

Evaluation of Tomato (*Solanum lycopersicum* L.mill) Varieties for Yield and Fruit Quality in Ethiopia. A Review

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Abstract

Tomato is one the most important vegetable crop in Ethiopia. Different variety evaluation experiments were conducted in regions and across regions of Ethiopia by research, higher learning institutions and non-governmental institutions. Among tomato varieties evaluated under open field and greenhouse condition at JUCAVM, variety Marglobe and Moneymaker showed the highest total fruit yield per plant in greenhouse. From ten improved tomato varieties with one local check evaluated at Agaro and Jimma for their yield, Varieties ARP tomato D2, showed superior and scored a marketable fruit yield of 22.18 ton ha⁻¹ at Jimma and variety Fetan showed highest yield 10.67 ton ha⁻¹ at Agaro. In Borena YPDARC, there were variations among the varieties evaluated in fruit yield ton ha⁻¹. In Erer valley of Babile, Melkashola scored 30.86 ton ha⁻¹ and Bishola 28.69 ton ha⁻¹. Under irrigation deficit experiment both shoot and fruit weight loss was decreased with increase in stress level while the fruit dry matter weight increased. The total yield and marketable yields were decreasing as the deficit level was increased. Fruit soluble solid content increased with increase in water stress. Among the Hybrid varieties evaluated at Melkassa, Debreziet, Koka, Wonji and Ziway districts in Central Rift Valley of Ethiopia during off-season under irrigation, variety Venis was the highest yielding with preferable quality tomato. In the response to tested locations, Koka site show the highest total yield of 93.45 ton ha⁻¹ which is all most all double of Melkassa area. From the nine Evaluated tomato varieties at Humera agricultural research center (HARC), the highest marketable yield was obtained by Melkasalsa (56.07ton ha⁻¹) and the least yield was recorded by Bishola (17.89 tonha⁻¹).

Keywords: fruit quality, fruit yield, improved variety and hybrid variety.

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most widely grown vegetable crops in the world. It is the 3rd largest vegetable crop after potato and sweet potato and as a processing crop it ranks first among all vegetables (Agrisnet, 2010). It was originally come from tropical area from Mexico, then to Peru (Maerere *et al.*, 2006; FAO, 2005). It had been used as a food in its origin country of Mexico. It spread throughout the world following the Spanish colonization of the Americas (Wikipedia, 2016). Currently, it is one of the most important edible and nutritious vegetable crops in the world. It is widely cultivated in tropical, subtropical and temperate climates. It ranks third in terms of world vegetable production (FAO, 2006).The leading tomato producing countries are China which is the biggest tomato producer in the world with annual production 34.1 million tons (FAOSTAT,2010), the United State of America, India, Egypt, Turkey, Iran, Mexico, Brazil and Indonesia (FAO, 2006).

In Ethiopia, there is no exact information as to when tomato was first introduced; however, the crop is cultivated in different major growing areas of the country. In 2015 cropping calendar, tomato production in Ethiopia was about 22,788 tons from harvested area of 3,677 hectare. Ethiopia is the world's 84th largest producer of tomato (CSA, 2012; CSA, 2015). In Ethiopia, tomato ranks fourth in total production (5.45%) after Ethiopian cabbage, red pepper and green pepper; third in area coverage (4.49%) next to red pepper and Ethiopian cabbage from vegetable crops cultivated. Its national mean yield is 6.2 ton ha⁻¹ (CSA, 2015, Regassa *et al.*, 2016). This is by far below the world average 34.84 ton ha⁻¹ which is due to poor management practice in Ethiopia (Lemma, 2002).

It is used as canned vegetable having multiple uses and supplies essential nutrients in human diets (Choudhury, 1979). It is popularly used for both commercial and home use purposes. The fresh produce is sliced and used as salad. The processed products are like tomato paste, tomato juice, and tomato catch-up. It is used in preparing soups, sauces, stews, salads , other dishes and used in large quantities as compared to other vegetables. Its fruit is fairly nutritious and contains high amount of vitamins A, B, C. Also the whole peel-tomato are produced in the country for local market and export. It was recognized as quality product for both local and export markets ; providing a route out of poverty for small scale producers who live in developing countries in general and in Ethiopia in particular (Tewodros and Asfaw, 2013).

