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Evaluation of Tomato Varieties for Fruit Yield and Yield Components in Western Lowland of Tigray, Northern Ethiopia

Shushay Chernet and Haile Zibelo
Humera Agricultural Research Center, Tigray Agricultural Research Institute, P.O. Box 62, Humera, Ethiopia

Corresponding Author: Shushay Chernet, Humera Agricultural Research Center, Tigray Agricultural Research Institute, P.O. Box 62, Humera, Ethiopia

ABSTRACT
The objective of the study was to evaluate nationally released tomato varieties for fruit yield and yield components in western Tigray, Northern Ethiopia. Nine tomato varieties collected from Melkassa Agricultural Research Center were evaluated in randomized complete block design in three replications. The study was conducted in Humera Agricultural Research Center experimental site during 2012 under irrigation condition. Tukey's test and Pearson correlation were used to compare treatment means and estimate association of characters. All the traits except number of flowers per plant and number of fruit per plant showed highly significant ($p<0.001$) difference among the varieties. Melkasalsa scored the highest number of fruits per plant (100), highest fruit yield per plant (2.491 kg) and marketable fruit yield (56.07 t ha^{-1}) while, the minimum (17.89 t ha^{-1}) marketable fruit yield was recorded from Bishola variety. Correlation studies showed that fruit yield per hectare had a very highly significant positive correlation with fruit yield per plant ($r = 0.903$), number of fruits per plant ($r = 0.807$), number of fruit clusters per plant ($r = 0.850$) and shape index ($r = 0.501$) indicated selection based on trait improve fruit yield per hectare. While, it showed significant negative correlation with fruit equatorial diameter ($r = -0.478$).

Key words: Tomato, variety, Tukey's test, Pearson correlation

INTRODUCTION
Ethiopia's wide range of agro-climatic conditions and soil types make it suitable for the production of diverse varieties of vegetables and fruits both under rain fed and irrigation condition. Tomato (*Solanum lycopersicon* L.) is one of the most important vegetable crops grown in different parts of the country. The total cultivated area covered by tomato was 7,237 ha with a total production of 55,514 tons (FAOSTAT, 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 Humera woreda for 2013/2014 cropping season was 1,655 ha. However, production of the crop in the study area is challenged by shortage of improved varieties, use of unknown and poor quality seed, disease and insect pests, poor agronomic practices and poor postharvest handling.

To alleviate some of the production challenges of tomato in Ethiopia, efforts were made by Ethiopian Institute of Agricultural Research Institute (EIAR), Melkassa Agricultural Research Center (MARC) and other research institutes. It is because of these efforts, many varieties including the varieties used in this study, were released. Moreover, Regassa *et al*. (2012), Abdelmageed and Gruda (2009), Hussain *et al.* (2001) and Dufera (2013) conducted a study on evaluation of tomato genotypes for yield and yield components for specific location (agro ecology). However, in the study area, limited effort was made to recommend adaptable, high yielding and good quality varieties. Therefore, a study was conducted to evaluate performance of nationally released tomato varieties for yield and yield components in western low land of Tigray, North Ethiopia.

MATERIALS AND METHODS

The experiment was conducted in Humera Agricultural Research Center (HuARC). Humera is located in northern part of Ethiopia in Tigray regional state at an altitude of 604 m above sea level 960 km North of Addis Ababa. It is located at 14° 06' N latitudes and 38° 31' E longitudes. It has chromic vertisol black in color. The maximum temperature varies from 33-42°C and the minimum temperature ranged from 17.5-22.2°C. The area receives an average rainfall of 400-650 mm year^{-1} (EARO, 2002).

The experimental materials comprised of 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. Melkashola was used as check, as it was widely cultivated in the study area.

