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Evaluation of Tomato (*Lycopersicon esculentum* Mill.) Varieties for Seed Yield and Yield Components under Jimma Condition, South Western Ethiopia

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ABSTRACT
An experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) experimental field to evaluate selected tomato (*Lycopersicon esculentum* Mill.) varieties for their seed yield under irrigated condition. The experiment was set using a Randomized Complete Block Design (RCBD) with three replications wherein nine tomato varieties: five determinate type (Bishola, Chali, Cochoro, Fetan and Melkasalsa) and four semi-determinate type (Metadel, Miya, Melkashola and Arp tomato d_2) and one local variety (Roma VF) were used. Data was collected on yield, seed weight per fruit, seed weight per plant, seed yield per hectare, number of seed per fruit, thousand seed weight, fruit diameter, fruit weight per plant and fruit yield per hectare. The results revealed that Variety had highly significantly ($p \leq 0.01$) affected the yield and yield component parameters. Significantly the highest fruit diameter (6.25 cm) was recorded from variety Bishola whereas the lowest seed yield per hectare was obtained from Fetan (58.1 kg). Correlation analysis also indicated that Seed weight per plant was significantly and positively associated with seed weight per hectare (r = 0.95), fruit yield per hectare (r = 0.40) and fruit weight per plant (r = 0.40). Fruit weight per plant was highly significantly and positively correlated with seed weight per hectare (r = 0.47) and fruit yield per hectare (r = 0.99). The tomato variety Bishola was found to be high seed yielder as compared to the other varieties compared and hence it is suggested that tomato producers in Jimma area can use Bishola variety for high seed yield.

Key words: Fruit yield, seed yield, tomato, varieties, yield components

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important edible and nutritious vegetable crops, widely cultivated in tropical, sub-tropical and temperate climates in the world. It ranks 1st with respect to world vegetable production and accounts for 14% (over 100 Mt year^{-1}) $1.6 billion market (Bauchet and Causse, 2010). Tomato is beneficial to human health being rich in minerals, vitamins, essential amino acids, sugars and dietary fibers (Naika *et al*., 2005).

In Ethiopia tomato is one of the most important and widely grown vegetable crops, both during the rainy and dry seasons for its fruit by smallholder farmers, commercial state and private farms (Gemechis *et al*., 2012; MoA., 2013; Emana *et al*., 2014). Lemma *et al*. (1994) indicated that the total production of tomato in Ethiopia has shown a marked increase, indicating that it has became the most profitable crop providing a higher income to smallholder farmers compared to other vegetable crops. However, average yield of tomato in Ethiopia is low, ranging from 6.5-24 Mt ha^{-1}(Gemechis *et al*., 2012) as compared with average yields of 51, 41, 36 and 34 Mt ha^{-1} in America, Europe, Asia and the entire world, respectively (FAOSTAT., 2010). The shortage of varieties that are adaptable to different agro-ecologies, poor quality seeds, disease and insect pests, high post harvest loss, lack of

Table 1: Description of the nine tomato varieties used for the experiment

Varieties	Altitude (masl)	Growth habit	Unique character	Utilization	Maturity days	Research yield (Q ha^{-1})
Fetan	700-2000	Determinate	Early maturing and concentrated fruit yield	Fresh	78-80	454
Bishola	700-2000	Determinate	Large fruit size, green shoulder fruit color before mature	Fresh	85-90	340
Arp tomato d_2	700-2000	Semi-determinate	Large fruit size, green shoulder fruit color before mature	Fresh	75- 80	394
Metadel	700-2000	Semi-determinate	Medium fruit size, slightly flatten fruit shape	Fresh	75-80	345
Cochoro	700-2000	Semi-determinate	Round fruit shape, green shoulder fruit color before mature	processing	75-90	350
Melkashola	700 -2000	Determinate	Globular fruit shape	Processing	100-120	430
Chali	700 -2000	Determinate	Round fruit shape	Processing	110-120	300
Miya	700-2000	Semi-determinate	High leaf coverage, hard skin fruit and plum fruit shape	Fresh	75- 80	471
Melkasalsa	700-2000	Determinant	Small fruit size, slightly cylindrical fruit shape	Processing	100-110	320
Local	700-200	Determinant	Globular fruit shape	Fresh	95-100	400

