of transplanting up to the date when 50% of the plants in plot flowered was recorded and used for analysis.

Days to 50% maturity: The number of days elapsed from date of transplanting up to the days when 50% of the plants in plot contained horticultural matured fruits was recorded and used for analysis.

Fruit yield and yield related traits

Number of clusters per plant: The number of clusters in five randomly selected plants in the plot was counted at 50% flowering and the mean values were used for further analysis.

Number of flowers per cluster: The number of flowers in lower, middle and upper clusters of five randomly selected tomato plants was counted and the mean values were computed and used for further analysis.

Number of fruits per cluster: The number of fruits in lower, middle and upper clusters of five randomly selected tomato plants was counted and the mean values were computed and used for further analysis.

Fruit set percentage (%)*:* it is the proportion of the number of fruits to the number of flowers per cluster expressed in percentage. It was calculated using the following formula.

$$\text{Fruit set (\%)} = \frac{\text{NFrPC}}{\text{NFlPC}} \times 100$$

Where
NFrPC = Number of fruit per cluster;
NFlPC = Number of flower per cluster

Fruit weight (g): The weight of five randomly selected fruits at each harvest was weighed with sensitive balance and average values were taken for further analysis

Fruit length (cm)*:* The fruit length of five randomly selected fruits at each harvest was measured using caliper meter and the mean values were used for further analysis.

Fruit width (cm): The diameter of five randomly selected fruits at each harvest was measured using caliper and the mean values were taken for analysis.

Marketable and unmarketable yield (t/ha): Diseased, insect pest, physiologically, and mechanically damaged fruits were considered as unmarketable (Lemma, 2000), while fruits free from any visible damages were considered as marketable. Both marketable and unmarketable fruits obtained from each net plot area were weighed with analytical balance in kg and converted into hectare basis.

Total fruit yield (t/ha): It was obtained by adding marketable and unmarketable fruit yields.

Chemical quality parameters

pH of tomato fruit juice: The juice of five randomly selected fruits from each replication was extracted using juice extractor. The aliquot of the juice was filtered with cheese cloth and the pH value of the juice was measured with a pH meter as indicated by Acedo and Thah (2008).

Total soluble solid (TSS) of fruit juice (^{o}Brix): An aliquot of juice was extracted from five randomly selected fruits harvested from each plot and 50 ml of the slurry was filtered using cheese cloth. The TSS was determined by hand refractometer with a range of 0 to 32 °Brix and a resolution of 0.2 °Brix by placing 1 to 2 drops of clear juice on the prism.

Titratable acidity of fruit juice (%): Aliquot of juice was prepared according to Acedo and Thanh (2008). The descant clear juice was used for the analysis. Titratable acidity was then determined by titrating 10ml of tomato juice with 0.01N NaOH and calculated with the following formula.

$$TA\ (\%) = \frac{\text{Titre} \times 0.1N\ NaOH \times 0.64}{1000} \times 100$$

Where, TA%=Titratable acidity percentage, Titre is the volume of tomato juice and 0.1N is the amount of NaOH used to neutralize 0.64 g of citric acid and 0.64 is the conversion factor.

Juice content (%): Five randomly selected five fruits from each plot were crashed and their juice was extracted by juice extractor and sieved with three level sieves and the juice content was calculated as follow:

$$\text{Juice content} = \frac{\text{Total weight of juice-beaker weight}}{\text{Total weight of fruit}} \times 100$$

The collected data were subjected to statistical analysis of variance (ANOVA) using (SAS 9.00 version, 2002) software and mean separation was done by Duncan's New Multiple Range Test (Duncan's New Multiple Range Test, 1995). Pearson`s correlation coefficient was used to evaluate the relationships among different parameters of tomato.

