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Response of Tomato Varieties for Yield and Related Traits in Dry Season Using Irrigation at Fogera Plane, Ethiopia

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Abstract: Irrigated dry season tomato production is widely practiced at Fogera district and its surrounding areas. However, the production does not meet farmers demand because of they use obsolete tomato varieties: Chochero and Roma F, which are becoming poor performances now a days. Besides, farmers in the areas have information gap on the availability of other improved tomato varieties. It was therefore conducted an experiment to evaluate the performance of improved tomato varieties in an open field using irrigation in dry season with the aim of identifying superior varieties with high productivity and good quality of fruits. Eleven tomato varieties were laid down in randomized complete block design with three replications at Fogera research station in dry seasons of 2018 and 2019. The combined mean analysis of variances (ANOVA) results showed highly significant ($P < 0.01$) effects of varieties and years but insignificant ($P < 0.05$) interaction effect of varieties with years for most traits considered. From the overall mean analysis results, ARPd2 tomato was best-performed variety with the highest yield and good desirable traits. Congruently, Chali, Gelelima, and Fetan varieties were also produced high yield with bigger fruit sizes. However, the result of the present investigation was only in a research station without farmer's participation. Therefore, it is recommended that varieties ARPd2 tomato, Chali, Gelelima, and Fetan needs further validation study on different farmers' fields with their active participate at Fogera and its surroundings to determine their stability and farmers preference.

Keywords: Fresh Tomato, Marketable Yield, Off-season, Selection

1. Introduction

Tomatoes (Lycopersicon esculentum Mill.) are members of the Solanaceae family, which includes peppers, eggplant, Irish potatoes and tobacco. The central and south America are the origin and diversification of tomato crop. It is one of the most important edible and nutritious vegetable crops in the world [5]. According to FAOSTA [7] explanation the total world tomato production in 2012 was estimated about 168.1 million tons with about 4.8 million ha of total production area. Tomato has high nutritional value like a source of vitamins, sugars, anti-oxidant- lycopene, potassium, calcium and other minerals [15]. Based on the description of [10] from a medium ripe tomato (145 grams) can provide up to 40 percent of the recommended daily allowance of vitamin C and 20 percent of vitamin A and also contribute vitamin B, Potassium, Iron and Calcium to the diet.

In Ethiopia, it is also one of the major commercial vegetable crops and grown widely. It can be grown between 700 and 2000 m above sea level, with about 700 to over 1400 mm annual rainfall in different soils under different weather conditions [12]. In Fogera, Dera and Libokemkem Districts in North West Ethiopia, small-scale tomato production for fresh market is a common practice and continues farming in off-season under irrigation for long time. Accordingly, growers, merchants, consumers, intermediaries and transporters are highly benefited from this tomato production in the areas.

However, the production in these areas does not meet the farmers and other producers demand due to different constraints faced in their field production. Mainly, growers use obsolete tomato varieties: Chochero and Roma F, which give relatively low yield and vulnerable to frost and other stress. This is due to growers lack information on the availability of many other new improved varieties released from different research centers and seed of those varieties are further unavailable in the surrounding town or market. Hence, to improve tomato productivity and address the

overall challenges, evaluation of improved and competitive varieties in these areas is crucial. Based on [6] description most modern/recently improved varieties have the ability to offer much higher yield, better quality and more stable than the obsolete ones/earlier modern varieties. This study was therefore conducted to evaluate the performance of released tomato varieties in an open field using irrigation in the dry season with the aim of identifying superior varieties with high productivity and superior quality of tomato fruits.

