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Evaluation of Tomato (*Lycopersicon Esculentum* Mill.) Varieties for Growth and Seed Quality under Jimma Condition, South Western Ethiopia

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ABSTRACT

Field and laboratory experiments were conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) to evaluate selected Tomato (*Lycopersicon esculentum* Mill.) varieties for their growth and seed quality under irrigated condition. The field experiment was set using Randomized Complete Block Design (RCBD), while the lab experiment was set using Completely Randomized Design (CRD) with three replications. Nine Tomato varieties: Five determinate types (Bishola, Chali, Cochoro, Fetan and Melkasalsa) and four semi-determinate types (Metadel, Miya, Melkashola and Arp tomato $d_{2)}$ and one local variety (Roma VF) were used for the experiment. Data were collected on growth and seed quality parameters including plant height, flower initiation, Days to 50 percent flowering, moisture content, germination percentage, field emergence, seedling dry weight, and root length. The results revealed that Variety had significantly ($p \leq 0.05$) affected growth and quality parameters. Significantly ($p \leq 0.05$) the shortest days to flower initiation and days to 50% flowering and the highest plant height were recorded from variety Arp tomato d_2 while the maximum germination percentage, field emergence, seedling dry weight and root length were obtained from tomato variety Cochoro. Significantly ($p \leq 0.01$) the minimum moisture content was recorded from Metadel and Arp tomato d_2. The tomato variety Cochoro was found to be high quality seed yielder as compared to the other varieties and hence it is suggested that tomato producers in Jimma area can use Cochoro variety for good quality seed production.

Key words: Growth, Seed quality, tomato, varieties

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., (2003) 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 metric tonne/ha (Gemechis et al.,2012) as compared with average yields of 51, 41, 36 and 34 metric tonne/ha 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 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 growth and seed quality 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 m above sea level . The area receives an average annual rainfall of 1250 mm and average maximum and minimum temperatures of 26.2°C 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.

Table 1**.** Description of the nine Tomato Varieties used for the experiment

Varieties	Altitude	Growth habit	Unique character	Utilization	Maturity days	Research yield (Q/ha)
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	Globulor fruit shape	Fresh	95-100	400

Source: Meseret *et al., (*2012)

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 m × 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 m and 1 m, respectively.

Experimental Procedures:

Field experiment

The study was conducted under irrigation during dry season (December 2013 to March 2014). Seedlings were raised in nursery beds at JUCAVM research site; the beds of 1.3 m × 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 cm 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@mz 63%) at a rate of 3.5 kg ha^{-1} in seven days intervals.

Laboratory experiment

The laboratory experiment was conducted at the plant pathology laboratory at the Jimma University College of Agriculture and Veterinary Medicine (JUCAVM). Seeds of the ten tomato varieties were used in the laboratory to test for seed germination and seed moisture content after harvesting. The experiment was laid out as completely randomized design (CRD) and replicated three times.

Data collection and analysis: The following data on growth and seed quality were collected:

Plant height (cm): Plant height was measured from the base of randomly selected plants in each plot to the main apex at flower initiation stage; mean values were expressed in centimeter.

Days to flower initiation: The days to first flowering in each treatment was recorded and expressed as days to initiation of flowering.

Days to 50 percent flowering: The number of days was noted from transplanting date to the day on which 50% of the plants in a plot flowered.

Seed extraction: **S**eeds 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.

Germination percentage: Three replicates of 100 seeds were placed in paper towel in the germination room which was maintained at 25^0C temperature and 95 percent relative humidity. At the end of

14th day of germination test, the number of normal seedlings in each replication was counted and germination was calculated and expressed in percentage.

Field emergence percentage: Three hundred seeds were selected randomly from each treatment and sown in three replications on well-prepared, raised seedbed and watered at regular interval to maintain adequate moisture in the bed. The number of seedlings emerged in replication on 7th to14th day was recorded and expressed as field emergence percent. Emergence percentage was calculated taking into account the number of seedlings emerged 3 cm above the soil surface.