RESULTS AND DISCUSSION

Growth Parameters

Plant height

The tested varieties differ highly significantly ($P<0.01$) in their plant height (Table 2). Sirinka-1 was the tallest variety followed by Mersa and Eshet varieties. Both varieties were however statistically similar in their plant height. On the other hand Melkasalsa was found to be the shortest variety among the 14 tested varieties. The mean plant height of the tested tomato varieties was in the range of 51.7 cm to 115.5 cm which is in line with the observations of Meseret *et al.* (2012) who found that the height of tomato plants ranged from 36.80-126.7 cm. The tallest tomato varieties generally require long growth period and special management practices such as stalking and may also face the incidence of diseases and insect pests in tropical climate. On the other hand the short varieties may not need stalking and their production may require less labor expense that makes them highly popular for commercial cultivation in tropical conditions (Naika, 2005). According to Baudoin (1995) short tomato varieties are most suitable to

produce two crops per season. Moreover, tallest tomato varieties needs more cost for stalking and pesticide application. On the other hand tall varieties can be harvested five times per cropping while short varieties three times.

Number of primary branches

The number of branches per plant is an important parameter which indicates the yielding capacity of tomato variety (Shushay *et al*., 2013). The highest number of primary branches in this study was counted in Mersa variety followed by Sirinka-1. Woyno and Oval red produced the least number of primary branches (Table 2). The results of this study coincide with the findings of Sharma and Rastogi (1993) who reported that there is significant variation in number of branches among cultivars of tomato and increasing tendency in the number of branches with an increase in plant height. Moreover the results are in agreement with the observations of Fayaz *et al.* (2007) who reported the primary branches of tomato ranges from 3.1 to 12.6 per plant. On the other hand, varieties with highest number of primary braches in this study gave low yield which is probably associated with the increased nutrient competition, as the experimental soil is generally low in its fertility (AARC, 2003).

Table 2: Growth and phenological parameters of tomato varieties grown at Koga Irrigation Scheme

Variety	Growth parameters			Phenological parameters	
	PH (cm)	NPBPP	NSBPP	DTF	DTM
Sirinka-1	115.45a	7.22ab	16.85ab	57.33a	111.66a
Mersa	110.08a	7.71 a	15.26bcde	56.33 a	111.33a
Woyno	64.46bcd	5.33cd	15.46bdc	50.33bcd	95.66 b
Cochoro	61.13bcd	5.40cd	13.60e	51.33b	96.00b
Miya	53.00d	5.86cd	14.20de	50.00cd	96.00b
Fetan	58.46bcd	5.60cd	14.06de	49.66d	96.00b
Metadel	71.06b	5.40cd	16.26 abc	51.33b	96.00b
Chali	57.13bcd	5.80cd	16.66ab	57.33a	111.66a
Eshet	102.20a	6.20bcd	17.13a	56.66a	111.00a
Melkasalsa	51.73d	4.86d	14.26de	57.33a	111.66a
Melkashola	70.20b	6.60abc	16.26abc	56.66a	111.66a
Bishola	69.06bc	5.40cd	14.53de	50.66bc	96.00b
D2	54.73cd	5.40cd	14.95cde	57.33a	111.00a
Ovalred	64.80bcd	5.53cd	14.60de	57.33a	111.33a
Sig difference	**	**	**	**	**
CV (%)	10.93	12.41	5.71	1.25	0.64
SE±	7.84	0.73	0.87	0.67	0.66

PH=plant height; NPBPP=number of primary branches per plant; NSBPP=number of secondary branches per plant; DTF=days to 50% flowering; DTM=days to maturity; **highly significant; CV=coefficient of variation; SE=standard error; means followed with the same letter(s) in the same column are similar

Number of secondary branches

The tested tomato varieties showed highly significant variation in the number of secondary branches per pant. The highest number of secondary branches was recorded by variety Eshet followed by Sirinka-1,

Metadel and Melkashola varieties which were statistically similar. Similar to the primary branches, secondary branches are important criteria for selection variety. These results were in conformity with the work of Shushay *et al.* (2013) who reported that there was significance difference between tomato varieties for the number of secondary branches. According to the authors when the number of secondary branch increased the fruit yield also increased. However in this study, varieties with the highest number of secondary branches recorded gave low yield is which associated with nutrient and area competition especially in low fertile soil.

