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 4,991.1 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 Solanaceae 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 28,664,83 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°37' - 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

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 |
|------|--------------|-----------------|-----------------------------|-------------|----------------|------------------------|-------------|
| 1    | Cochore      | 2007            | Altitude (m): 800-2000, Rainfall (mm): 1400 | Determinate | 100-120        | 350                    | Processing   |
| 2    | Miya         | 2007            |                             | Indeterminate | 82             | 471                    | Fresh       |
| 3    | Fetan        | 2005            |                             | Determinate | 78-80          | 454                    | Fresh       |
| 4    | ARP d2       | 2012            |                             | Determinate | 100-120        | 394                    | Fresh       |
| 5    | Bishola      | 2005            |                             | Determinate | 85-90          | 340                    | Fresh       |
| 6    | Melkashola   | 1998            |                             | Determinate | 100-120        | 430                    | Processing   |
| 7    | Chali        | 2007            |                             | Determinate | 110-120        | 300                    | Processing   |
| 8    | Melkasaalsa  | 1998            |                             | Determinate | 100-110        | 320                    | Processing   |
| 9    | Metadel      | 2005            |                             | Indeterminate | 78-80        | 345                    | Fresh       |
| 10   | Eshete       | 2005            |                             | 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) | 3,848.44 | 9437.78 | 486644391.7*** | 1094962556*** | 328891442 | 26.86 | 679067 | 3110.90 |
| Unmarketable yield (Kg ha⁻¹) | 34.54 | 48.25 | 175.98 | 55.65 | 53.59 | 17.27 | 42.98 | 12.56 |
| Total fruit yield (Kg ha⁻¹) | 4991.11 | 11215.56 | 66570708.00*** | 129778771.0* | 4797186.90 | 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 ('Eshe'). The highest plant was 'Eshe' followed by 'Melkasalsa' 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. 'Melkasalsa' 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), 'Melkasalsa' (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 clusters plant⁻¹, average fruit diameter and average fruit weight) whereas highly significant differences among the tested varieties (P≤0.001) were observed for characters namely; plant height, marketable yield and total yield. The rest showed insignificant differences among the varieties under study.

The maximum number of fruits plant⁻¹ was obtained with 'Melka shola' (36.53(1.55)) followed by 'Bishola' (30.88(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 Melkasshola (7.27) and the least number of clusters plant⁻¹ was observed in Fetan (4.40) followed by Eshe (4.80). This study was in agreement with the findings of Kah 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                      | 28.9bc               |
| Cochore       | 60.40bc           | 4.93abc       | 6.47bc                       | 22.1bcd              |
| Metadel       | 67.47bc           | 4.67bc        | 5.13cd                       | 13.3e                |
| Chali         | 67.40bc           | 5.27abc       | 5.60bcde                     | 19.5ecd              |
| 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                       | 24.7abd              |
| Eshete        | 82.40a            | 5.40abc       | 4.80cd                       | 16.9cd               |
| ARP-d2        | 67.93bc           | 4.40bc        | 5.00cd                       | 15.9de               |
| 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 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 a variety ‘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              | 58.00d                  | 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               | 6116bc                     | 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)a              | 8680abc              |
| Fetan         | 18.00bc             | 116.67abc               | 3284d                      | 1706.7(41.12)ab             | 4991c                |
| Bishola       | 11.53d              | 59.63e                  | 8756ab                     | 2397.8(48.26)a              | 11,531a              |
| Miya          | 16.67c              | 85.73cd                 | 7658ab                     | 1475.6(37.94)ab             | 9133ab               |
| Eshete        | 20.80a              | 142.80a                 | 6171bcd                    | 1806.7(42.24)a              | 7978abc              |
| ARP-d2        | 17.13bc             | 93.87bcd                | 4440cd                     | 1217.8(34.54)b              | 5658abc              |
| LSD           | 2.66f               | 39.522                  | 3110.9(42.34)ab            | 3757.1(41.57)ab             | 7357100              |
| 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 off-season 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 us to 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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