The experiment was conducted under irrigation condition in 2012 cropping season. Seedlings of each varieties were raised in a seed bed of 1.05 m^2 (1 m length, 7 rows, 0.15 m spacing between row). Seedlings were transplanted to main field after four weeks of seed sowing. The trial was laid out in Randomized Complete Block Design (RCBD) with three replications. Each variety was planted in the main field in a plot size of 20 m^2 (5 rows, 4 m row length, 1 m spacing between rows). Spacing between rows and plants were maintained 100×30 cm, respectively. The middle three rows were used for data collection leaving the two rows as borders. The 200 kg ha^{-1} DAP and 100 kg ha^{-1} Urea were applied at time of sowing and two weeks after transplanting as of recommended for the crop (Desalegne, 2002). All agronomic practices (irrigation, cultivation, weeding and stacking) were applied uniformly for all plots.

Ten plants and ten fruits were tagged to measure quantitative traits such as days to 50% flowering, days to maturity, plant height (cm), number of branches, flowers per cluster, fruits per cluster, fruit clusters per plant, fruits per plant, fruit yield per plant (kg), fruit weight (g), fruit polar diameter (mm), fruit equatorial diameter (mm), shape index, marketable yield (t ha^{-1}) and unmarketable yield (t ha^{-1}).

Analysis of variance (ANOVA) was done using Proc GLM procedures of SAS version 9.2, (SAS, 2008). The difference between treatment means was compared using Tukey's test at 5% probability level. Pearson correlation was used to measure association of characters among themselves and fruit yield. Correlation analysis was made using Proc corr procedures of SAS.

RESULTS AND DISCUSSION

Results of the analysis of variance (ANOVA) showed highly significant difference for most of the characters among the varieties (Table 1 and 2). Days to maturity showed highly significant ($p<0.01$) difference among the variety studied (Table 1). The mean value varied from 96-120 days (Table 2). Miya and Marglobe took the shortest period (96 days) to mature while Bishola was the late (120 days) among the varieties. This is in agreement with the finding of Emami *et al.* (2013) who found wide difference (103-127 days) in maturity for 25 tomato genotypes studied in Iran.

Table 1: Mean square results for growth and yield components of tomato obtained from ANOVA

		Mean square						
Source of variation	df	DFL	DM	PHT (cm)	NBR	FlPC	FrPC	FrCPP
Block	2	4.11	18.48	47.98	0.567	0.053	0.008	2.398
Varieties	8	29.00**	241.43**	456.53****	4.74*	0.29ns	0.31ns	96.060***
Error	16	5.5.27	28.64	13.245	1.231	0.1117	0.179	5.765

df: Degree of freedom, DFL: Days to 50% flowering, DM: Days to maturity, PHT: Plant height, NBR: No. of branches, FlPC: No. of flowers per cluster, FrPC: No. of fruits per cluster, FrCPP: Fruit cluster per plant, ns: Non significant, **,***Highly and very highly significant, respectively

Table 2: Mean square results for yield components, fruit yield and fruit characteristics of tomato obtained from ANOVA

		Mean square						
Source of variation	df	FrPP	FrYPP	FrW (g)	MYLD (t ha^{-1})	FPD (mm)	FED (mm)	SHI
Block	2	2.440	19.602	4.25	2.43	24.41	0.685	0.008
Varieties	8	2017.600***	1071.100***	561.60***	548.90***	177.40**	130.600***	0.332***
Error	16	23.138	45.270	56..47	19.30	45.42	18.735	0.0048

df: Degree of freedom, FrPP: No. of fruits per plant, FrYPP: Fruit yield per plant, FrWt: Single fruit weight, MYLD: Marketable yield, FPD: Fruit polar diameter, FED: Fruit equatorial diameter, SHI: Shape index, **,***Highly and very highly significant, respectively

Dufera (2013) also reported wide range of difference in maturity (73-93 days) for 21 tomato genotypes studied in Mizan Tepi, Ethiopia. Similarly, Chernet *et al.* (2013) reported significant variation in maturity (69-156 days) for 36 tomato genotypes evaluated in Humera, Ethiopia.