Days to 50% flowering

Days to 50% flowering ($P < 0.01$) is highly significantly influenced by tomato varieties. Tomato varieties of Fetan, Metadel, Cochoro, Miya, Woyno and Bishola flowered relatively earlier than the remaining varieties (Table 2). Days to 50% flowering in the present study ranged from 49.7 to 57.3 which is not in agreement with the findings of Meseret *et al.* (2012) and Fayaz *et al.* (2007) who found that days to 50% flowering of tomato varieties ranged between 40 and 49, perhaps their working sites were much wormer than that of the experimental site of present study. All the tested varieties took a little bit longer time to attain 50% flowering that might be due to relatively low thermal and poor soil conditions of the study site for growth and development of tomato. According to Adet Agricultural Research Center (2003), the soil fertility of Koga irrigation command area is poor and the pH is acidic for most vegetable crops. This might result to the slow growth and prolongation of the phenological development of tomato apparently observed in the present study. According to Parvej (2010), days to 50% flowering are one of important phenological parameters and determinant factors for growth and productivity of tomato plants. Moreover the difference in 50% flowering days can also be attributed by the genetic makeup of genotypes as observed by Abdelmageed and Gruda (2009).

Days to 50% maturity

There was highly significant difference ($P < 0.01$) among tested tomato varieties for days to the first harvest. Fetan, Woyno, Cochoro, Miya, Metadel and Bishola tomato varieties matured relatively earlier than the rest of the tested varieties (Table 2). In the present study, the tested tomato varieties took 95.0 to 111.5 days to produce horticultural matured fruit in the first harvest. Various researchers reported that tomato varieties give the first harvest in 70-120 days after transplanting (Moraru *et al.,* 2004; Fayaz *et al.,* 2007; Abrar *et al*., 2011). In the present study, 16 days difference was observed between late variety Sirinka-1 and early Woyno varieties which is relatively a normal range as observed by various authors mentioned above. Early matured varieties are important for early marketing in the season which mostly fetch good price. On the other hand late maturing tomato varieties need extra management and their production is mostly labor intensive.

Moreover, Lohar and Peat (1998) reported that the delay in flowering can correspondingly lead to the delay of fruit maturity in tomato. Furthermore, according to Fayaz *et al*. (2007) the early or late maturity is attributed by genotypic character and in the extent influenced by the environmental factors of any particular growing area.

Yield and Yield Related Traits
Number of clusters per plant

Among the tested tomato varieties D_2 produced the highest number of clusters followed by Eshet, Chali and Woyno varieties (Table 3). On the other hand variety Bishola produced the least number of clusters per plant (26.87). The observed difference in the production of clusters is probably due to the inherent potential of the varieties which was also indicated by the research results of Mohanty *et al*. (2001). The production of clusters is one of the major criteria in selecting tomato varieties and it determines the yielding potential of a variety (Pandey, 2006).

Number of flower per cluster

The number of flowers produced per cluster deferred among the tested varieties. The highest number of flowers per cluster was produced by variety Sirinka-1 while least number of flowers per cluster was recorded by variety Fetan followed by Bishola variety. These results resembled with the observation of Meseret *et al.* (2012) where they found 2.27 to 5.89 flowers per cluster in various tomato varieties. Increased production of flowers on tomato plant means high probability in fruit set percentage that may lead to higher yield (Abdelmageed and Gruda, 2009). In this study however varieties with moderate number of flowers per cluster like Melkashola and Cochoro gave the highest yield of tomato which is probably due to nutrient competition among flowers in the cluster which is more intensive in soils with low fertility like the one in the study area.