2. Materials and Methods

The field experiment was laid down in Randomized Complete Block Design with three replications. The plot size was 4m long and 3m wide ($12m^2$) with 1.5m and 1m spacing between replications and plots, respectively. The spacing between plants was 30cm. 11 tomato varieties viz: Gelelima, Cochero, Metadel, Miya, ARPd2tomato, Bishola, Chali, Fetan, Eshet, Melka Salsa and Melka shola were tested in dry-season using irrigation. They are open pollinated varieties that were released from Melkasa Agricultural Research Center [4, 13]. About 300g per ha (0.36kg/plot) of seed rate was used to grow the healthy seedling. The seed was sown in a raised seedbed with the height of 15cm and 1m x 10m width and length, respectively. Transplanting of seedling on a prepared ridge with 20- 35 cm height and 1m spacing between ridges were taken places after seedlings attain transplantable size in four weeks [8]. Fertilizer was applied with the amount of 242 kg/ha NPS and 100 kg/ha Urea. NPS was fully applied at transplanting while urea is applied in two splits, the first half percent a week after transplanting and the second half- percent half months after transplanting. Irrigation was supplied immediately after sowing at nursery or transplanting at open field as well as per a week during growing times [8]. Weeding, hoeing and all other important recommended cultural practices were applied uniformly to the entire plots.

Data collections for some important traits were collected at plant basis from ten randomly selected plants from each plot while some were at plot basis level.

On plant Basis: Fruit length (mm): recorded at polar of fruit (from stem end to blossom end) for ten random selected samples per plot at harvesting stages.

Fruit diameter (mm): measured at the largest cross-sectioned of fruit from ten random selected samples per plot at harvesting stages and the mean value was taken for evaluation.

Individual fruit weight (gram): recorded mean value from ten randomly selected samples of individual fruit weight from each plot during harvesting.

On Plot Basis: Days to 50% flowering: recorded the number of days from transplanted to the date of 50% flowering for each plots.

Days to maturity: count up the number of days from transplanted to the date of matured for each plots.

Marketable fruit yield (ton/hectare): marketable fruits selected and recorded from each successive harvested matured fruits per plots and then sum up and converted to ton per hectare.

Non-marketable yield (ton/hectare): recorded the non-marketable fruit yield which were under size, diseased, cracked and sunscald) from each successive harvested fruits and expressed in terms of percent calculated as (non-marketable fruit yield/ the total harvested fruit yield) x 100.

Total fruit yield (kg/ha): was calculated as the sum of weight of marketable and non-marketable fruit yield from the net plot areas and converted into ton per hectare.

Data was subjected to analysis of variance (ANOVA) using SAS [14] version 9.1 Software, and varieties means were compared using list significant difference (LSD) at 5% significant level [9].

3. Results and Discussion

The combined mean analysis of variances (ANOVA) for fruit yield and related traits of eleven tomato varieties growing in dry season of 2018 and 2019 are presented in Table 1. The analysis of variance showed highly significant ($p<0.01$) effect of year for all traits considered except total fruit yield and non-marketable fruit yield. Likewise, highly significant ($P<0.01$) effect of varieties were observed for fruit length, fruit width, fruit weight and days to first harvest and significant ($P<0.05$) varieties effect for marketable yield and days to 50% flowering. The results indicated that the observed difference among varieties for these traits were might be due to genetic potential of varieties differed from one another. Similarly, [16] also found that the marketable fruit yield (t/ha) was highly significantly ($P<0.01$) different among 12 tomato varieties for the marketable fruit yield over two locations under irrigation growing condition in Western Ethiopia. The statistical analysis result in this experiment also showed that varieties were not significant effect on total fruit yield and non-marketable fruit yield. In the same way, the interaction effect of variety with year was insignificant for all traits considered except individual fruit weight. These results indicated the consistence response of tested tomato varieties across seasons for those traits even if the variations between two dry seasons were observed.

The response of different varieties for fruit yield in Fogera plane over two dry seasons (2018 and 2019) was showed in table 2. As a result, significant ($P<0.05$) differences were observed among varieties with regard to marketable fruit yield in both dry seasons of 2018 and 2019 and total fruit yield in the dry season of 2018. The maximum marketable fruit yield was recorded from Gelelima (41.3t/ha) variety in dry season of 2018 while the minimum was from Bishola (18.53t/ha) variety in dry season of 2019. The present investigation was in covenant to [17] and they obtained the average marketable fruit yield ranged from 33.85 t/ha to 46.05t/ha in open field using irrigation. The results also indicated that the performance of varieties regards to total fruit yield was higher in the first dry season (44.23t/ha) than the second ones (37.15t/ha). The results in table 2 also

revealed that varieties have no significant (P<0.05) difference for days to 50% flowering. The shortest number of days to 50% flowering was recorded from Chochero variety (46 days) in dry season of 2018 while the maximum days to attained 50% flowering was recorded from Bishola variety (63.3 days) in dry season of 2019.