Plant height showed very highly significant difference ($p<0.001$) among the varieties (Table 1). Mean value of the varieties ranged from 62.1-105.3 cm with a mean of 79.3 cm. Of the 9 varieties evaluated, Marglobe was the tallest (105.3 cm) while Miya scored the shortest plant length (62.1 cm). This finding is in relation with the report of Hussain *et al.* (2001) who found wide range of difference (61.6-126.5 cm) in plant length for 10 tomato genotypes evaluated in Pakistan. Similarly, Dufera (2013) obtained wide difference (51.5-129.7 cm) for plant height in tomato.

Number of fruit clusters per plant was significantly ($p<0.001$) different for the varieties (Table 1). The highest number of fruit clusters were recorded by Melkasalsa (27.4) and the minimum by Bishola (9.6) (Table 3). Total number of fruits per plant showed very highly significant ($p<0.001$) difference among the varieties. Mekasalsa scored the highest number of fruits per plant (100) followed by Cochoro (64). While, Bishola scored the minimum (16). Many authors such as Emami *et al.* (2013) (33-79), Abdelmageed and Gruda (2009) (17.16-50.7) and Chernet *et al.* (2013) (4-97) reported wide range of difference in number of fruits per plant in tomato genotypes.

Fruit yield per plant showed very highly significant difference ($p<0.001$). The highest fruit yield per plant was scored by Melkasalsa (2.491 kg) and the minimum by Bishola (0.891 kg). This is in line with the finding of Saleem *et al.* (2013) who found highest fruit yield per plant (2.48 kg) for 30 tomato genotypes evaluated in Pakistan. Similarly, Chernet *et al.* (2013) reported highest fruit yield per plant (2.10 kg) for 36 tomato genotypes. Fruit yield per hectare showed very highly significant ($p<0.001$) difference among the varieties (Table 2). The highest marketable yield was obtained by Melkasalsa (56.07 t ha^{-1}) and the least yield was recorded by Bishola (17.89 t ha^{-1}). Melkasalsa had 73.86% yield increment over Melkasola (32.25 t ha^{-1}), the check used (Table 4).

Table 3: Response of tomato varieties for different growth and yield components

Varieties	DFL	DFr	DM	PHT (cm)	NBR	FlPC	FrPC	FrCPP	MFrPP
Bishola	38^{a}	94^{a}	121^{a}	83.2^{cb}	10.7^{bac}	3.8	2.6	9.6^{e}	16^{e}
Chali	29^{c}	76^{cb}	103^{dc}	70.1^{e}	8.9^{dc}	3.9	2.7	17.1^{cb}	40^{c}
Cochoro	29^{c}	72^{cde}	102^{d}	70.4^{e}	9.3^{bdc}	4.0	3.1	24.1^{a}	62^{b}
Marglobe	32^{bc}	66^{f}	96^{d}	105.3^{a}	9.0^{dc}	4.2	2.8	17.9^{b}	27^{d}
Fetan	29^{c}	73^{cd}	104^{bdc}	77.6^{cd}	10.4^{bac}	3.8	2.6	12.0^{ed}	21^{ed}
Melkasalsa	31^{bc}	67^{fe}	112^{bac}	76.3^{ed}	12.3^{a}	4.4	3.0	27.4^{a}	100^{a}
Melkashola (check)	32^{bc}	80^{b}	117^{a}	83.5^{cb}	11.0^{ba}	3.9	2.5	13.3^{ced}	45^{c}
Metadel	35^{ba}	65^{f}	113^{ba}	85.2^{b}	10.6^{bac}	4.1	3.0	15.2^{cbd}	25^{d}
Miya	35^{ba}	68^{fe}	96^{d}	62.1^{f}	8.3^{d}	4.0	3.1	16.2^{cb}	44^{c}
SEM (±)	0.68	1.76	3.85	2.38	0.29	0.08	0.09	1.11	4.85
CV (%)	7.3	4.37	5	4.60	11.04	8.23	15.36	14.15	11.51