Number of fruit per cluster and fruit set percentage

The tested varieties showed variations in the number of cluster and fruit set percentage (Table 3). The variety Mersa recorded the highest number of fruits per cluster and fruit set percentage followed by Melkasalsa variety in both parameters. Variety Bishola produced the lowest fruit number per cluster while the fruit set percentage in variety Bishola was the least among the tested tomato varieties. According to Parvej *et al*. (2010) 4.5 - 4.7 tomato fruits per cluster is assumed to be high which is relatively higher than the number of fruits obtained on a cluster of the tested varieties. The number of fruits per cluster is affected by the number of flowers per cluster (Meseret *et al*., 2012). It is one of the major criteria to select variety for its higher yielding potential. In general, the higher the number of fruits per cluster the more fruit yield is expected, although fruit size also determines the yield estimation (Pandey, 2006).

The fruit set results recorded in this study is in general with the results of Meseret *et al*. (2012), Khah *et al*. (2006) and Abrar *et al*.(2011) who indicated that the average fruit set percentage of tomato flowers lays in the ranges between 36.9% and 98.5%. However the higher the fruit set percentage the smaller is the fruit size as observed in Marsa variety of tomato which resulted low yield in this study. On the other hand Sirinka-1 and Bishola varieties gave the lowest fruit set percentage. According to Jones (2008), fruit set percent is one of the major important parameters in choosing tomato varieties for summer and rainy season production, thus it determines the resistance and/or tolerance of a variety to temperatures and other environmental conditions.

Fruit weight, length and width

The results indicated that there was highly significant difference ($P < 0.01$) for fruit weight among the tested tomato varieties. Accordingly, the variety D2 recorded the highest fruit weight followed by Cochoro (Table 3). The lowest fruit weight was scored by Sirinka-1 vareity. The fruit sizes of the tested varieties are within the standard ranges for tomato fruits as reported by Lemma (2002). According to the

report, the average weight of tomato fruits is in the range of 20 to180 g. According to Rubatzky and Yamaguchi (1997) tomato fruits are categorized into small, medium and large based on the fruit weights with the value of <50g, 70-110g, 110-170g and >180g, respectively. Medium and large fruit categories are preferred generally for fresh market.

Similarly, there was highly significant difference in fruit length of the tested tomato varieties (Table 3). The highest fruit length was recorded from Mersa variety, followed by D2, Ovalred and Melkashola varieties. The lowest fruit length was recorded by Sirinka-1 variety. The findings of this study are in agreement with Hossain *et al*., (2010) who reported that the average fruit length of tomatoes is ranging from 3.35 to 5.14 cm, an important parameter for variety selection and customer preference (Meneberu *et al.*, 2011).

Depending on the type of variety, tomato fruit width is at the range of 3.2-10.67 cm (Kaushik *et al*., 2011; Rashidi and Gholami, 2011) which is in line with the findings of the present study (Table 3). The size, length and width of tomato fruits are influenced by the genetic makeup of the varieties (Atherton and Rudich, 1986).

Marketable, unmarketable and total fruit yield

Marketable fruit yield is the major determinant variable for selection of a particular tomato variety, as it directly affects commercialization and thus income generation of the farms (Pandey, 2006). In the present study the highest marketable fruit yield was recorded by variety Melkashola followed by Metadel, Cochoro, Ovalred, and Miya which were statistically similar when compared each other. The lowest fruit yield was recorded from variety D2 followed by Sirinka-1 (Table 4). The marketable yields of the above mentioned tomato varieties were relatively good compared to the findings of Znidarcic *et al.* (2003) and Meseret *et al.* (2012) who reported the marketable fruit yield ranging from 7.21-43.80 t ha^{-1} in their study. However Rida *et al*. (2002) reported the marketable yield of tomatoes in the range of 37.1 t ha^{-1} to76.2 t ha^{-1}.

According to Lemma (2002), sun burnt, small sized cracked disease and insect pest damaged fruits are considered as unmarketable. Accordingly the highest unmarketable fruit yield was recorded in variety Cochoro while the least was recorded in Sirinka -1 (Table 4). Diseases and insect pests are the major constraints of tomato production in tropical country which result an increase in unmarketable yield. Although insecticides such as Endosulfan, Dimetot and Prophet were applied, bollworm and aphids created major problem in the present study. The observed varietal differences of unmarketable yields in the present study might be due to the difference in fruit pericarp thickness as indicated by Capuno *et al.* (2007).

