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Adaptability evaluation of improved Tomato (*Lycopersicon esculentum* Mill.) varieties for yield and other quantitative traits in Arba Minch, Southern Ethiopia

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A B S T R A C T

Tomato is one of the important vegetables grown all over the world for its nutritious and economic value. Varietal improvement for high yielding, pest resistance and tolerance, drought tolerance and processing quality traits are vital thereby to enhance production and productivity of the crop. Due to lack of improved varieties in the study area, local productivity of tomato is challenged and its production is very limited. Hence, identification of improved tomato varieties that are adaptable, high yielding and disease resistant is crucial before dissemination to boost its productivity in the study area. Therefore, this experiment was conducted at Arba Minch to evaluate ten improved tomato varieties for yield and yield components under irrigation condition using randomized complete block design replicated three times. ANOVA result indicated that there is a significant variation among tested varieties in all studied parameters. The mean total yield and number of fruits plant^{-1} of tomato varieties varied from 4991.1 to 11,215 kg ha^{-1} and 13.33 to 36.53 fruits plant^{-1}, respectively. 'Melkashola' scored the highest marketable yield (9,438 kg ha^{-1}) and total yield (11,216 kg ha^{-1}) being followed by 'Bishola' (8,756 kg ha^{-1}) and 'Melkasalsa' (8,367 kg ha^{-1}). On the other hand, 'Melkasalsa' and 'Miya' with moderately high yield might also be regarded as other potential varieties. Therefore, the first three varieties are recommended for cultivation in the study area and similar agro-ecology.

Keywords: Evaluation, Fruit yield, Irrigation, Melkashola, Varieties

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanacaea and it is the most important vegetable crop consumed as both fresh and processed. In terms of production, tomato ranked second after potato, whereas as a processing crop, it ranks first among all vegetables (AGRISNET, 2010). Due to its multiple uses and being nutritious (AVRDC, 2004), tomato is the most popular and widely cultivated crop. It is grown all over the world while China is the leading tomato producer in the world with an annual production of 58.968 million tons (FAOSTAT, 2017).

Ethiopia has diverse agro-ecologies that allow the country to produce different crops including tomatoes in different cropping seasons. The shortage of varieties and recommended information packages, poor irrigation systems, lack of information on soil fertility, diseases and insect pests, high postharvest loss, lack of awareness of existing improved technology, and poor marketing system are the major challenges in Ethiopian tomato production (Lemma, 2002). However, tomato is mostly grown under irrigation conditions in the country due to high disease pressure in the rainy season. Oromiya and Southern Nations, Nationalities and Peoples' (SNNP) are the two major tomato-producing regions of Ethiopia. According to Central Statistical Agency (CSA) (2017) of Ethiopia, about 6298.63 ha of land were covered by tomato with the total production of 28364.83 tons during the 2016-2017 cropping season. Gamo and Gofa zones are among the potential areas for tomato production in the SNNP regional state. In Gamo

zone, small-scale farmers of the Arba Minch Zuria and Mirab Abaya districts widely cultivate tomato using irrigation mainly for income generation due to multiple harvesting opportunities that the crop has. However, the productivity of tomato was not more than 6 ton ha^{-1} both at national and regional levels in the last five years due to many factors. The use of low yielding tomato varieties and diseases and insect pest occurrence are among the major factors that affect the productivity of the crop in Arba Minch area. These can be solved by either adopting or generating improved crop technologies for specific localities. Therefore, this study was conducted to evaluate the adaptability of released tomato varieties under irrigation conditions in Arba Minch area, Southern Ethiopia.

Materials and Methods

Description of the study area

The experiment was conducted at Chano Mille research site of the Arba Minch Agricultural Research Center under irrigation conditions during the 2017 cropping season. Geographically, the study site is located between a latitude of 5°7' - 6°21' and a longitude of 37°31'-37°67' at 485 km south of Addis Ababa, the capital city of Ethiopia. The altitude of the site is 1216 meters above sea level. The area received an average rainfall of 752.9 mm with maximum and minimum temperatures of 31.7 and 17.5°C, respectively, in the cropping season (Arba Minch Meteorology Station, 2018).

Experimental Materials

The experiment consisted of ten released tomato varieties, namely: Chali, Bishola, Melkashola, Melkasalsa, Cochore, Miya, Eshete, Metadel, ARP- d2 and Fetan as treatments. The tomato varieties used in the experiment were different in their growth habits have distinct characters and as a result released by Melkassa Agricultural Research Center (MARC) for production both for fresh and processing purposes (MoA, 2013). Seeds of the varieties used were obtained from MARC. Some descriptions of the varieties are given below (Table 1).