In Ethiopia, several tomato varieties had been released nationally and recommended by the Melkassa Agricultural Research Center for commercial production and small scale farming systems in Ethiopia. The average yield of tomato in Ethiopia is low as compared with world average yields (FAOSTAT, 2012). This may be related to limited access and use of improved commercial tomato varieties, adaptation and poor production management. As a result of these, different experiments were conducted in regions and across regions by research and higher

learning institutions. The main objective this paper is to review different research experiment conducted on tomato variety evaluation for yield and fruit quality in different regions of Ethiopia.

Tomato Production Ecology and Importance in Ethiopia

The climatic and soil conditions of Ethiopia allows the cultivation of a wide range of fruit and vegetable crops including tomato, which is largely grown in the eastern and central parts of the mid-to low-land areas of the country. The crop has been grown between 700 and 2200 meter above sea level having 700 to over 1400 mm annual rain fall in different seasons, under different weather conditions, at different levels of technology and yield (Birhanu and Ketema, 2010).

Large scale production of tomato takes place in the upper Awash valley under irrigated and rain-fed conditions where as small scale production for fresh market is a common practice around Koka, Ziway, Wondo-Genet, Guder, Bako and many other areas (Lemma, 2002). In 2008, tomato production in Ethiopia reached about 41, 815 tons from a total harvested area of 3542 ha (FAO, 2009). In Ethiopia, several tomato varieties were released nationally and recommended by the Melkassa Agricultural Research Center for both commercial production and small scale farming systems in Ethiopia. Varieties such as Melkashola and Marglobe are widely produced while Melkasalsa and Heinz 1350 have limited distribution and production (Lemma, 2002).

In Eastern part of Ethiopia, especially Harerghe farmers produce locally known tomato variety in their gardens which is very small in size and low in fruit yield. Tomato production is rare due to shortage of rainfall and irrigation water unavailability. However, some farmers those settled around the rift valley of Babile produce local tomato on small units of land for consumption and rarely for income generation (CSA, 2016). The crop has high economic importance in the West Shewa of Ethiopia. Recently, a total of 7,255.93 hectares of land was under tomato in the country and yielding about 81,738.05 tons of tomato production in Ethiopia (CSA, 2012). It is consumed in every household in different styles, but in certain areas, such as Walo, Hararge, Shawa, Jimma and Wallaga, it is also an important co-staple food (Ambecha *et al.*, 2012). In Tigray Regional state, the western lowland of Tigray is one of the potential areas suitable for cultivation of tomato. The total cultivated area under tomato production in Kafta of Humera woreda since 2013/2014 cropping season was 1,655 ha (Regassa *et al.*, 2012). It can be eaten either fresh or processed in to different products. It is used for healing wounds because of antibiotic properties found in ripe fruits. It is a good source of Vitamins A, B and C (Baloch, 1994).

In Ethiopia, the demand of commercial hybrid vegetables seed has been rapidly increased. After adaptation and verification, more than 90 hybrid vegetable have been approved and registered for production in Ethiopia. Tomato takes the highest share of commercial vegetables. About 20 commercial hybrid tomato varieties were verified and under production in Ethiopia (MARDPR, 2016). Small holders have grown tomato for long time for their livelihood needs since the start of its commercialization (FAOSTAT, 2012).

Tomato (*Solanum lycopersicum L. mill*) Yield and Fruit Quality Attributes as affected by Varieties and growth conditions in Jimma area

Since 2011/2012 four improved tomato varieties: Eshete, Marglobe, Moneymaker and Bishola were tested under irrigation in greenhouse and open field condition at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM). Result revealed that, Variety Moneymaker and Marglobe produced 7.28 and 6.84 fruits numbers per cluster respectively. This indicated that the differences among the varieties which were observed due to the highest number of flowers per cluster developed to fruits. Number of fruits per plant was higher in greenhouse than in open field. Among varieties, Moneymaker gave the highest number of fruits per plant (46.4) than any other tomato varieties. Fruit weight is one of the important traits that were directly linked with yield (Jindal *et al.*, 2015). In greenhouse growing condition, variety Bishola produced fruits with average weight of 139.2 g per plant and followed by Eshete (130.0 g) and Marglobe (123.6 g) which may probably due to larger number of fruits per cluster (Yeshiwas *et al.*, 2016). In line with this, Mohanty and Prusti (2006) reported that, genotype 'ET 35' scored large sized fruits (92.67g). Also Shah *et al.* (2011) reported an average fruit weight of 67.60 g.

