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Adaptability study and evaluation of improved varieties of tomato (*Lycopersicon esculentum* L.) under irrigation for their yield and yield components in east Wollega, western Ethiopia.

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Abstract

The objectives of the study were to evaluate and select the best adapted released varieties of tomato under irrigation in east Wollega, western Ethiopia. Five of tomato varieties were tested for yield and yield related traits in completely randomized block design in three replications at Wayutuka district, Alaltu Negade irrigation project on farmer land in 2020/21 under irrigation. Data were taken days to 50% flowering, days to first harvest, plant height, number of primary branches, number of fruit per plant, single fruit weight, fruit length, fruit width, fruit yield per hector, marketable fruit yield and unmarketable fruit yield. The analysis of variance showed that the varieties were significantly different for all traits except for plant height and number fruit per plant. Among all tested varieties ARP-d2 tomato variety gave the maximum fruit yield (23.7 t/ha) followed by Melka shola (21.8 t/ha). Also the maximum marketable yield was recorded from ARP-d2 tomato variety (22.7 ton/ha). Results of the analysis of variance (ANOVA) showed highly significant difference for most of the characters among the varieties. Pearson correlation (r) of fruit yield with other characters showed highly significant positive correlation with number of primary branches, marketable yield) and non-significantly positive correlation with fruit number per plant, single fruit weight, fruit width and fruit length. Fruit number per plant was showed positive correlation with characters' plant height (r=0.02), number of primary branches, single fruit weight and fruit width. Marketable yield was highly significant and positive correlation with number of primary braches, fruit number per plan, fruit width and fruit yield.In the present study, variety ARP d2 variety and Melka shola were found superior in economic yield (marketable yield) and other parameters that it was recommended for further popularization in east Wollega, WayuTuka district under irrigation. Since the experiment is one site one season experiment, further studies using combination of locations and seasons is required to generate more reliable information on performance of varieties across location and year.

Keywords: Tomato, variety evaluation, analysis of variance, correlation

Introduction

Tomato (*Lycopersicon esculentum* L.) is one of the most widely grown vegetable crops in the world, second to potato (FAO, 2005; Maerere et al., 2006). Tomatoes are used not only for fresh table food, but also for ketchup, puree, sauces and in many other ways. Tomatoes have been used as food by the inhabitants of Central and South Americas since prehistoric times (Choudhoury, 1967). It originally came from tropical area from Mexico to Peru. All tomato varieties in Europe and Asia are said to be descendants of the seeds taken from Latin America to Europe and Asia by the Spanish and the Portuguese merchants during the 16th century. African tomatoes, on the other hand, were introduced by European merchants or colonizers. Thus, today, modern tomato cultivars and hybrid can be grown and can produce fruit in climates far different from the site of its origin. It has become one of the most popular vegetables in the tropics and other countries in Asia and the rest of the world (Villareal, 1979). Tomato is a warm season crop and plants cannot stand severe frost. The crop does well under an average monthly temperature of 21 oC to 23 oC but commercially it may be grown at a temperature ranging from 18 oC to 27 oC. In most tropical countries, average yield ranges between 2 to 10 tons of fruit/ha, against yields of 20 tons in South Korea, 40 tons in the USA, 50 tons in Japan and over 130 tons in the Netherlands (Von Uexkull, 1979). It is obvious that the highest yields are found in the temperate countries. On the other hand, tomato production in the hot, wet, lowland tropics is often hampered by diseases and pests (Yang, 1979). In the hot season needs heat tolerant because of the period of high temperatures during summer. Furthermore, the to be used should be resistant to the major yield-reducing pests and diseases such as nematodes and late blight (Villareal& Lai. 1979).

In Ethiopia, there is no exact information as to when tomato was first introduced; however, the crop is cultivated in different major growing areas of the country. In 2015 cropping calendar, tomato production in Ethiopia was about 22,788 tons from harvested area of 3,677 ha (CSA 2015). It is used as canned vegetable having multiple uses and supplies essential nutrients in human diets (Choudhury, 1979). It is popularly used for both commercial and home use purposes. The fresh produce is sliced and used as salad. It is also cooked for making local saucer ('watt'). The processed products like tomato paste, tomato juice, tomato catch-up and whole peel-tomato are produced in the country for local market and export. It was recognized as quality product for both local and export markets and providing a route out of poverty for small scale producers who live in developing countries in general and in Ethiopia in particular (Tewodros and Asfaw, 2013).Despite the importance of this crop, the production and productivity is constrained by different biophysical and socio-economic reasons, such as lack of adapted and improved tomato technologies, land shortage, inadequate knowledge on production and management (processing) systems, poor extension services, poor marketing system and proper utilization of the crop are a few to mention (Mersha, 2008). A number of technologies exist and if adopted would improve yield of tomato. One of the key technological components in tomato production is the development of new varieties which are pest and disease resistant that would contribute to increased yield. Improved new varieties which can resist and tolerate the aforementioned unfavorable factors are among the technologies developed.