Table 1. *Combined mean squares (ANOVA) for fruit yield and related traits of eleven tomato varieties over two dry seasons.*

Source of Variation	DF	Mean squares							
		MFY	Non-MFY	TFY	FL	FWD	FWT	DFD	DM
Replication	2	161.8	2.2	199.5	5.7	3.6	78.0	38.924	0.92
Year	1	854.5**	24.9ns	1171.0**	3.12ns	368. 63**	126227**	643.0**	268.02**
Variety	10	119.40*	9.14ns	117.2ns	63.2**	307.9**	1394**	28.98*	231.6**
Year*Variety	10	68.5ns	6.15ns	77.4ns	16.7ns	48.2ns	1390**	18.24ns	14.948ns
Error	42	55.5	11.0	67.8	12.0	40.0	59.0	12.12	24.62

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, respectively. Df= Degree of freedom, MFY=Marketable fruit yield, TFY=Total fruit field, FL= Fruit length, FWD= Fruit width, FWT=Fruit weight, DFD=Days to 50% flowering and DM= Days to Maturity.

Table 2. *Response of eleven tomato varieties to fruit yield and days to 50% flowering in dry seasons of 2018 and 2019.*

Varieties	Marketable yield (t/ha)		Total Yield (t/ha)		Days to 50% flowering		Percent of non-marketable yield	
	2018	2019	2018	2019	2018	2019	2018	2019
Melka Salsa	30.0	31.24	33.5	38.01	50.7	52.3	10.4	17.8
Eshet	33.0	20.04	40.4	28.35	48.3	57.0	18.4	29.3
Metadel	40.9	27.64	51.3	34.66	48.3	59.3	20.4	20.3
Melka Shola	38.4	32.84	47.7	44.26	50.7	56.0	19.6	25.8
Miya	36.2	31.35	46	40.95	49.7	54.7	21.5	23.4
Gelelima	41.3	35.29	49.5	42.74	49.3	56.7	16.6	17.4
ARPd2 tomato	38.3	39.00	45.3	46.35	49.3	50.3	15.5	15.8
Bishola	23.3	18.53	29.3	27.11	52.3	63.3	20.4	31.7
Chali	41.9	33.38	49.7	38.85	47.7	53.3	15.5	14.1
Chochero	36.3	27.08	45.6	31.63	46.0	55.0	16.4	14.4
Fetan	40.2	31.62	48.1	37.15	52.0	55.0	18.0	14.8
GM	36.34	29.82	44.23	37.28	49.5	55.7	-	-
CV	19.51	21.70	16.12	19.6	5.12	7.2	-	-
LSD 0.05	11.9 *	11.02 *	1.215 *	12.4 NS	4.31 NS	6.8 NS	- -	- -

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, GM= Grand Mean, CV=Coefficient of Variation and LSD= Least significant difference.

Table 3. *Response of eleven tomato varieties to days to maturity, fruit weight, fruit width and fruit length in dry seasons of 2018 and 2019.*