Harvested period of fruit varied among tomato varieties grown under greenhouse (Table 1). Variety Marglobe and Bishola had a total of 12 to 13 pickings in green house and a maximum of 5 to 6 rounds in open sun growing condtion (Yeshiwas *et al.*, 2016).

Table 1. Number of fruits per cluster, number of fruit per plant, average fruit weight and number of harvest period of tomato varieties grown under greenhouse climate and open field

Varieties	Number of fruits		Number of fruit		Average fruit		Number of	
	per cluster	per plant	per cluster	per plant	weight (g)	per plant	fruit harvests	per plant
	Green house	Open field	Green house	Open field	Green house	Open field	Green house	Open field
Bishola	4.75b	5.37	26.11c	21.83b	139.20a	133.24	6.66c	4.00
Eshete	5.73ab	4.37	26.32c	14.41c	130.02a	103.56	10.66b	3.66
Marglobe	6.84a	5.45	35.47b	17.52bc	123.60a	140.01	12.66a	5.00
Moneymaker	7.28a	4.76	46.36a	31.91a	94.72b	99.23	12.33a	5.33
LSD (5%)	1.91	NS	5.41	5.12	34.25	NS	1.29	NS
CV (%)	15.52	12.20	8.06	11.67	14.36	17.20	6.09	15.27

Means followed by the same letter within the same column are not significantly different at 5% level of significance.

Source: (Yeshiwas *et al.*, 2016).

Total fruit yield per plant in the greenhouse ranged from 1898 to 2144 g per plant, while the in open sun, it was ranged from 1115 to 1505 g per plant. Among varieties tested, variety Marglobe and Moneymaker grown in greenhouse had the highest total fruit yield per plant. In open field the highest yield was obtained from Bishola and Moneymaker. Similarly, total fruit yield per hectare ranged from 86 to 102 and 53 to 71 ton ha⁻¹, respectively for greenhouse and open field growing conditions (Yeshiwas *et al.*, 2016). A yield by far less than this report was reported by indicating the potential yields of tomato ranged from 4.2 to 18.6 tons per hectare for the tomato varieties evaluated. Of these, the variety ‘Soraya’ presenting the highest mean yields of marketable fruit (Richardson, 2013).

A total soluble solid (TSS) is very important quality character and degree of sweetness is determined by TSS. Total soluble solids were varied among varieties grown in greenhouse. Variety Eshete in green house scored the highest TSS (5.5 °brix) while Moneymaker had the lowest in both growing conditions. As a result of this fact, tomato TSS is variety dependent. An agreement to this result, Jindal *et al.* (2015) stated that, the mean performance of three years of tomato TSS was recorded in the variety HS-18 (4.72 ° Brix) which was maximum TSS and followed by Dev and TAI-687 (3.99°Brix). Similar results were also reported by Zhu-wei Min *et al.* (2003) that indicate tomato cultivar ‘Puhong 909’ had maximum TSS content (4.5%) under the multispan greenhouse. Singh(2011) also reported that, the maximum TSS was present in ‘Naveen’ (5.60) under naturally ventilated polyhouse. The value of total soluble solids content varied from 4.79% to 6.02% in different variety (Hossain *et al.*, 2010). In line with this report, Dar *et al.* (2012); Gupta *et al.* (2011) were reported that, quality attributes like total soluble solids of the fruit ranged from 3.67 to 6.0 ° Brix in different tomato varieties.