Successful cultivation of tomato is based essentially upon the choice of suitable varieties for a particular location (Chaerani, 2006). The farmers choose tomato variety to grow depending on a number of factors which include production potential, market demand, regional adaptability, pest and disease resistance and the end use of the product (Orzolek et al., 2006). One of the key constraints in adapting tomato varieties are crop pests and diseases which may require integrated pest and disease management options (Raini et al., 2005). The availability of seeds and the cost of seeds affect the adoption of the varieties by the farmers. If the seeds are expensive and difficult to obtain, the farmers find other available cheaper varieties in the local market. Resistance in the host plant has been reported to be the most effective means of management (Yu et al., 1995; Blancard (1997) other methods of managing the diseases and pests include removal of plant debris, removal of weeds, rotation, and the use of non-infested seed and seedlings (CAB International 2005). Farm chemicals have also been used, but these may not be effective where the weather is favorable for pest and disease development. In view of increasing concerns over the long term negative environmental impact of some chemicals (Stoll 1998), their rising costs, the search for effective options for managing the pests and diseases has recently focused on the development and evaluation of pest and disease varieties. Most vegetable cultivar trials, including tomato, focus on yield and quality attributes at different areas of Ethiopia, but similar research is not conducted in western parts. Therefore, it was very important to evaluate the performance of these varieties at western Ethiopia. The objective of the trials was to evaluate the yield performance and productivity of varieties of tomato in east Wollega

Objectives

The general objectives of the study were;

✓ To evaluate differenttomato varieties for their yield and yield components under irrigationin east Wollega, western Ethiopia.
✓ To select the high yielder varieties of tomato for the area.

Materials and Methods

Description of study area

The experiment was conducted at WayuTuka district, Gida Abalokebele east wollega, under modern irrigation of Alaltu Negade project, in western Ethiopia. Its locatedat 320km away from the capital city(Addis Ababa) to the south on the way to Nekemte, latitude of 8°52'40.89"Nand 36°32'58.38"E longitude at altitude 1630 m.a.s.l. The area is categorized as sub-tropical agro ecology receiving mono-modal type of rainfall from Aprilto December. Production system of the area is mixed agriculture where the farmers produce field crops such as maize, teff, sorghum, finger millet and livestock such as cattle, sheep and chicken all in traditional method and root and tuber crops like potatoes, anchote, sweet potatoes and yam (Wayu Tuka Agricultural office, unpublished).

Planting materials

Four improved and recommended varieties of tomato, namely: ARP tomato d2, Melkashola, Miya and Gelelma, collected from Melkassa Agricultural Research Center and one local variety called Roman VFN introduced by Adama Farmers and Advisory Services, were tried for their adaptation using canal irrigation.

Table 1. Description of four tomato varieties and one local check used for the experiment.

Name of varieties	Year of release	Maintainer
ARP tomato d2	2012	MARC/EIAR
Melkashola	1997/98	MARC/EIAR
Miya	2007	MARC/EIAR
Gelelma	2015	MARCEIAR
Roman VFN	--------	-------

Source; Ministry of Agriculture and Natural Resources, crop variety register, issue no. 19

The experiment design was a RCBD with three replications. Four rows and ten plants per row with 70 cm inter rows and 30cm intra rows were used for this experiment. Two middle rows were used for data per plot leaving the two rows as border. A fertilizer rate of 200 kg/ha of NPS and 50 kg/ha of Urea (46-0-0) were applied at transplanting time and 50 kg/ha urea was applied after 7 weeks of transplanting. The seedlings were raised on bed at 10 cm distance between rows. The bed was kept moist but not wet. Transplanting was done at 32 days after sowing when the seedlings were about 10 to 15 cm length and at 2 to 3 leaf stage. Frequency of irrigation on field was at 3days'interval using surface canal water for two weeks and 7 days' interval after two weeks from transplanting until the soil is moist but not wet. All the agronomic practices were as per the recommendation from Melkasa Agriculture research center. No serious diseases were observe during this experiment, but local tomato worm was a problem so that removing of the attacked fruit was done by the daily laborers to reduce the transmission to the healthy fruits as much as possible.