DFL: Days of 50% flowering, DFr: Days of 50% fruiting, DM: Days to maturity, PHT: Plant height, NBR: No. of branches, FlPC: No. of flowers per cluster, FrPC: No. of fruits per cluster, FrCPP: No. of fruit clusters per plant, MfrPP: No. of matured fruits per plant, SEM: Standard error of the mean, CV: Coefficient of variation, Means in the same column connected with the same letter are not significantly different at $p \leq 0.05$

Table 4: Response of tomato varieties to yield components, fruit yield and fruit characteristics

Varieties	FrYPP (kg)	FrWt (g)	FDP (mm)	ED (mm)	SHI	MYLD (t ha^{-1})	UnMYLD (t ha^{-1})
Bishola	0.8910^{e}	86.40^{a}	48.50^{bc}	53.30^{a}	0.90^{e}	17.89^{e}	1.11^{c}
Chali	2.2590^{a}	66.20^{bc}	55.70^{ba}	45.10^{b}	1.20^{c}	49.28^{ab}	1.97^{bc}
Cochoro	$2.143.1^{ba}$	77.90^{ba}	61.50^{a}	49.00^{ba}	1.30^{c}	48.26^{ab}	1.33^{c}
Marglobe	1.8580^{bc}	58.80^{c}	39.10^{c}	45.90^{ba}	0.90^{e}	36.52^{bc}	3.43^{a}
Fetan	0.8950^{e}	66.40^{bc}	54.50^{ba}	45.50^{b}	1.20^{c}	21.78^{de}	1.38^{c}
Melkasalsa	2.4910^{a}	40.40^{d}	56.90^{ba}	31.20^{c}	1.80^{a}	56.07^{a}	2.81^{ab}
Melkashola (check)	1.1970^{de}	53.43^{c}	59.90^{ba}	36.60^{c}	1.60^{b}	32.25^{cd}	1.34^{c}
Metadel	$1.274.8^{d}$	55.50^{c}	42.50^{c}	47.10^{ba}	0.90^{e}	26.06^{cde}	1.78^{bc}
Miya	1.5570^{dc}	57.20^{c}	49.00^{bc}	45.50^{b}	1.10^{d}	39.66^{bc}	1.62^{c}
SEM (±)	0.1150	2.77	1.77	1.38	0.06	12.40	18.90
CV (%)	13.1500	12.03	12.98	9.76	5.72	2.615	0.20

FrYPP: Fruit yield per plant, FrWt: Single fruit weight, FDP: Fruit polar diameter, ED: Equatorial diameter, SHI: Shape index, MYLD: Marketable yeild, UnMYLD: Unmarketable yeild, SEM: Standard error of the mean, CV: Coefficient of variation, means in the same column connected with the same letter are not significantly different at $p \leq 0.05$

Single fruit weight showed a very highly significant difference ($p<0.001$). The largest fruit size was obtained from the variety Bishola (86.4 g) whereas, the smallest fruit size was recorded from Melkaslsa (40.4 g). Similarly, Hussain *et al.* (2001) reported a wide difference (48.7-88.3 g) in fruit weight for 11 tomato genotypes.

A very highly significant difference ($p<0.001$) was also recorded in shape index (Table 2). Mean result of the varieties ranged from 0.9-1.8. Melkasalsa and Melkashola scored the highest index (1.8 and 1.6) indicated that they have relatively pear or oblong shape while, Metadel and Bishola scored the least index (0.9) revealed that they have relatively round/flattened shape.

Generally, mean result demonstrated that Melkasalsa scored the highest marketable yield (56.07 t ha^{-1}) which is statically at par with Chali (49.28 t ha^{-1}) and Cochoro (48.26 t ha^{-1}). While, the highest unmarketable fruit yield recorded from Marglobe (3.43 t ha^{-1}) indicated this variety deteriorate easily than other varieties.