Titrateable acidity and pH are the most commonly used acidity indicators of tomato and influenced by both growing conditions and differences in tomato varieties (Table 2). The highest TA and pH were observed in greenhouse than in open field. Among the varieties, Marglobe had the highest value for both variables (Yeshiwas *et al.*, 2016). Tomato dry matter production was also founded to be affected by both varieties and growing conditions (Table 2). In greenhouse, variety Marglobe accumulated the highest dry matter. In open sun, maximum dry matter was accumulated in the variety Moneymaker (Yeshiwas *et al.*, 2016). An agreement to this, Davis and Hobson (1981) also found the variation in dry matter content among the different variety of tomato. Dry matter content of tomato grown in greenhouse ranged from 13 to 22% while 12 to 18% in open field condition (Yeshiwas *et al.*, 2016). In line with this report, Hossain *et al.* (2010) reported that, the range of dry matter 10.60% to 17.54% for different varieties of tomato.

Table 2 . Total soluble solid (°Brix), Titrateable acidity, pH and dry matter content of tomato varieties grown under greenhouse and open field climate condition.

Varieties	Total soluble solids (°Brix)		Titrateable acidity (% citric acid)		pH		Dry matter content	
	Green house	Open field	Green house	Open field	Green house	Open field	Green house	Open field
Bishola	4.16c	5.33	0.24a	0.21ab	4.31b	4.38a	12.59c	17.37a
Eshete	5.50a	5.33	0.15b	0.25a	4.07b	3.87b	15.94bc	12.00b
Marglobe	4.83b	5.00	0.28a	0.17bc	4.57a	4.29a	21.47a	17.56a
Moneymaker	4.16c	4.50	0.12b	0.13c	4.30b	4.34a	17.23b	17.66a
LSD (5%)	0.471	NS	0.046	0.053	0.243	0.268	4.035	3.272c
CV (%)	5.05	7.20	11.42	13.87	2.59	3.18	12.01	10.14b

Means followed by the same letter within the same column are not significantly different at 5% level of significance

Source: (Yeshiwas *et al.*, 2016).

Evaluation and adaptation of tomato varieties in Jimma, South West Ethiopia.

Since 2014/15 ten improved tomato varieties with one local check were evaluated at Agaro and Jimma for their yield and yield component by Jimma Agricultural research center. Varieties ARP tomato D2, Cochoro and Fetan gave the highest fruit cluster 8, 7 and 7 per plant respectively. Similarly, variety ARP tomato D2 showed superior in the rest parameters and scored a marketable fruit yield of 22.18 ton ha⁻¹ followed by Cochoro which scored highest marketable fruit yield of 16.89 ton ha⁻¹ (JARC, 2014/15). This indicate that, variety vary from each other. An agreement to this, the variety Martha Washington scored greater marketable yield (44,092 lbs /acre) (Shubin *et al.*, 2013). Also, Pruden's Purple variety had higher marketable yield (28,024 lbs/acre) than all other heirloom varieties with the exception of Cherokee Purple (Shubin *et al.*, 2013). At Agaro; Melka Salsa showed highest in marketable fruit cluster per plant and marketable fruit number per plant (JARC, 2014/15). In similar manner, variety Martha Washington scored greater marketable fruit number (110,183 fruit/acre) over season tested compared to any of the heirloom varieties (Shubin *et al.*, 2013)

In yield, Fetan variety showed highest difference from the rest treatment followed by Chali and Melka Salsa 10.67 ton ha⁻¹, 9.64 ton ha⁻¹ and 9.48 ton ha⁻¹ respectively. The varieties were well adapted at Jimma than at Agaro with good performance in yield and yield related variables (JARC, 2014/15). Contrary to this, as varietal difference was obvious, the variety UC82B produce more total fruit yield ha⁻¹ than Roma VF with 10.6% higher on the average (Isah *et al.*, 2014). In same way, Olaniyi *et al.* (2010) reported that, the highest fruit yield values were recorded from UC82B and closely followed by Ibadan and Ogbomoso Local with better growth, marketable and good quality fruit yield performance under hazardous climatic condition Oyo sate of Nigeria.