Design and trial management

The experimental plots were laid out in Randomized Complete Block Design (RCBD) with three replications. Seedlings were raised in well-prepared seedbeds, which were thoroughly prepared, 1 m x 5 m in size, raised 15 cm from the soil surface for each variety. Seeds were sown in rows spaced 10cm apart and covered lightly with fine soil before irrigation. The beds were irrigated twice a day until germination and then once a day. Uniform, healthy and vigor tomato seedlings were carefully transplanted to the prepared plots with 5 m x 3 m dimensions to accommodate 50 plants $plot^{-1}$ at a recommended spacing of 100 cm x 30 cm between row and plant, respectively. Recommended agronomic practices such as weeding, cultivation, irrigation, fertilizer application (100 and 200 kg ha^{-1} Urea and NPS, respectively) and staking were carried out uniformly during the growing season for all plots. Fruits were harvested at the mature green stage.

Table 1. Description of the tomato varieties used for the experiment.

S/No	Variety name	Year of release	Environmental requirements		Growth habit	Maturity (days)	Research Yield (Q ha^{-1})	Utilization
			Altitude (m)	Rain fall (mm)				
1	Cochore	2007	800-2000	1400	Determinate	100-120	350	Processing
2	Miya	2007	500-2000	1200	Indeterminate	82	471	Fresh
3	Fetan	2005	700-2000	1200	Determinate	78-80	454	Fresh
4	ARP d2	2012	700-2000	1400	Determinate	100-120	394	Fresh
5	Bishola	2005	700-2000	1200	Determinate	85-90	340	Fresh
6	Melkashola	1998	700-2000	1400	Determinate	100-120	430	Processing
7	Chali	2007	700-2000	1400	Determinate	110-120	300	Processing
8	Melkasalsa	1998	700-2000	1400	Determinate	100-110	320	Processing
9	Metadel	2005	700-2000	1400	Indeterminate	78-80	345	Fresh
10	Eshete	2005	700-2000	1400	Determinate	75-80	---	---

Source: Adapted from Tujuba and Ayana (2020); Balcha et al. (2015)

Data collection and analysis

Data were collected for plant height, number of fruits $plant^{-1}$, number of fruit clusters $plant^{-1}$, average fruit diameter, and average fruit weight on the basis of five sample plants randomly taken from the central rows while fruit yield related data (marketable, unmarketable and total fruit yield) were recorded on a plot basis. These data were analyzed by using analysis of variance via Statistical Analysis System (SAS) software version 9.2. Least significant difference (LSD) at 5% level of significance was used for mean separation for the treatment that had a significant effect.

Results and Discussion

Analysis of Variance (ANOVA)

Mean squares of the tested characters are presented in Table 2. ANOVA revealed that highly significant differences among the tested varieties (P≤0.001) were observed for four characters (number of fruits plant^{-1}, number of clusters plant^{-1}, average fruit diameter and average fruit weight) whereas highly significant differences at (p≤0.01) were observed for characters namely; plant height, marketable yield and total yield. The rest showed insignificant differences among the varieties under study.

Table 2. Analysis of variance (Mean squares) for the characters of 10 tomato varieties evaluated at Chano Mille, Arba Minch (2017).

Source of Variation	Range of Means		Mean Squares			CV (%)	GM	LSD(0.05)
	Min.	Max.	Replication (d.f=2)	Treatment (d.f=9)	Error (d.f=18)			
Days to 50% flowering (days)	57.70	66.30	1.90ns	24.87ns	14.64	6.10	62.60	6.56
Days to 50% fruit set (days)	71.70	76.00	4.43ns	5.26ns	2.36	2.08	73.67	2.63
Days to 90% maturity (days)	93.70	99.00	0.10ns	11.64 ns	7.98	2.94	96.20	4.84
Plant height (cm)	56.30	82.40	47.03ns	153.01*	52.46	10.81	67.03	12.42
Branch number	4.30	6.20	0.60ns	0.99ns	0.55	14.44	5.14	1.27
Number of fruits plant^{-1}*	1.12	1.55	0.10***	0.07***	0.01	9.33	1.31	0.21
Number of clusters plant^{-1}	4.13	8.60	9.27***	4.38***	0.96	16.61	5.90	1.68
Fruit diameter (cm)	11.53	20.80	0.12ns	28.41***	2.41	9.57	16.20	2.66
Average fruit weight (g)	45.80	142.80	43.37ns	3,023.36***	530.82	25.01	92.11	39.52
Marketable yield (Kg ha^{-1})	3284.44	9437.78	48,664,439.17***	10,940,625.56**	3,288,914.2	26.86	6750.67	3110.90
Unmarketable yield (Kg ha^{-1})*	34.54	48.25	175.98	55.65	53.59	17.27	42.38	12.56
Total fruit yield (Kg ha^{-1})	4991.11	11,215.56	66,570,708.00***	12,977,877.10*	4,797,186.90	25.45	8607.42	3757.10