Varieties	Days to Maturity		Fruit weight (gm.)		Fruit width (mm)		Fruit length (mm)	
	2018	2019	2018	2019	2018	2019	2018	2019
Melka Salsa	76.4	75.0	42.1	35.5	39.5	50.0	60.6	64.9
Eshet	88.0	93.7	53.3	56.2	93.7	140.0	55.1	58.9
Metadel	85.7	95.3	55.4	62.2	127.2	180.0	59.2	57.5
Melka Shola	82.0	82.7	37.5	48.8	53.5	70.0	60.5	62.9
Miya	78.0	82.7	39.2	48.9	58.9	90.0	51.8	51.6
Gelelima	80.7	81.3	43.7	55.4	70.7	100.0	60.6	65.4
ARPd2 Tomato	75.0	77.3	54.5	56.2	107.4	100.0	61.4	59.6
Bishola	91.7	98.7	58.3	64.2	123.8	120.0	56.6	56.2
Chali	81.3	83.0	45.2	53.5	68.6	80.0	57.7	58.9
Chochero	84.7	90.0	57.5	56.8	111.8	90.0	61.4	54.9
Fetan	79.3	86.0	54.6	55.5	108.3	70.0	59.2	58.2
GM	82.0	86.0	49.2	53.9	87.6	100.0	58.6	59.0
CV	5.98	5.9	13.6	11.6	12.3	31.5	3.5	7.0
LSD 0.05	8.35 *	8.7 **	11.4 **	10.6 **	18.3 **	61.0 **	3.5 **	7.0 *

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, GM= Grand Mean, CV=Coefficient of Variation and LSD= Least significant difference.

The studied varieties showed highly significant (P<0.05) difference regards to fruit weight and width, and significant (P<0.05) difference in terms of days to 50% flowering in dry season of 2018 and fruit length in dry seasons of 2019. In this study, ARPd2 tomato required shortest day (75 days) to mature in dry season of 2018 meanwhile Melka salsa attained shortest day (75 days) to mature in dry season of 2019. Bishola variety gave highest fruit weight in both dry seasons of 2018 and 2019 with values of 58.3gm and 64.2gm, respectively. In similarly manner, Metadel variety

attained the highest fruit diameter in both dry seasons of 2018 and 2019 with the values of 127.2mm and 180mm diameters, respectively. The results also indicated that the longest fruit size was recorded from ARPd2 tomato and Chochero varieties (61.4mm) in 2018 dry season. However, longest fruit size in 2019 dry season was exhibited from Gelelima (65.4mm) followed by Melka salsa (64.9mm) varieties.

The overall mean analysis results over two dry seasons of 2018 and 2019 for marketable fruit yield, total fruit yield, percent of no-marketable fruit yield and days to 50% flowering were displayed in table 4 below. The highest marketable fruit yield from combined analysis over two dry seasons was obtained from variety ARPd2 Tomato (38.7 t/ha) followed by Gelelima (38.3 t/ha), Chali (37.7t/ha), and Fetan (35.93t/ha) while the lowest was from variety Bishola (20.91 t/ha). Percent of non- marketable yield on the other hand was high for variety Bishola (31.3%) and low for variety Chali (15.0%) and ARPd2 tomato (15.7%). The total produced fruit yield ranged from Bishola variety (28.21t/ha) to Gelelima variety (46.12t/ha). The present finding was in line with [3] who indicated the mean fruit yield of varieties ranged from 14.88t/ha to 47.55t/ha with significant varietals differences. ARPd2 tomato variety gave the shortest days to 50% flowering (49.8days) and Bishola variety attained the longest days to 50% flowering (57.8days) from the overall mean result of two dry seasons. This result values were similar to [1] who found that highly significant difference among their tested tomato varieties with the range values of 47.7 to 57.3 days to 50% flowering.

Table 4. *Overall mean analysis results of two dry seasons for marketable yield, total yield, percent of non-marketable yield and days to 50% flowering.*

Varieties	Marketable yield (t/ha)	Total yield (t/ha)	Non-marketable yield (t/ha)	Percent of non-marketable yield	Days to 50% flowering
Melka Salsa	30.62	35.77	7.93	22.2	51.5
Eshet	26.51	34.36	7.85	22.8	52.7
Metadel	34.27	42.98	8.74	20.3	53.8
Melka Shola	35.60	45.99	10.39	22.6	53.3
Miya	33.75	43.48	9.73	22.4	52.2
Gelelima	38.29	46.12	7.83	17.0	53.0
ARP d2 tomato	38.66	45.85	7.19	15.7	49.8
Bishola	20.91	28.21	8.84	31.3	57.8
Chali	37.66	44.30	6.64	15.0	50.5
Chochero	31.68	38.64	6.95	18.0	50.5
Fetan	35.93	42.66	6.72	15.8	53.5
GM	33.42	40.76	8.07	-	52.6
CV	22.3	19.84	41.15	-	6.62
LSD 0.05	8.68	9.59	3.87	-	4.05
	NS	NS	NS	-	NS

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, GM= Grand Mean, CV=Coefficient of Variation and LSD= Least significant difference.