Since 2015/16 the same varieties were re-evaluated at Jimma for their Yield and yield component. The result showed that, all the parameters were different from each other in varieties. Accordingly, the variety Melka Salsa was the highest in fruit number per plant (54) and flowed by local and Cochoro varieties (JARC, 2015). In line with this result, variety Martha Washington scored higher fruit number (110,183 fruit/ acre) over season tested compared to any of the heirloom tomato varieties (Shubin *et al.*, 2013).

In fruit cluster per plant, the local one showed the highest and followed by Melkasalsa. In yield ton per hectare Melka salsa and local showed highest which is 35.66 and 35.76 ton per hectare respectively and followed by Cochoro with 25.13 ton per hectare. In general the highest yield was obtained from Melka salsa and the lowest yield was obtained from Bishola verities which had direct relationship with fruit number and cluster per plant (JARC, 2015). Close to but below this value of tomato yield, Adelana (1978) reported that, about 20 tons per hectare of tomato yield in temperate region.

Tomato variety evaluation under irrigation of tap water in Borena area, Southern Ethiopia.

Four improved varieties of tomato: Fetan, Melkashola, Miya and Cochoro from Melkassa Agricultural Research Center and one variety called CAL-J introduced from Kenya, were evaluated for their adaptation at Yabello pastoral development agricultural research center (YPDARC). The result showed that, there was a variation among the varieties for all most all parameters (Regassa *et al.*, 2016). Variety Miya gave higher marketable fruit yield and higher average of single marketable fruit weight than other varieties (Regassa *et al.*, 2016). In line this result, weights per plant ranged from 0.6 kg per plant for 'Yellow Jubilee' to 2.1 kg per plant for 'Soraya' (Richardson, 2013). The variety "Soraya" also had the highest marketable fruit weights per plant and the largest number of marketable fruit per plant (Richardson, 2013). The least mean marketable fruit yield was obtained from the variety Fetan (Regassa *et al.*, 2016). The mean marketable fruit yield obtained (11.61 to 22.95 ton ha⁻¹) was an agreement to the result reported by Lemma (2002) with a mean marketable fruit yield between 7.21 to 48.80 ton ha⁻¹. Marketable fruit yield was significantly and positively correlated with fruit number per plant and single fruit weight which indicates that, varieties with higher fruit number per plant and higher single fruit weight gives high marketable fruit yield (Regassa *et al.*, 2016).

Performance Evaluation of Tomato Varieties for Yield and yield component under Supplemental Irrigation at Erer Valley, Babile District, Ethiopia.

Ten tomato varieties, five of which are determinate (Chali, Bishola, Melkashola, Melka Salsa, Fetane) while another four are indeterminate (Miya, Eshete, Metadel and R/VF) with one farmers' genotypes (Babile local) were evaluated in Erer valley of Babile Woredas in Harer city, Eastern part of Ethiopia under irrigation for two consecutive years during offseason (Benti *et al.*, 2017). Result indicated that, mean value of plant height ranges between 39.34 cm and 96.67 cm. The tallest plant was Eshete followed by Babile local, R/VF and Melkashola over the two years while the shortest were Chali, Miya, Melkasalsa and Fetane (Benti *et al.*, 2017). This result was agree with the findings of Meseret *et al.* (2012) who reported that, the plant height of tomato varieties range between 40.20 cm and 107.00 cm.

Total fruit yield per hectare and average fruit weight were different among the varieties (Table 3). Bishola and Metadel were the biggest fruit size and maximum fruit weight while the remaining varieties were smallest in fruit weight. The maximum fruit yield per hectare were obtained from Melkashola, Bishola while the minimum

were from Chali, Fetan and 'Babile local (Table 3) (Benti *et al.*, 2017). In line to these varieties scored minimum result, tomato variety DT97/215A gave the least values (Olaniyi *et al.*, 2010). The varietal differences in growth and yield might be attributed to the differences in ecological distribution of the tomato varieties. Besides the differences of varietal, due to the genetic makeup; the low marketable yield obtained for some tomato varieties might be due to non-development of flowers into fruits as about 50% of the flowers developed into fruits. In line to this, Adelana (1975) reported that, only 50% of the flowers developed into fruits. Ecological conditions can also affect the fruit yield of tomato. An agreement to this, poor fruit set in tomato may be as a result of high temperatures that are not conducive for good fruit set (Simon and Sobulo, 1974; Olaniyi, 2007)