Root length (cm): Five normal seedlings in each treatment were randomly selected for the measurement of root length on 14th day. After watering the seed bed, the seedlings were carefully selected and pulled out without damaging roots. The root length measured from tip of the primary root to base of hypocotyls and mean root length was express in centimeters.

Seedling dry weight (mg): Five normal seedlings used for measuring seedling length were taken in butter paper and dried in a hot-air oven maintained at 80 ^{0}C temperature for 24 hours. Seedlings were removed and allowed to cool in a desiccator for 30 minutes before weighing in an electronic balance. The average weight was calculated and expressed as seedling dry weight in milligrams.

Seed Moisture Content (%): Moisture content of the seed was determined by using hot air oven method. As per ESTA rules, grams of seed material from each treatment in three replications were dried in a hot air oven maintained at a temperature of 80 ^{0}C for a period of 24 hours (ESA, 2000). Then samples were cooled in desiccators and moisture content was determined by using the formula given below and expressed in percentage.

$$\text{Moisture content (\%)} = \frac{W2 - W3}{W2 - W1} \times 100$$

where W1 = Weight of empty aluminum cup (g), W2 = Weight of empty aluminum cup with seed before drying (g), W3 = Weight of empty aluminum cup with seed after drying (g). Finally, data were analyzed using the GLM procedure of SAS Version 9.2 statistical software (SAS Institute, 2002) and treatment means were also compared using LSD value at 5% significance level.

RESULTS AND DISCUSSION

Analysis of variance revealed that plant height and days to 50% flowering varied significantly ($P \leq 0.01$) while days to flower initiation showed significant ($P < 0.05$) difference among the tomato varieties studied (Table 2). The mean value of plant heights ranged from 39.50 to 74.33 cm. The tallest plants were recorded by Arp tomato d 2 (74.33 cm) and Miya (71 cm) which were not statistically different from one another, followed by Local and Fetan varieties. While the shortest plants were Melkasalsa (39.5 cm), Melkashola (41.02 cm) and Bishola (44.43 cm) (Table 4) all of which were statistically on par. Consistent with the results of this study, Meseret et al., (2012) reported that the mean value of plant height was laid between 40.20 cm and 107cm and the authors also reported that Bishola was the shortest (51.07 cm).In agreement with the results of this study, Hussain et al., (2001) reported wide range of difference (61.6-126.5cm) in plant height among the 10 tomato genotypes evaluated in Pakistan. Similarly, Dufera (2013) obtained wide difference (51.5-129.7 cm) for plant height in tomato. Shushay Cherenet and Haile Zibelo (2014) also obtained wide difference (62.1-105.3 cm) among the nine tomato varieties evaluated in western lowland of Tigray, Northern Ethiopia. Emami, A., & Eivazi, A. R. (2013) also

indicated a wide range of variability in plant height.

Days to flower initiation showed significant (P<0.05) difference among the varieties (Table 2). The period between transplanting and flowering ranged from 31 to 37days (Table 4). Among the different varieties, Local, Arp tomato d2, Chali, Matadel and Bishola showed earliest flowering with no significant difference from Cochoro and Miya (31-33.33 days) whereas Fetan, were late in flowering (36 – 37 days) (Table 4). Comparing 25 Tomato varieties with regard to flower inititiation in Iran, Emami et al. (2013) has found a wide difference (103-127 days).

Highly significant (P<0.01) variation was observed among the tomato varieties in the number of days plants took to attain 50 % flowering (Table 2). The mean value varied from 37.66 to 46.33 days. The Arp tomato d2 variety required the shortest time to flower. Melkashola, Fetan, Miya and Melkasalsa required more time (43.66-46.33 days) to attain 50 % flowering (Table 4). This result is in agreement with the finding of Shushay Cherenet and Haile Zibelo (2014) who found that days to 50% flowering ranged from 29 to 38. Meseret et al., (2012) also reported that the period between transplanting and flowering ranged from 38 to 49 days. However, the authors indicated that among the different varieties, 'Miya' and 'Fetan' showed earliest flowering whereas 'Bishola' and 'Jimma local' showed statistically late flowering. In contrast to this study, osei et al., (2015) found that days to 50% flowering ranged from 29.3 to 30.7. Ajal, M. O., & Ajani, O. O. (2014) also reported that days to 50% flowering ranged from 46.75 to 64.