Source: Regassa *et al*. (2012)

awareness of existing improved technology and poor marketing systems are some of the major constraints associated with tomato production in Ethiopia (Lemma, 2002). Seed yield and quality of tomato is mainly dependent on the variety selected for seed production (George, 1999). A number of improved varieties and other agronomic packages have been recommended to the users to overcome the low productivity and quality of tomato in the country. According to MoA (2013), Ethiopian National Agricultural Research System (NARS) has released about 25 tomato varieties thus far. Open pollinated tomato varieties such as 'Melkashola', 'Marglobe', 'Melkasalsa', 'Heinz 1350', 'Fetan', 'Bishola', 'Eshet' and 'Metadel' had been released by the Melkassa Agricultural Research Center (MARC) and nationally recommended both for commercial and small-scale production in Ethiopia (Lemma, 2002). However, due to lack of sound seed multiplication and distribution system, the varieties had not reached farmers. Tomato production has been restricted to certain regions of the country for several reasons, including the shortage of varieties and the lack of recommended package regarding production. Attempts have been made to evaluate performances of different tomato varieties at Jimma condition (Regassa *et al*., 2012; Gemechis *et al*., 2012). Works of these authors revealed that Jimma area has enormous potential for successful production of tomato. However, no research has been conducted in Jimma area to assess the potential of tomato varieties for quality seed production. Therefore, the objective of this study was to assess the effect of varieties on seed yield and yield components of selected tomato varieties cultivated under Jimma condition.

MATERIALS AND METHODS

Description of study area: The study site, Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) is located at the Southwestern part of Ethiopia in Oromia Regional State at mid-altitude sub humid zone and 356 km Southwest of Finfinne (Addis Ababa), at 7°42' N latitude and 36°50' E longitude with an altitude of 1710 masl. The area receives an average annual rainfall of 1250 mm and average maximum and minimum temperatures of 26.2 and 11.3°C, respectively and average maximum and minimum relative humidity of 91.40 and 37.92%, respectively (BPEDORS., 2000).

Experimental material: Nine tomato varieties were used in the experiment, five of which are determinate type (Bishola, Chali, Cochoro, Fetan and Melkasalsa) while another four are semi-determinate type (Metadel, Miya, Melkashola and Arp tomato d_2) and one local variety (Roma VF). The seeds of all the varieties were obtained from the germplasm collections maintained at Melkasa Agricultural Research Center (MARC). The description of these varieties is presented in Table 1.

Treatments and experimental design: The treatments consisted of nine improved and one local (Roma VF) tomato varieties. The experimental plots were laid out in a Randomized Complete Block Design (RCBD) with three replications. Seedlings were carefully transplanted after 6 weeks to the experimental plots (2.1×5 m dimensions) which were prepared to accommodate 28 plants per plot (four rows) at a recommended spacing of 100 cm between rows and 30 cm between plants (Lemma, 2002). The spacing between two plots in each replication and between adjacent blocks was 0.5 and 1 m, respectively.

Experimental procedures: The study was conducted under irrigation during dry season (December 2013 to March, 2014). Seedlings were raised in nursery beds at JUCAVM; the beds of 1.3×1.3 m size were well prepared and were raised 5 cm from the soil surface to provide good drainage for the removal of surplus irrigation water. The seeds were sown in rows spaced 15 cm apart and covered lightly with fine soil before irrigation. The beds were irrigated every day until the seeds germinated fully and twice a week afterwards. Seedlings were thinned until an intra-row spacing of 3 cm was achieved. The spacing between two plots in each replication and between adjacent blocks were 50 and 100 cm, respectively. Recommended agronomic practices such as weeding, cultivation, irrigation, fertilizer application, staking and disease management were carried out uniformly during the

growing season for all plots. Similarly, pre-plant granular, Di-ammonium phosphate at a rate of 200 kg ha^{-1} and urea fertilizer at rate 100 kg ha^{-1} were applied (Lemma, 2002). Experimental plots were irrigated every day for the first two weeks to secure uniform establishment and then at weekly interval. Disease was managed by application of recommended fungicides (Ridomil at mz 63%) at a rate of 3.5 kg ha^{-1} in seven days intervals.