Table 3. Mean performance of yield and some agronomic parameter of two years(2012-2014)

Treatments	Plant height (cm)	days to 50% flow	Clusters/plant	Fruits/Cluster	Fruit weight (g)	Fruit yield (kg/ha)
Miya	44.63cd	36.50c	14.87de	3.167ab	41.50b	24762abc
Chali	39.43d	39.17abc	14.27def	2.667b	42.67b	19494c
Bishola	56.23bcd	37.00c	15.43d	2.667b	87.83a	28690a
Eshete	96.67a	39.67abc	11.83ef	3.000ab	39.33b	26964ab
M/shola	60.87bc	42.00a	24.63a	3.333ab	47.67b	30863a
M/salsa	46.23cd	38.50bc	17.50cd	3.167ab	32.67b	24940abc
Fetan	46.40cd	39.67abc	11.07f	1.883c	46.83b	19137c
R/ VF	64.00bc	37.67c	20.37bc	3.333ab	40.50b	20402bc
Metadel	53.03bcd	36.17c	15.63d	3.667a	80.50a	25268abc
Local	71.07b	40.67ab	23.33ab	3.500ab	34.00b	18557c
LSD	24.6	4.359	4.304	0.9454	19.04	8478.1
CV%	25.7	6.8	15.4	20.1	23.3	21.5

Source: (Benti *et al.*, 2017)

Evaluation of drip irrigated Tomato genotypes for Fruit yield and quality under deficit Irrigation at Melkassa, Central rift valley of Ethiopia

Four level of irrigation deficit (0%, 25%, 50% and 75%) assigned as main plot and two tomato varieties were Melkashola (semi determinate) and Melkassa Marglob (indeterminate) to subplot and evaluated in split pilot design. Result indicated that, total plant fresh biomass (shoot and fruit weight) at maturity of both tomato cultivars was significantly affected by irrigation water applied. Both shoot and fruit weight loss was decreased with increase in stress level. While shoot dry weight consistently decreased with increase in stress level, the fruit dry matter weight increased. The fruit dry matter increased by 29.1%, 37.9%, and 39.3% for Melkashola cultivar and 17.2%, 19.3%, and 23.9% for Melkassa Marglobe, at 25%, 50%, 75% deficit levels relative to the non-stressed treatment (0% deficit level). There was a significant difference between the cultivars regarding shoot and fruit dry weights. However, there was a non-significant difference for the interaction effect of cultivar and irrigation (Birhanu and Tilahun, 2010).

The harvest indices HI (which is fruit dry matter weight per plant dry weight) were significantly affected by irrigation deficit levels. The harvest index was higher for more stressed tomatoes of both cultivars, an indication of high dry matter accumulation as the crop was stressed.

In the interaction effect, the number of fruits per plant was affected both by water deficit level and cultivars. Fruit size as well as number of fruits per plant was reduced with reduction in the amount of irrigation water applied for both cultivars. The difference between the cultivars was significant in Melkashola cultivar consistently having more number of fruits per plant and lower fruit size compared with that of Melkassa Marglobe. The numbers of smallest fruits size of both tomato cultivars were lower at higher water stress levels. Melkashola cultivar produced significantly lower smallest fruit size than that of Melkassa Marglobe (Birhanu and Tilahun, 2010).