Similar to marketable and unmarketable yields there was highly significant ($P<0.01$) difference in total fruit yield among the tested varieties. The variety Cochoro followed by Melkashola and Oval red produced significantly highest total fruit yield which were statistically similar when compared each other (Table 4). On the other hand the lowest total yield was obtained from variety D2.The results are generally in agreement with Lemma (2002) and Meseret *et al*. (2012) who reported that total fruit yield of tomato ranging from 6.46-82.50 t ha^{-1} in their study.

Table 3: Yield related parameters of tomato varieties grown at Koga Irrigation Scheme

Variety	NCPP	NFlPC	NFrPC	FrS (%)	FWT (g)	FL (cm)	FW (cm)
Sirinka-1	38.97bcd	6.60a	3.26b	49.81c	41.75g	4.04g	4.27de
Mersa	47.77ab	5.41b	4.06a	75.17a	62.80def	8.05a	3.42f
Woyno	39.00bcd	4.80bcd	3.06bcd	63.84abc	72.24cde	5.44cdef	4.74bcd
Cochoro	33.40cde	4.40cd	2.46de	56.21bc	100.70b	6.07bcd	5.04bc
Miya	32.60cde	5.66b	2.86bcd	50.47c	55.51efg	5.30def	4.39de
Fetan	30.00de	4.06d	2.53cde	63.22abc	73.33cde	5.60bcdef	5.14b
Metadel	38.00bcde	4.93bcd	2.53cde	52.58bc	80.24cd	5.22ef	5.06bc
Chali	53.86a	4.80bcd	2.40de	50.05c	70.46de	5.98bcde	4.50cde
Eshet	55.13a	5.46b	3.26b	59.71abc	68.28def	4.89f	4.74bcd
Melkasalsa	36.73bcde	4.96bc	3.40b	68.54ab	50.31fg	5.80bcde	3.98e
Melkashola	41.86bc	4.86bcd	2.86bcd	58.88abc	62.78def	6.19bc	4.27de
Bishola	26.86e	4.26cd	2.06e	49.35c	89.41bc	4.87f	5.29ab
D2	56.95a	4.98bc	3.20bc	65.13abc	120.97a	6.37b	5.73a
Oval red	32.00cde	4.86bcd	3.06bcd	63.44abc	64.3def	6.18bc	4.11e
Significance	**	**	**	*	**	**	**
CV (%)	14.63	12.47	9.20	14.84	13.65	7.72	6.93
SE±	5.88	0.46	0.36	8.76	9.88	0.44	0.32

NCPP=number of clusters per plant; NFlPC=number of flowers per cluster; NFrPC=number of fruits per cluster; FrS=fruit set; FWT=Fruit weight; FL=Fruit length; FW=Fruit width; **highly significant; *significant; CV=coefficient of variation; SE=standard error

Means followed with the same letter(s) in the same column are similar

Table 4: Yields of tomato varieties grown at Koga Irrigation Scheme

Variety	Fruit yield (t ha^{-1})		
	Marketable	Unmarketable	Total fruit yield
Sirinka-1	29.51bc	7.36d	36.87bc
Mersa	38.26abc	11.46bcd	49.72abc
Woyno	42.29abc	16.46bcd	58.75abc
Cochoro	49.31ab	27.85a	77.15a
Miya	47.08ab	20.42ab	67.50ab
Fetan	37.78abc	20.63ab	58.40abc
Metadel	49.51ab	18.26abc	67.77ab
Chali	42.85abc	11.81bcd	54.65abc
Eshet	45.37abc	16.59bcd	61.94abc
Melkasalsa	40.83abc	20.49ab	61.32abc
Melkashola	58.75a	17.06bcd	75.81a
Bishola	40.69abc	14.17bcd	54.86abc
D2	22.29c	9.79cd	32.08c
Oval red	48.96ab	20.48ab	69.44a
Significance	*	**	**
CV %	22.22	23.61	20.50