*C.V= Coefficient of Variation, GM= Grand mean; *, ** and ***, are significant at P≤0.05, P≤0.01 and P≤0.001 respectively and ns=not significant at P>0.05.*

Plant height and branches

The mean values for plant height ranged between 56.3 cm ('Fetan') and 82.4 cm ('Eshete'). The highest plant was 'Eshete' followed by 'Melkashola' and 'Bishola' while the shortest were 'Fetan', 'Cochore' and 'Melkasalsa' (Table 3). Tallness, shortness, and other morphological differences are varietal characteristics, which are controlled and expressed by certain genes. 'Melkashola' performed to be mature earlier than others, followed by 'Melkasalsa' and 'Metadel' whereas ARP-d2 was the late maturing one. The maximum number of primary branches plant^{-1} was recorded in the varieties 'Bishola' (6.2), Melkashola' (5.67), and 'Fetan' (5.33) and the minimum number of primary branches plant^{-1} was recorded in varieties, 'Miya' (4.33) and 'ARP-d2' (4.44). These findings are in agreement with the work of Shibiru (2016) who reported 5.67 primary branches plant^{-1} under field conditions. The results are also in close conformity with the findings of Meseret *et al.* (2012) who reported that significant variations among the varieties of tomato for the number of branches plant^{-1}.

Number of fruit plant^{-1} and number of fruit clusters plant^{-1}

The mean values of fruit clusters plant^{-1} laid between 13.33 (1.12) and 36.53 (1.55) while the number of clusters plant^{-1} ranged from 4.4 to 8.27. The number of fruits plant^{-1} were significantly (P<0.001) different among the varieties (Table 3).The maximum number of fruits plant^{-1} was obtained with 'Melka shola' [36.53(1.53)] followed by 'Bishola [35.83(1.55)] and the minimum number was in varieties, 'Fetan' [15.06 (1.17)] and 'Metadel' [13.33(1.12)]. On the other hand, 'Melkasalsa', 'Miya' and 'Cochoro' also showed the moderate fruit number plant^{-1}. This result agrees with Meseret *et al.* (2012) who reported that 'Fetan' variety showed the lowest fruit number when compared with other treatments in their experiment. The result showed an increasing tendency in the number of branches plant^{-1} with an increase in the fruit number. These results are also in close conformity with the findings of Sharma and Rastogi (1993) who reported significant variations among cultivars of tomato for the number of branches and fruits plant^{-1}.

Number of clusters plant^{-1}, number of fruits cluster^{-1}, and fruits plant^{-1} are the most important yield attributes in tomato (Pandey *et al.*, 2006). Among the varieties tested, the maximum number of clusters plant^{-1} (8.27) was recorded in Bishola followed by Melkashola (7.27) and the least number of clusters plant^{-1} was observed in Fetan (4.40) followed by Eshete (4.80). This study was in agreement with the findings of Khah *et al.* (2006) and Abrar *et al.* (2011) who indicated that the average number of clusters plant^{-1} lay between 2.27 and 5.89.

Table 3. Mean performance of ten tomato varieties evaluated at Chano Mille, Arba Minch during the 2017 cropping season.

Varieties	Plant height (cm)	Branch Number	No of Fruit Clusters plant^{-1}	No of Fruits plant^{-1}
Melkashola	71.07ab	5.67ab	7.27ab	36.5a
Melkasalsa	60.60bc	5.20abc	5.60bcd	28.5bc
Cochore	60.40bc	4.93abc	6.47bc	22.1bcd
Metadel	67.47bc	4.67bc	5.13cd	13.3e
Chali	67.40bc	5.27abc	5.60bcd	19.5cd
Fetan	56.27c	5.33abc	4.40d	15.1de
Bishola	68.93ab	6.20a	8.27a	35.8b
Miya	67.80bc	4.33c	6.47bc	24.7abcd
Eshete	82.40a	5.40abc	4.80cd	16.5cd
ARP-d2	67.93bc	4.40bc	5.00cd	15.3de
LSD	12.42	1.30	1.68	2.1
CV (%)	10.81	14.44	16.61	9.33

Means within the same column with the same letter are not significantly different at P≤0.05.