Data collection and analysis: The following data on seed yield and yield components was collected:

- **Fruit diameter (cm):** Five fruits were used for measuring fruit diameter. The diameter was measured at the centre of the fruit with the help of vernier caliper. The mean fruit diameter was computed and expressed in centimeters. Average was measured by taking the mean weight of all ripe fruits from five tagged plants in successive harvests and expressed in gram per plant
- **Fruit yield (t ha^{-1}):** The matured fruits were harvested from five tagged plants at each picking and the total fruit yield was recorded and expressed in tonnes per hectare
- **Seed weight per fruit (g):** In each treatment five fruits from tagged plants were selected randomly and seeds were extracted by fermentation method, dried to 7% moisture and seed weight from five fruits were recorded in grams and mean seed weight per fruit were calculated
- **Seed extraction:** Seeds were extracted from fully mature red ripe fruits collected from five randomly tagged plants and seeds from fruits of each variety were extracted separately by fermentation method. For tomato seed extraction, fruit is placed into a crusher that pulverizes the fruit and separates the gelatinous seed from the remaining fruit tissues by pressing them through screens. The extract containing the gelatinous seed material must still be separated from the remaining pulp in various method hot water treatments
- **No. of seeds per fruit:** Number of seeds per fruit was counted manually and added and the mean number of seeds per fruit was worked out
- **Seed weight per plant (g):** The total seed weight of five randomly selected plants was recorded and the mean seed weight per plant in grams was record
- **Seed yield (kg ha^{-1}):** Seed yield per ha was calculated based on seed yield per plot and expressed in kilogram per hectare
- **Thousand seed weight (g):** Three samples of 1000 seeds from each treatment were taken at random and weighed and the mean weight of 1000 seeds was expressed in grams. Finally, data was analyzed using the GLM procedure of SAS Version 9.2 statistical software and treatment means were also compared using LSD value at 5% significance level. Pearson's correlation within yield parameters and its components were also evaluated using Pearson correlation analysis of SAS Version 9.2 statistical software (SAS., 2002)

RESULTS AND DISCUSSIONS

Seed yield components: Analysis of variance revealed that fruit diameter, fruit yield per plant and fruit yield per hectare varied significantly ($p \leq 0.01$) among the tomato varieties studied (Table 2). The highest fruit girth was observed in Bishola (6.25 cm) (Table 3). This is attributed to the fact that 'Bishola' had large fruit sized than the other varieties. On the other hand, the lowest value of fruit girth (3.76 cm) was recorded in Melkasalsa. The finding is in line with that reported by Chernet and Zibelo (2014), who indicated the existence of variability in terms of fruit diameter among nine tomato varieties evaluated under lowland Tigray, Northern Ethiopia condition.

Fruit weight per plant showed significant difference ($p \leq 0.01$) among the tomato varieties (Table 2). The highest fruit weight per plant (1446.64 g) was obtained from Miya variety while, the lowest values of fruit weight per plant obtained from the varieties Faten (446.46), followed by Metadel (459.75 g), Cochoro (547.70 g), Bishola (566.63g) and Malkashola (574.51 g) all of which were not statistically different from one another (Table 3). The fruit weight per plant in this study agrees with previous reports by Regassa *et al.* (2012), who reported fruit weight per plant ranging between 1.1 and 1.7 kg. The result is also in line with the findings of Saleem *et al.* (2013), who found highest fruit yield per plant (2.48 kg) evaluating 30 tomato genotypes in Pakistan. Similarly, Chernet *et al*. (2013) reported the highest fruit yield per plant (2.10 kg) comparing 36 tomato genotypes.