SE±	9421.71	3927.242	12100.19

**highly significant; *significant; CV=coefficient of variation; SE=standard error
Means followed with the same letter(s) in the same column are similar

Tomato Fruit Quality Parameters

Fruit juice content

Juice content of tomato fruit is an important parameter for selection of variety as it determines its utilization. The fruits of Sirinka-1 variety have the highest juice content followed by Eshet with the values of 93.5 and 92.5 %, respectively (Table 5). Statistically the lowest juice content was found in the fruits of Cochoro with the value of 75.72 %. Based on the juice content of the fruits, the varieties Sirinka-1, Eshet and chali which have relatively high juce content, are suitable for agro-processing industry (Moreno *et al.,* 2009), while the varieties Cochoro, Melkasalsa, Melkashola, and Ovalred with relatively low juice content are suitable for fresh market.

According to Miles *et al.* (2012), tomatoes generally have juice content in the range of 75.1% to 99.3% which is in agreement with the results of this study. Tomato varieties with high juice content are mostly suitable for agro-processing industries as reported by. According to the authors, tomato products such as tomato pastes and tomato juices have remarkably high concentration of minerals and vitamins such as vitamin C, vitamin E and pro-vitamin A. In addition, tomato juices also contain valuable phytochemicals or bioactive components such as lycopene and phenolic compounds and carotenoids (b-carotene). These nutritionally valuable compounds are however affected by the types of variety and the stages of maturity, and processing and storage conditions of tomatoes (Moreno *et al.,* 2009).

Fruit juice pH value

PH value is the other quality parameter which determines the flavor and sourness of the juices made from tomato fruit. In the present study there was highly significant ($P<0.01$) difference in pH value of juices of the tested tomato varieties. Juices made from Mersa, Melkasalsa, Cochoro and Melkashola were strongly acidic with the pH values of 3.77, 3.78, 3.82 and 3.84, respectively which were statistically similar when compared to each other (Table 5). However, fruit juices of Bishola, Ovalred and Sirinka -1 varieties had relatively higher pH values. The findings of this study are generally in agreement with the findings of Caliman *et al.* (2010) where tomato fruit jucies were categorized as acidic with the pH value generally less than 5. Low pH values of tomato juice are associated with high fruit quality which is accounted to the flavor and sourness of the fruits. The genetic makeup of a variety determines the pH of the fruits and thus the flavor and sourness of the fruits (Ram, 2005).

Total soluble solid (TSS) and titratable acidity (TA) content

The TSS and TA contents of fruit is one of the major criterions in selecting of tomato variety for fresh market as it determines the sugar and acid content of a fruit that influences the overall flavor of the fruit (Stevens *et al*., 1977). In the present study, the fruits of Sirinka-1 and Mersa varieties recorded the highest TSS while the variety Ovalred recorded the lowest TSS (Table 5). The present results agreed with the findings of Sacco (2005) who reported that TSS of cultivated tomato comprised 4.0-7.5 % of its fresh weight. On the other hand Caliman *et al*. (2010) reported that TSS different tomato varieties grown under protected condition varied from 3.60-3.83%.

In the case of TA, significant highest values of TA were recorded in the fruit of Sirinka-1 followed by Woyno and Chali which were statistically similar when compared each other. The lowest TA values were recorded in Metadel and Cochoro varieties (Table 5). The findings in this study are generally comparable with the findings of other researchers. According to Stevens and Rick (1986) TA of tomato fruits varies from 0.40% to 0.91%. The results are also in line with the report of Kader *et al*. (1978) where high quality fruit should have TA and TSS greater than 0.32% and 3%, respectively. TA and pH values of a give fruit are inversely related (Young, 1993). TA and TSS of tomato fruit are influenced mostly by the genetic makeup of the variety (Caliman *et al*., 2010; Mahakun *et al*., 1979).