Fruit diameter and single fruit weight

Equatorial diameters of the fruits and single fruit weight were significantly (P<0.001) different among the varieties (Table 4). The mean values lay between 11.53 cm and 20.80 cm and among the treated varieties, 'Eshete' (20.80) showed the highest fruit diameter. Except for 'Bishola', 'Melkashola' & 'Melkasalsa', all rest varieties had relatively maximum fruit diameter. Data in (Table 3) revealed that the variety 'Eshete' with 142.80 g single fruit weight plant^{-1} was significantly high yielder when compared to 'Metadel', 'Cochore' and 'Fetan', which gave a remarkably good fruit weight plant^{-1} of 126.73 g, 107.40 g and 116.67 g, respectively. The minimum single fruit weight plant^{-1} (45.80 g) was recorded for 'Melkasalsa' followed by 'Melkashola' (58.00 g) and Bishola (59.63 g). Jiregna (2013) also reported differences in fruit weight among varieties of tomato, which confirms our findings.

Marketable Yield, Unmarketable Yield and Total Yield

In this field study, the marketable and total fresh fruit yield results indicated significant variations among the varieties (at P<0.01 and P<0.05), respectively (Table 4). The highest marketable yield (9,438 kg ha^{-1}) was recorded in Melkashola followed by Bishola (8,756 kg ha^{-1}) and Melkasalsa (8,367 kg ha^{-1}), respectively. The rest varieties had higher yield ha^{-1} except for 'Fetan', which gave the lowest marketable yield (3,284 kg ha^{-1}). Similar finding was reported by Shibiru (2016) which confirms our result by recording the highest marketable yield for avariety 'Melkashola'.

Table 4. Mean performance of yield and yield contributing traits of ten tomato varieties tested at Chano Mille, Arba Minch (2017).

Varieties	Fruit diameter (cm)	Single fruit weight (g)	Marketable Yield (kg ha^{-1})	Unmarketable Yield (kg ha^{-1})	Total Yield (kg ha^{-1})
Melkashola	13.33d	58.00de	9438a	1777.8(41.57)ab	11,216a
Melkasalsa	12.07d	45.80e	8367ab	1800.9(42.34)ab	10,168a
Cochore	16.60c	107.40abc	6116bcd	1820.0(41.43)ab	7936abc
Metadel	19.73ab	126.73ab	6760abc	2402.2(48.15)a	9162ab
Chali	16.13c	84.47cde	6518abc	2162.2(46.23)ab	8680abc
Fetan	18.00bc	116.67abc	3284d	1706.7(41.12)ab	4991c
Bishola	11.53d	59.63de	8756ab	2397.8(48.26)a	11,153a
Miya	16.67c	85.73cd	7658ab	1475.6(37.94)ab	9133ab
Eshete	20.80a	142.80a	6171bcd	1806.7(42.24)ab	7978abc
ARP-d2	17.13bc	93.87bcd	4440cd	1217.8(34.54)b	5658bc
LSD	2.661	39.522	3110.900	12.558	3757.100
CV (%)	9.57	25.01	26.86	17.27	25.45

Within the same column with the same letter are not significantly different at P≤0.05 and figures in the parentheses are transformed values.

Conclusions and Recommendations

Evaluation of improved tomato technologies for adaptability, fruit yield, and yield related parameters is very important in Arba Minch, South Ethiopia. Arba Minch area has the potential for the production of tomatoes since offseason production through irrigation is easily applicable in the area, especially Mirab Abaya and Arba Minch Zuria districts. Therefore, an

experiment was designed with the objective to evaluate tomato varieties for yield and other quantitative parameters. This investigation allowed so infer that 'Melkashola' and 'Bishola' were the best-performing varieties under the irrigated season in Arba Minch and hence can be suggested for commercial cultivation. 'Melkasalsa' and 'Miya' with moderately higher yield might also be regarded as other potential varieties. Therefore, these three varieties could be recommended for popularization and adoption in the study area(s) with similar agro-ecology.

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