Pearson correlation (r) of marketable fruit yield with other characters showed that fruit yield per hectare had a very highly significant positive correlation with fruit yield per plant ($r = 0.903$),

Table 5: Pearson correlation (r) of yield components and fruit yield of tomato varieties studied in Humera

Correlation	PHT	NBR	FlPC	FrPC	FrCPP	FrPP	FrYPP	FrWt	FPD	FED	SHI	MYLD
DM	0.125	0.438*	-0.295	-0.288	-0.222	-0.008	-0.360	0.081	0.146	-0.115	0.256	-0.336
PHT		0.132	0.427*	-0.141	-0.125	-0.321	-0.134	-0.038	-0.441*	0.048	-0.299	-0.257
NBR			0.055	-0.184	0.157	0.328	-0.045	-0.266	0.217	-0.343	0.460*	0.015
FlPC				0.335	0.376*	0.207	0.335	-0.323	-0.270	-0.222	0.001	0.354
FrPC					0.439*	0.219	0.301	-0.189	-0.015	0.058	-0.085	0.420*
FrCPP						0.853***	0.840***	-0.373	0.205	-0.456*	0.467*	0.850***
FrPP							0.746***	-0.480*	0.446*	-0.640***	0.784***	0.807***
FrYPP								-0.251	0.280	-0.301	0.400*	0.903***
FrWt									0.217	0.839***	-0.444*	-0.423*
FPD										-0.018	0.695***	0.267
FED											-0.718***	-0.478*
SHI												0.501***

DM: Days to maturity, PHT: Plant height, NBR: No. of branches, FlPC: No. of flowers per cluster, FrPC: No. of fruits per cluster, FrCPP: Fruit cluster per plant, FrPP: No. of fruits per plant, FrYPP: Fruit yield per plant, FrWt: Single fruit weight, FPD: Fruit polar diameter, FED: Fruit equatorial diameter, SHI: Shape index, MYLD: Marketable yield, *,***Significant and very highly significant, respectively

number of fruits per plant (r = 0.807), number of fruit clusters per plant (r = 0.850) and shape index (r = 0.501) (Table 5). Similarly, Regassa *et al.* (2012) reported highly positive significant association of fruit yield per plant (0.98) and number of fruits per plant (0.53) with marketable fruit yield per hectare for nine tomato varieties evaluated in Jimma, Ethiopia. Akindele *et al.* (2011) also found highly significant positive association of number of fruits per plant (0.67) and fruit yield per plant (0.61) with fruit yield per hectare for ten hybrid tomato varieties evaluated in Nigeria. Marketable fruit yield had significant negative correlation with fruit equatorial diameter (r = -0.478). This demonstrated that fruits with pear/oval shape had highest yield (t ha^{-1}) than the flattened/round shaped once under the study area for the specified varieties.

Correlation among other characters demonstrated that number of fruit cluster had very highly significant positive correlation with number of fruits per plant (r = 0.853) and fruit yield per plant (r = 0.840). Similarly, number of fruits per plant had very highly significant correlation with fruit yield per plant (r = 0.746). Fruit equatorial diameter had very highly significant negative association of shape index (r = -0.718). This is in agreement with the finding of Regassa *et al.* (2012), who reported highly significant negative correlation of shape index (-0.70) with equatorial diameter, significant positive association of number of fruits per cluster (0.52) with number of fruits per plant and fruit yield per plant (0.50). Number of fruits per plant showed significant negative correlation with single fruit weight (r = -0.480). This is because the varieties which had highest number of fruits per plant had relatively small size fruit.

Generally, 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.

CONCLUSION

Of the studied nine tomato varieties, Melkasalsa showed highest scores in number of branches (12.3), number of fruit clusters (27.4), fruits per plant (100), fruit yield per plant (2.491 kg) and marketable fruit yield per hectare (5.607 t ha). Melkasalsa showed 73.6% yield increment over the check (Melkashola). Association of characters indicated that fruit yield per plant, number of fruits per plant, number of fruit clusters per plant and shape index are most important fruit yield components. Therefore, the above traits could be considered as selection criterion in tomato improvement program.

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