Table 5. *Overall mean analysis results of two dry seasons for days to maturity, fruit weight, fruit width and fruit length.*

Varieties	Days to Maturity	Fruit weight (gm.)	Fruit width (mm)	Fruit length (mm)
Melka Salsa	75.7	38.8	44.7	62.7
Eshet	90.8	54.7	116.8	57.0
Metadel	90.5	58.8	127.2	58.3
Melka Shola	82.3	43.1	61.3	61.7
Miya	80.3	44.0	74.4	51.7
Gelelima	81.0	49.6	85.4	63.0
ARP d2 Tomato	76.2	55.3	103.7	60.5
Bishola	95.2	61.2	121.9	56.4
Chali	82.2	49.4	74.3	58.3
Chochero	87.3	57.1	100.9	58.1
Fetan	82.7	55.1	89.2	58.7
GM	84.0	51.6	90.9	58.8
CV	5.91	12.3	24.7	5.9
LSD0.05	5.78	7.4	26.9	403.0
	NS	NS	NS	NS

Where, *, ** and NS indicates significant, highly significant and insignificant at 0.05 probability level among varieties, GM= Grand Mean, CV=Coefficient of Variation and LSD= Least significant difference.

The combined analysis of days to maturity, individual fruit weight, fruit width and fruit length revealed no significant ($P<0.05$) difference among studied tomato varieties from one another for these traits considered (Table 5). The early matured variety was recorded from Melka Salasa (76 days) followed by ARPd2 tomato (77days) whereas the late matured variety was Bishola (95 days) which is similar to [11] results who reported Bishola variety matured within 100 days. In this study, individual fruit weight was also ranged from 61.2gm to 38.8gm produced by Bishola and Melka Salsa varieties,

respectively. This finding was in agreement with the observation of [2] who reported the maximum and minimum average fruit weight for Bishola (0.17kg) and Melkasalsa (0.04kg) from twelve tested tomato varieties at Tepi in South Western Ethiopia. In this experiment, the widest fruit size was obtained from Bishola variety (121.9mm) while the longest fruit size was recorded from Gelelima variety (63.0mm). On the other hand, the lowest diameter and shortest polar of fruit sizes were obtained from Melka salsa (44.7mm) and Miya (51.7mm) varieties, respectively.

4. Conclusion and Recommendation

The overall mean analysis results of this study showed highly significant ($P<0.01$) effects of years and varieties for most traits considered. On the other hand, insignificant ($P<0.05$) interaction effect of varieties with years were found for most traits measured. In this study in general, variety ARPd2 tomato was best performed with good desirable traits. It was produced the highest marketable fruit yield with early maturing date and less percentage of non-marketable fruit yield from the overall mean analysis result of two dry seasons at Fogera Plane. Furthermore, variety ARPd2 tomato produced the bigger fruit size regards to fruit weight, length and width that are preferred for good market prices in the areas. Correspondingly, Chali, Gelelima, and Fetan varieties were also produced high yield with bigger fruit sizes in open fields at Fogera research station in two dry seasons using irrigation. However, the result of the present investigation was only in a single environment / research station over two dry seasons without farmer's participation. That means, further study in different locations with the complementary of farmer preference using their criteria is required to determine their stability and environmental interactions as well as farmers demand. It is therefore, varieties ARPd2 tomato, Chali, Gelelima, and Fetan will be recommended for further validation on different farmers' fields with their active participate at Fogera and its surroundings.

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