Data collection

Data was collected from eleven (11) quantitative characters sampled from each plot per replication, via; days to 50% flower, days to first harvest, Plant Height (PH), number of primary branches, number of fruits per plant, single fruit weight, fruit length, fruit width, fruit yield per hectar, marketable yield and unmarketable yield.

Data Analysis

Analysis of variance for all the collected parameters was performed as per the methods described by Gomez and Gomez (1984) using SAS computer software (SAS9.3 version) for randomized complete block design and treatment mean comparison is done by Fisher's list significance difference (LSD) at 5%. Pearson's correlations among all the collected parameters were also evaluated.

Results and Discussion

Analysis of variance (ANOVA)

Results of the analysis of variance (ANOVA) showed highly significant difference for most of the characters among the varieties (Table 2). Days to 50% flower showed highly significant (P<0.01) and the mean ranges from 47.5-65.7 it means that Melka shola took the shortest period (47.5) to flower while Miya (65.7) was the late among five varieties (Table 3), this finding was agreed with the findings of Saleem *et al*. (2013). Days to first harvest also showed highly significant and the mean ranges from 62.9-82.5 these result also agreed with Eshteshabul et al. (2010) and Kaushik *et al*. (2011) and disagreed with the findings of Saleem *et al*. (2013) which was non significantly different. Fruit width showed highly significant difference and ranges from 12.5-19.2. Fruit length, Fruit yield and Marketable yield were highly significant among the varieties and ranges, 6.4cm-9.3cm, 13.8 ton-23.7ton and 11.7 ton-22.7 ton respectively which was agreed with Emami *et al*. (2013) for Fruit length and Marketable yield and disagreed for Fruit Yield. Plant height and number of primary branches were the traits which are non-significant among the five varieties of tomato grown in east Wollega under irrigation.

Table 2. Mean squares due to varieties and error for growth and yield components of 5tomato varieties grown in east Wollega in 2020/2 under irrigation.

Traits	Mean square		
	Variety	Error	P value
Days to 50% flower	168.4**	3.9	<0.0001
Days to first harvest	179.9**	5.6	<.0001
Plant height	93.4ns	27.8	0.06
No. of primary branch	2.06ns	1.3	0.27
Fruit no. per plant	359.9*	18.18	0.0003
Single fruit weight	34.02*	5.0	0.0252
Fruit width	24.7**	0.81	<.0001
Fruit length	2.28**	0.28	0.0067
Fruit yield	50.9**	0.59	<.0001
Marketable yield	59.4**	0.88	<.0001
Unmarketable yield	0.57*		0.0106

**-highly significant, *-significant, ns-non significant

Number of primary braches was non significantly different among the varieties of tomato. These finding was agreed with the findings of Baliyan and Rao (2013). Plant height was non-significantly different among the varieties of tomato and ranges from 47.3cm-62.1cm the longest plant height was recorded from Melka shola (62.1cm) whereas the shortest plant height was recorded from ARP-d2 tomato (47.3 cm) variety which was disagreed with the findings of Hussein *et al*. (2001) and Dufera (2013) who were found highly significant for plant height.

Table 3.Mean value of yield and yield components of five tomato varieties grown in east Wollega, Ethiopia.

Varieties	DF	DFH	PH	NPB	FNP	SFW	FW	FL	FY	MY	UMY
Gelelma	54.7c	68.0bc	51.2	6.56	32.0b	49.4c	12.5c	8.0[bc]	16.1c	14.8[c]	1.2[b]
ARP-d2	50.4d	62.9d	47.3	6.10	45.1a	58.1a	19.2a	9.3[a]	23.7a	22.7[a]	1.06[b]
Melka shola	47.5d	65.2cd	62.1	7.76	42.0a	50.8bc	15.9b	8.9[ab]	21.8b	20.7[b]	1.16[b]
Miya	65.7a	82.5a	51.2	6.86	24.4bc	52.7bc	13.4c	7.1[c]	20.5b	18.9[b]	1.6[ab]
Roman VFN (local)	60.9b	72.2b	54.7	5.56	19.6c	54.1ab	17.9a	7.8[c]	13.8d	11.7[d]	2.1[a]
C.V (%)	3.5	3.38	9.8	17.5	13.0	4.2	5.6	6.4	4.0	5.29	20.04
LSD (0.05)	3.7	4.47	ns	ns	8.02	4.2	1.69	1.0	1.45	1.77	0.54