Irrigation positively influenced tomato productivity. That was due both increased in number of berries per plant and the fruit average weight as irrigation increased. The total yield and marketable yields were significantly decreasing as the deficit level was increased. The yield amounted to 45.1 ton ha⁻¹ on average for 0% deficit irrigation treatments and 18.4 ton ha⁻¹ for 75% deficit irrigation treatment for Melkashola cultivar. These values were 45.2 ton ha⁻¹ and 13.1 ton ha⁻¹ for Melkassa Marglobe cultivar. The marketable yield was 41.5 ton ha⁻¹ and 15.1 ton ha⁻¹ at 0% and 75% deficit levels, respectively for Melkashola cultivar. These values were, respectively 41.3 ton ha⁻¹ and 11.2 ton ha⁻¹ for Melkassa Marglobe cultivar. The total and marketable yield of tomato was lowest in the most stressed treatment of 75% deficit level (Birhanu and Tilahun, 2010). For both tomato cultivars, the fresh fruit yields were reduced in 25%, 50%, and 75% deficit level treatments by 6.8%, 48.5%, and 71.0%, respectively. Deficit irrigation treatments had pronounced effect on the total soluble solute (TSS) content of the fruits. Fruit soluble solid content increased with increase in water stress. The TSS content of the most stressed treatment (75% deficit level) increased by 2.3% for Melkashola and 4.2% for Melkassa Marglobe relative to the respective fully irrigated treatments (0% deficit level)(Birhanu and Tilahun, 2010)

Performance Evaluation of Introduced Hybrid Tomato (*Solanum lycopersicum* Mill.) Cultivars in the Rift Valley of Ethiopia

The study was conducted at Melkassa, Debreziet, Koka, Wonji and Ziway districts of Central Rift Valley of Ethiopia during off-season by irrigation since 2015 using 12 known hybrid variety which were believed to be adapted to Ethiopian agro-ecology. Their adaptability and yield performance of 7 newly and 5 previously introduced hybrid tomato varieties was carried out on four locations of major tomato growing areas of Central rift valley of Ethiopia on farmers and researcher fields (Binalfew *et al.*, 2016). The result indicated that, varieties Venise was the highest yielding with preferable quality of tomato in Ethiopia. Awassa, Monica and Tesha varieties are also good yielder tomatoes with extended shelf life and low unmarketable yield. Awassa and Awash River tomato varieties are characterized with large fruits size over the rest newly introduced tomatoes. Galilea has still equivalent fruits size with rational fruit number. The newly introduced cultivar Venise and Tesha were chosen for export due to their reasonable fruit size and low perishable. Tomato cultivars Awassa and Awash River had good acceptance for local fresh consumption (Table 4) (Binalfew *et al.*, 2016).

Table 4. Yield and yield components of hybrid introduced and evaluated tomato varieties.

No	Cultivar	No of fruits per cluster	Yield (ton/ha)	Fruit number per plant	unmarketable %	%TSS	Average fruit weight (gm)
1	Monica	3.1	59.5	24.02	25.51	4	102.7
2	Barnum	7.3	63.7	31.68	25.08	4	62.2
3	Eden	6.6	73.3	23.05	39.17	3.9	111.3
4	Galilea	6.1	57.9	20.11	39.97	3.7	126.6
5	Tesha	3.6	70.3**	36.17	31.02	3.1	83.2
6	Bridget 40	3.7	63.5	30.2	33.87	3	95.7
7	Venise	3.9	87.1**	40.49	22.81	3	99.5
8	Awash River	5.6	60.1	23.03	39.07	3.1	126.3
9	Awassa	6.1	69.8**	25.07	12.56	3.1	126.9
10	Chibli	3.8	43.4	19.27	23.25	3.9	105.9
11	Momtanz	3.8	54.8	18.16	30.23	3.8	108.5
12	Topspin	3.6	46.8	30.06	22.52	4	73.8
LSD		2.9	38.5	18	20.78	1.4	61.34
CV		12	22.7	15.2	16	13	17

Source: (Binalfew *et al.*, 2016)

In the response of tomato varieties to tested locations, Koka site showed the highest of total yield (93.45 ton ha⁻¹), all most all double of Melkassa area. Tomato varieties showed good yield response at Debreziet site next to Koka, 81.76 ton per ha. Concerning number and size of fruits, considerably high number of fruits per plant was observed at Koka, while the larger fruits size recorded at Ziway area. From this, we can clearly understand that the hybrid tomato varieties are more suitable to Debreziet and Koka area which is relatively low temperature and high altitude areas. The low response of tomato at Melkassa might be due to high temperature of the area and low fertility of the soil (Binalfew *et al.*, 2016).