Mean fruit yield of the varieties ranged from 14.88 t ha^{-1} in Fetan to 47.55 t ha^{-1} in Miya and was found to

Table 2: Mean square values for yield components of nine tomato varieties

		Yield components parameters		
Source of variation	Df	FD	FW/P	FW/H
Varieties	9	2.201**	276562.94**	297.22**
Error	18	0.025	5599.83	4.86
CV		3.15	10.03	8.89

CV: Coefficient of variation, Df: Degrees of freedom, FD: Fruit diameter, FW/P: Fruit weight per plant, FW/H: Fruit weight per hectare, **Highly significant at $p \leq 0.001$

Table 3: Response of tomato varieties to yield components

Treatments (Varieties)	Fruit diameter (cm)	Fruit weight per plant (g)	Fruit yield (t ha^{-1})
Local	3.96^{g}	889.82^{b}	29.65^{bc}
Arp tomato d_2	5.73^{b}	761.74^{c}	25.39^{d}
Metadel	5.75^{b}	459.75^{d}	15.32^{g}
Chali	4.83^{f}	812.53^{c}	27.08^{d}
Cochoro	5.57^{c}	547.70^{d}	18.52^{ef}
Melkashola	4.10^{g}	574.51^{d}	19.14^{e}
Miya	5.19^{e}	1446.64^{a}	47.55^{a}
Fetan	5.41^{d}	446.46^{d}	14.88^{g}
Melkasalsa	3.76^{h}	948.07^{b}	31.60^{b}
Bishola	6.25^{a}	566.63^{d}	18.88^{ef}
LSD	0.146	70.303	2.07
CV (%)	3.15	10.03	8.89

Means within the same column followed by different letter are significantly different at $p \leq 0.05$, LSD: Least significant difference, CV: Coefficient of variation

be significantly ($p \leq 0.01$) different among varieties (Table 2). The highest fruit weight per hectare (47.55 t) was obtained from the variety 'Miya' (Table 3). The minimum fruit yield per ha was recorded by Fetan (14.88 t) which was statistically similar with Metadel (15.32 t) and Cochoro (18.52 t) (Table 3). This is in agreement with the finding of Saleem *et al.* (2013), who found the highest fruit yield per hectare (2.48 kg) comparing 30 tomato genotypes in Pakistan. Similarly, Chernet *et al*. (2013) reported highest fruit yield ha^{-1} (56.07 t ha^{-1}) evaluating 36 tomato genotypes.

Analysis of variance showed the existence of significant ($p \leq 0.01$) difference among the tomato varieties with regard to seed number per fruit, seed weight per fruit (g), seed yield per plant (g), seed yield per hectare (kg) and thousand seed weight (g) (Table 4). Bishola variety recorded significantly the highest number of seeds per fruit (231), while the lowest number of seeds per fruit was recorded from Melkasalsa (71) (Table 5). In agreement with this finding, Tasisa *et al*. (2011) reported that there was wide difference in seed number per fruit (59.47-227) among the 23 tomato genotypes compared in west Shoa, Ethiopia.

Highly significant ($p \leq 0.01$) difference was observed among the varieties with regard to seed weight per fruit (g) (Table 4). The variety Bishola recorded significantly the highest seed weight per fruit (0.75 g) and the lowest seed weight per fruit was recorded from Melkasalsa (0.17 g). This is in agreement with the finding of Kumar (2007), who reported varietal difference (0.511-0.483 g) in seed weight per fruit for hybrid seed production in tomato (*Lycopersicon esculentum* Mill.) in India.