Table 2.Mean square values for growth parameters of nine tomato varieties

		Growth parameters		
source of variation	Df	Ph	DFI	DF
Varieties	9	447.91**	14.996*	36.941**
Error	18	8.74	3.44	3.792
CV		5.30	5.57	4.68

CV indicates Coefficient of variation, DF =Degrees of freedom, Ph = plant height, DFI=Days to flower initiation, DF= Days to 50% flowering, *= significant at 5% probability level, and **= highly significant at p≤0.01.

Table 3. Mean square values for seed quality of nine tomato varieties.

		Quality parameters				
source of variation	Df	RL	FE (%)	SDW (gm)	G%	MC (%)
Varieties	9	3.033**	235.62*	0.056*	37.12*	1.78***
Error	18	0.848	48.25	0.021	6.82	0.15
CV		10.54	11.02	17.27	2.845	5.61

CV indicates Coefficient of variation, DF =Degrees of freedom, RL = Root length, FE (%) = Field emergence, SDW = Seedling dry weight, G% = Germination percentage, MC (%) Seed moisture content, *= significant at 5% probability level, **=highly significant at 1% probability level and ***=highly significant at 0.1% probability level.

Table 4: Response of Tomato varieties to different growth parameters

Varieties	Days to initiation of flowering	Days to 50 percent flowering	Plant height (cm)
Local	31.00c	38.00cd	63.55b
Arp tomato d2	31.00c	37.66d	74.33a
Metadel	32.00c	39.00cd	55.80c
Chali	31.66c	39.66cd	56.00c
Cochoro	33.33bc	40.00bcd	50.00d
Melkashola	36.00ab	46.33a	41.01e
Miya	33.33bc	45.33ab	71.00a
Fetan	37.00a	46.33a	62.83b
Melkasalsa	36.00ab	43.66abc	39.5e
Bishola	32.00c	39.66cd	44.43e
LSD	1.74	1.82	2.77
CV (%)	5.57	4.68	5.30

Means within the same column followed by different letter are significantly different at $P \leq 0.05$

Seed quality parameters

Analysis of variance showed the existence of significant ($p \leq 0.01$) difference among the tomato varieties with regard to seed moisture content, germination percentage, field emergence, root length (cm), and seedling dry weight (mg) ((Table 3).

Maximum moisture content (8.03%) was observed in Local variety, however, it was not significantly different from Cochoro (7.43 %) while significantly the least moisture content was obtained from Matadel (5.50%) which was statistically on par with Arp tomato d2 (Table 5). Such difference was mainly due to genetic make-up of varieties. High seed moisture is more injurious to seed quality as it increases the metabolism and favors the growth of microorganism at higher temperature especially in tropics, where tomato is widely grown. The results agree with national tomato seed moisture content which was maximum 10 % (ES, 2000). The result is in agreement with the finding of Nassari et al., (2014) who reported variation in seed moisture content of tomato ranging from 7.6% to 7.0%.

Highly significant ($P \leq 0.01$) difference was observed among the varieties with regard to germination percentage (Table 3). Variety Cochoro recorded significantly the highest germination percentage (95.25%), however, it was not significantly different from Melkasalsa (94.75 %), Local (94.25%), Bishola (93.5%), Chali (92.75%), and Miya (92.33%), all of which were statistically similar among each other. The least germination percentage was recorded in Metadel (85%) which was not significantly different from Melkashola (87.33%) (Table 5).This result was in line with national standard minimum tomato seed germination percentage at laboratory which was ranged from 70% to 85% (ES, 2000) and also agreed with the finding of Hill and West (1983) who found wide difference (96.3% - 71.6%) in germination percentage for 9 tomato cultivars in Florida. Ajal, M. O., & Ajani, O. O. (2014) also reported the wide difference (40.7-95 %) of standard germination across the two locations.