Evaluation of tomato varieties for fruit yield and yield components in western lowland of Tigray, Northern Ethiopia

An experiment was conducted under irrigated condition in 2012 cropping season in Humera agricultural research center (HARC) with Nine nationally released tomato varieties, five of which (Bishola, Chali, Cochoro, Marglobe, Fetan and Melkasalsa) have determinate growth habit while (Metadel, Miya and Melkashola) have semi determinate growth habit with Melkashola as check. Result showed that, there is highly difference for most of the characters among the varieties. Among the variety studied, Miya and Marglobe took the shortest period (96 days) to mature while Bishola was the late (120 days) among the varieties. This finding was an agreement with the finding of Emami *et al.* (2013) on 25 tomato genotypes studied in Iran. Dufera (2013) also reported wide range of difference in maturity for 21 tomato genotypes studied in Mizan Tepi (Chernet and Zibelo, 2014). Number of fruit clusters per plant, total number of fruits per plant, fruit yield per plant, single fruit weight, shape index and fruit yield per hectare showed difference among the varieties. The highest marketable yield was obtained by Melkasalsa and the least yield was recorded by Bishola. The association of characters indicated that, fruit yield per plant, number of fruits per plant, number of fruit clusters per plant and shape index are the most important fruit yield components which contributes more to highest fruit yield per hectare. Therefore, to improve fruit yield, selection based on these characters is important (Chernet and Zibelo, 2014).

Summary and conclusions

The climatic and soil conditions of Ethiopia allow cultivation of a wide range of fruit and vegetable crops including

tomato. In Ethiopia, several tomato varieties had been released nationally for commercial production and small scale farming systems. The average yield of tomato in Ethiopia is low (8 ton ha⁻¹) compared with world average yields of 34 ton ha⁻¹ (FAOSTAT, 2012). This may be related to limited access and use of improved commercial tomato varieties, adaptation and poor production management. As a result of these, different experiments were conducted in regions and across regions by research and higher learning institutions. Under open field and greenhouse condition at JUCAVM, tomato varieties Marglobe and Moneymaker in greenhouse showed the highest total fruit yield per plant. Ten improved tomato varieties with one local check were evaluated at Agaro and Jimma for their yield by JARC. Varieties ARP tomato D2, showed superior and scored a marketable fruit yield of 22.18 ton ha⁻¹ at Jimma. At Agaro, variety Fetan showed highest significance difference in yield 10.67 ton ha⁻¹. At Borena YPDARC, there was variation among the varieties evaluated in fruit yield. In Erer valley of Babile, Melkashola scored 30.86 ton ha⁻¹ on and Bishola 28.69 ton ha⁻¹. Under irrigation deficit both shoot and fruit weight loss was decreased with increase in stress level while the fruit dry matter weight increased. The total yield and marketable yields were significantly decreasing as the deficit level was increased. Deficit irrigation treatments had pronounced effect on the total soluble solute (TSS) content of the fruits. Fruit soluble solid content increased with increase in water stress. Hybrid evaluation was done at Melkassa, Debreziet, Koka, Wonji and Ziway districts of Central Rift Valley of Ethiopia during off-season under irrigation and the result indicated that varieties Venis was the highest yielding with preferable quality tomato. In the response to tested locations, Koka site showed the highest of total yield (93.45 ton ha⁻¹), all most all double of Melkassa area. Nine nationally released tomato varieties were evaluated at Humera agricultural research center (HARC). The result showed that there is highly significant difference for most of the characters among the varieties. The highest marketable yield was obtained by Melkasalsa (56.07 ton ha⁻¹) and the least yield was recorded by Bishola (17.89 ton ha⁻¹).

Abbreviations used

JARC	Jimma Agricultural research center
FAO	Food and Agricultural Organization
CSA	Central Statics Authority
JUCAM	Jimma University College of Agriculture and veterinary Medicine
HARC	Humera Agricultural research center.
YPDARC	Yabello Pastoral Development and Agricultural research Center
MM	Melkassa Marglobe
MS	Melkashola
TSS	total soluble solute

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