Table 4: Mean square values for seed yield of nine tomato varieties

Source of variation	Df	Yield parameters				
		TSW	SW/P	SW/H	NS/F	SW/F
Varieties	9	0.120**	4.34**	4237.32**	9112.003**	0.104**
Error	18	0.00021	0.181	164.10	3.025	0.000029
CV		0.54	14.90	12.62	1.20	1.36

CV: Coefficient of variation, Df: Degrees of freedom, TSW: Thousand seed weight, SW/P Seed weight per plant, SW/H: Seed weight per hectare, NS/F: No. of seeds per fruit, SW/F; Seed weight per fruit, **: Highly significant at 1% probability level

Seed yield per plant (g) showed very highly significant ($p \leq 0.01$) difference among the varieties (Table 4). Seed yield per plant was significantly the highest in Bishola (5.31 g), followed by Melkasalsa (4.52 g). Significantly the lowest seed yield per plant (1.42 g) was recorded by Fetan variety; however, it was not significantly different from Chali (1.94 g), Cochoro (2.04 g) and Metadel (2.14 g). Arp tomato d_2 (2.53g), Melkashola (2.78), Miya (2.9 g) and Local (3.11g) have given comparable seed yield per plant. This indicated selection would be useful in improving seed yield per plant. This is in agreement with the finding of Hill and West (1983), who found wide difference in seed weight per plant (0.88-9.35 g) comparing nine tomato cultivars in Florida.

Highly significant ($p \leq 0.01$) variation was observed among the varieties compared (Table 4). Significantly the highest seed yield ha^{-1} (177.26 kg) was obtained from Bishola variety, followed by Melkasalsa (150.81 kg). The lowest seed yield per hectare was obtained from Fetan (58.1 kg), however, it was not significantly different from Metadel (70.44 kg), Chali (75.92 kg) and Cochoro (79.11 kg). These results are in conformity with finding of Rajashekar *et al.* (2006), who reported the existence of difference in tomato seed yield ha^{-1} (287.39 kg) in India. The average seed yield of tomato cultivar is 100-120 kg ha^{-1} (Chowdhury, 1976) but good yield of tomato may reach 600-700 kg ha^{-1} (Singh *et al*., 1964). On the other hand, Agrawal (1980) reported average seed yield of tomato cultivars to vary from 50-80 kg ha^{-1}. According to the ESA (2000), tomato seed yield potential in the country was ranged from 100-150 kg ha^{-1}.

Varieties Bishola (3.13 g), followed by Cochoro (3.10 g) had significantly ($p \leq 0.01$) the highest thousand seed weight, while Arp tomato d_2 (2.62 g) and Melkashola (2.63 g) had the least thousand seed weight (Table 5). This finding is in agreement with the finding of Kumar (2007), who reported variation of thousand seed weight ranging between 3.69 and 3.79 g) for hybrid seed production in tomato (*Lycopersicon esculentum* Mill.) in India.

Correlation coefficient analysis: Correlation analysis showed that fruit diameter (R = 0.56**), seed weight per plant (R = 0.95**), fruit weight per plant (R = 0.47**) and fruit weight per hectare (R = 0.47**) were highly significantly and

Table 5: Difference of significance values of tomato varieties to yield parameters

Treatments (Varieties)	No. of seeds per fruit	Seed weight per fruit (g)	Seed weight per plant (g)	Seed yield per hectare (kg)	Thousand seed weight (g)
Local	136.33^{e}	0.42^{e}	3.11^{c}	114.88^{c}	2.74^{e}
Arp tomato d_2	224.66^{b}	0.69^{b}	2.53^{de}	84.70^{ef}	2.63^{h}
Metadel	117.33^{g}	0.26^{i}	2.14d^{ef}	70.44^{g}	2.70^{g}
Chali	110.33^{h}	0.38^{g}	1.94^{f}	75.92^{fg}	2.78^{d}
Cochoro	194.33^{c}	0.54^{c}	2.04^{f}	79.11^{fg}	3.10^{b}
Melkashola	88.00^{i}	0.25^{h}	2.78^{cd}	92.88^{e}	2.62^{h}
Miya	150.33^{d}	0.48^{d}	2.9^{cd}	108.00^{dc}	3.07^{c}
Fetan	125.33^{f}	0.39^{f}	1.42^{g}	58.11^{h}	2.70^{g}
Melkasalsa	71.00^{j}	0.17^{j}	4.52^{b}	150.81^{b}	2.72^{f}
Bishola	231.00^{a}	0.75^{a}	5.31^{a}	177.26^{a}	3.13^{a}
LSD	1.63	0.005	0.40	12.01	0.014
CV (%)	1.20	1.36	14.90	12.62	0.54