Field emergence showed highly significant ($P<0.01$) difference among varieties (Table 3). Field emergence was

significantly the highest in Malkasalsa (76%), however, it was not significantly different from Arp tomato d2 (74 %), Cochoro (72%) and Local (66.67 %) (Table 5). Significantly the lowest field emergence (51.33 %) was recorded by Fetan with no statistical deference from Melkashola (55.33 %), Bishola (57.33 %) and Miya (59.33 %) (Table 5). The result of this work is in agreement with the finding of Kumar (2007) who found that the variety Arka Vikas recorded significantly higher field emergence percentage (82.43) compared to Megha (80.44) for hybrid seed production of tomato (Lycopersicon esculentum Mill.) in India. Ajal, M. O., & Ajani, O. O. (2014) also found the wide range (28-80 %) of field emergence for tomato in Nigeria.

Seedling dry weight (mg) was significantly ($p \leq 0.05$) different among the varieties. Metadel recorded maximum seedlings dry weight (1.07 g), However, this variety is statistically similar with Chali, Miya, Meilkashola, Cochoro, and Fetan (0.86-0.99 g) while the lowest seedlings dry weight were obtained from Bishola (0.63 g), however, it was not significantly different from Local, Melkasalsa, and Arp tomato d2 (0.72 – 0.75 g), (Table 5). In agreement with the finding of this research, Kumar (2007) reported that there were small differences (25.12-25.90 m) in seedling dry weight for hybrid seed production of tomato (Lycopersicon esculentum Mill.) in India.

Varieties Cochoro (13.5 cm) and Chali (12.33 cm) had significantly ($p \leq 0.05$) the longest root, while the shortest roots were recorded from Miya (4.17 cm) and Arp tomato d2 (5 cm). This finding is in agreement with the finding of Kumar (2007) who reported small difference (6.4-6.59 cm) in the root length of tomato varieties (Lycopersicon esculentum Mill.) in India.

Table 5. Response of Tomato varieties to seed quality parameters

Varaieties	Seed moisture content (%)	Germination percentage	Field emergence percentage	Root length(cm)	Seedling dry weight (mg)
Local	8.03a	94.25abc	66.66abc	7.66d	0.72cd
Arp tomato d2	5.96de	91.25c	74.00ab	5.00e	0.75bcd
Metadel	5.50e	85.25d	64.00bcd	9.33bcd	1.07a
Chali	6.43cd	92.75abc	54.00de	12.33a	0.99ab
Cochoro	7.43ab	95.25a	72.00ab	13.50a	0.87abcd
Melkashola	7.36b	87.5d	55.33cde	8.66bcd	0.90abc
Miya	7.30b	91.75bc	59.33cde	4.16e	0.98ab
Fetan	6.36cd	91.5bc	51.33e	9.66b	0.86abcd
Melkasalsa	6.80bc	94.75ab	76.00a	10.00b	0.74bcd
Bishola	7.20b	93.5abc	57.33cde	8.00cd	0.63d
LSD	0.36	4.48	6.52	0.86	0.14
CV (%)	5.68	2.845	11.02	10.54	17.27

Means within the same column followed by different letter are significantly different at $P \leq 0.05$

CONCLUSION

Results of the present study indicated that growth and seed quality parameters were significantly different among the tomato varieties evaluated. Accordingly, the tomato variety Cochoro was found to be superior as compared to other tomato varieties with regard to Germination percentage, Field emergence, Root length and Seedling dry

weight. Variety Arp tomato d_2 is also better with regard to days to initiation to flowering, days to 50% flowering, and plant height in addition to having the minimum moisture content that able the seed to store for long period of time without losing viability.

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