Table 5: Quality parameters of tomato varieties grown at Koga Irrigation Scheme

Variety	Quality parameters			
	pH	TSS (%)	TA (%)	JC (%)
Sirinka-1	4.16a	5.36a	1.04a	93.33a
Mersa	3.77c	5.36a	0.89cd	75.07g
Woyino	4.02b	4.66cd	1.00ab	80.85f
Cochoro	3.82c	4.93abc	0.78e	75.71g
Miya	4.01b	5.23a	0.99ab	87.46cd
Fetan	3.96 b	5.10ab	0.97abc	87.86cd
Metadel	4.00b	4.40d	0.77e	86.40de
Chali	3.99b	4.40d	1.00ab	91.26abc
Eshet	3.96b	5.23a	0.91bcd	92.49ab
Melkasalsa	3.78c	4.70bcd	0.83de	76.71g
Melkashola	3.84c	4.47d	0.85de	84.66def
Bishola	4.14a	4.46d	0.96abc	87.26cd
D2	4.04b	4.53cd	0.99ab	88.18bcd
Ovalred	4.15a	3.93e	0.97abc	82.38 ef
Significance	**	**	**	**
CV	1.22	5.03	5.53	2.89
SE±	0.048	0.23	0.05	2.46

TSS=Total Soluble Solid; TA=Titratable Acidity; JC=juice content; **highly significant; CV=coefficient of variation; SE=standard error

Means followed with the same letter(s) in the same column are not significant

CONCLUSIONS AND RECOMMENDATION

Conclusion

The objective of this study was to evaluate the performance of released tomato varieties in Mecha District under irrigation production system. The tested varieties performed differently in growth, yield and yield parameters as well as in fruit quality parameters. Sirinka-1, Mersa and Eshet varieties were the tallest, while the variety Melkasalsa was the shortest one. Mersa and Sirinka-1 vareities produced the highest number of primary branches. On the other hand Eshet, Sirinka-1, Metadel and Melkashola varieties produced the highest secondary branches in the study area.

The tested tomato varieties required about 95.0-111.5 days to give the first harvest where the variety Fetan required the shortest days. The marketable fruit yield of the tested varieties varied from 22.29-58.75

t ha^{-1}. However the highest yield was recorded from the variety Melkashola followed by Metadel, Cochoro and Ovalred varieties. The lowest marketable yield (22.29 t ha^{-1}) was obtained from variety D2.

The pH values of fruit juices of the tested varieties were in the range of 3.77-4.16 which is very acidic. The TSS and TA contents of the fruits of the tested varieties were in the range of 3.93-5.37% and 0.77-1.04 which is generally high for tomato. Most of the tested varieties have high juice content which ranges from 75.05% to 93.5%.

From the evaluated treats quality parameter also showed significant difference in the analysis of variance. From physical quality parameter fruit length ranged 4.05-8.05cm and variety Mersa was highest. Fruit width varied from 3.42-5.73cm and fruit weight comprise from 41.75-120g in these parameters variety D2 was high. In chemical quality parameter pH value was ranged from 3.77-4.16.Total soluble solid varied from 3.93-5.37 % on average. Titrable acidity showed inverse relation with PH between varieties which means the variety which had low pH value showed high titrable acidity. Concerning on fruit juice content percentage comprise from 75.05-93.5 %. Mersa and Sirinka was well performed variety in the point of quality. Generally yield and quality was highly influenced by genetic makeup of the varieties of tomato. Tomato grower in the study area should be encouraged to use the best performed variety in yield and quality to increase their productivity and quality.

Recommendations

Based on the findings obtained in this study, most of the tested tomato varieties are suitable for Koga Irrigation Scheme of Mecha District to improve the incomes of smallholder farmers in the study area. Nevertheless, in terms of marketable yield Melkashola, Metadel, Cochoro, Ovalred and Miya tomato varieties can be recommended for the study area. Moreover, Mersa and Sirinka-1 varieties are more suitable for agro-processing industries in the area as their fruits have the best fruit quality parameters required for processing industry. To develop forceful recommendation however it is advised to repeat the experiment on different sites and years.

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