Means within the same column followed by different letter are significantly different at $p \leq 0.05$, LSD: Least significant difference, CV: Coefficient of variation

Table 6: Pearson's correlation(r) of yield parameters and its components of tomato varieties

Correlation parameters	FD	THSW	SWP	FWP	FWHA	SNF	SWF	SWHA
FD								
THSW	0.43*							
SWP	-0.57***	-0.04^{ns}						
FWP	-0.31^{ns}	0.24^{ns}	0.40*					
FWHA	-0.32^{ns}	0.24^{ns}	0.41*	0.99***				
SNF	0.75***	0.52**	-0.16^{ns}	-0.09^{ns}	-0.10^{ns}			
SWF	0.70***	0.53**	-0.14^{ns}	-0.02^{ns}	-0.02^{ns}	0.97***		
SWHA	0.57***	0.07ns	0.95***	0.47**	0.47**	-0.13^{ns}	-0.09^{ns}	

FD: Fruit diameter, THSW: Thousand seed weight, SWP: Seed weight per plant, FWP: Fruit weight per plant, FWHA: Fruit yield per hectare, SNF: Seed number per fruit, SWF: Seed weight per fruit, SWHA: Seed weight per hectare.*, ** and ***Significant correlation at $p \leq 0.05$, $p \leq 0.01$ and $p \leq 0.001$, respectively ns: Non significant at $p \geq 0.05$

positively correlated with seed weight yield per hectare. Pearson correlation (r) of fruit diameter was highly significantly and positively correlated with seed number per fruit (r = 0.75), seed weight per hectare (r = 0.56), seed weight per fruit (r = 0.69) and thousand seed weight (r = 0.43*). Thousand seed weight was highly significantly and positively correlated with seed number per fruit (r = 0.51) and seed weight per fruit (r = 0.52). Similarly, seed weight per plant was significantly and positively correlated with seed weight per hectare (r = 0.95). Fruit weight per plant was highly significantly and positively correlated with seed weight per hectare (r = 0.47) and fruit yield per hectare (r = 0.99). In agreement with this finding, Regassa *et al.* (2012) reported highly significant and positively association between fruit weight per plant (r = 0.98) and number of fruit per plant (r = 0.53) with marketable fruit yield for nine tomato varieties evaluated in Jimma, Ethiopia. Akindele *et al.* (2011) also found highly significant and positive association between fruit weight per plant (r = 0.61) and number of fruit per plant (r = 0.67) with fruit yield per hectare for nine tomato varieties evaluated in Nigeria. Number of seeds per fruit was highly significantly and positively correlated with seed weight per fruit (r = 0.97) (Table 6).

CONCLUSION

Results of the present study indicated that yield and yield component parameters were significantly different among the tomato varieties evaluated. Accordingly, the tomato variety Bishola was found to be superior as compared to other tomato varieties with regard to seed weight per plant, seed weight per hectare, number of seeds per fruit, seed weight per fruit, thousand seed weight and fruit diameter whereas the performance of tomato variety Fetan was poor with regard to seed weight per plant, seed yield per hectare, Fruit weight per plant and fruit weight per hectare. Correlation analysis showed highly significant and positive association of seed weight yield per hectare with that of fruit diameter, seed weight per plant, fruit weight per plant and fruit weight per hectare. Therefore, to improve seed yield, selection of tomato variety could be made based on these characters.

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