DF-Days to 50 flowering, DFH-Days to first harvest, PH-Plant height, NPB-Number of primary branch, FNP-Fruit number per plant, SFW-Single fruit weight, FW-Fruit width, FL-Fruit length, FY-Fruit yield, MY-Marketable yield, UMY- Unmarketable yield.

Number of fruits per plant was highly significantly different (<0.0001) for the varieties tomato (Table 2). Fruit number per plant was ranges from 19.6-45.1. The highest number of fruits per plant were recorded from ARP-d2 tomato variety whereas the lowest number of fruit per plant was recorded from the local Roman VFN (Table 3). These finding was agreed with the findings of Saleem et al. (2013) who found highly significant for number of fruits per plant for tomato genotypes evaluated in pakistan and Chernet *et al*. (2013).

Single fruit weight was significantly different among the varieties of tomato evaluated at East Wollega of west Ethiopia which was agreed with the findings of Baliyan and Rao (2013) and Hussein *et al*. (2001) who were found highly significant for single fruit weight of tomato varieties evaluated for pest and disease and production in Botsawana. The highest single fruit weight was recorded from ARP-d2 (58.1g) and the lowest single fruit weight was recorded from Gelelma (49.4g) (Table 2).

Fruit width and fruit length were highly significant for five tomato varieties evaluated for their high yield in east Wollega and the finding was in line with the findings of Hussein *et al*. (2001) who was reported highly significant different for fruit width and fruit width for 11 different tomato varieties evaluated for their yields. From the current result the largest fruit width was recorded from ARP-d2 (19.2 cm) and the lowest was recorded from Gelelma (12.5 cm) and the largest fruit length was recorded from ARP-d2 (9.3 cm) variety and the lowest was recorded from Miya (7.1 cm) (Table 2) which is lower than the local variety Roman VFN (7.8 cm).

Fruit yield per hectare showed highly significant difference (<0.0001) and the result ranges from 13.8 ton/ha-23.7 ton/ha. The highest fruit yield was recorded from ARP-d2 (23.7 ton/ha) tomato variety whereas the lowest fruit yield per hectare was recorded from the local tomato variety Roman VFN (13.8 ton/ha) this might be due to different fruit size and shape of varieties; which indicates the best variety of the area is ARP-d2 these result was agreed with the findings of Chernet *at al*. (20013) and Baliyan and Rao (2013) who founds the highly significant different for fruit yield per plants.

Marketable yield was highly significant different (<0.0001) and the mean results ranged from 11.7 ton/ha recorded from local variety it's because of this local variety was highly affected by the local tomato worms before its maturity and 22.7 ton/ha the highest marketable yield recorded from ARP-d2 variety and the result was agreed with the findings of Gebisa *et al.*, (2017), Palada and Allison(2001) this variety was less affected by local tomato worms when its compared with all varieties planted at the study area and also this variety has high number of fruits per plant(Table 3).

Estimation of correlation coefficients of fruit yield and other parameters

Table 4. Pearson correlation for yield and other collected parameters from five tomato varieties grown in East Wollega in 2020/21 under irrigation.

Variables	DF	DFH	PH	NPB	FNP	SFW	FW	FL	FY	MY	UMY
DF	_	_	_	_	_	_	_	_	_	_	_
DFH	**0.84****	_	_	_	_	_	_	_	_	_	_
PH	**-0.32**	**-0.03**	_	_	_	_	_	_	_	_	_
NPB	**-0.22**	**--0.01**	**0.51**	_	_	_	_	_	_	_	_
FNP	**-0.79****	**-0.66***	**0.02**	**0.24**	_	_	_	_	_	_	_
SFW	**0.04**	**-0.23**	**-0.33**	**-0.23**	**0.15**	_	_	_	_	_	_
FW	**-0.31**	**-0.47**	**-0.05**	**-0.29**	**0.26**	**0.76****	_	_	_	_	_
FL	**-0.78**	**-0.84****	**-0.02**	**0.06***	**0.60***	**0.33**	**0.49**	_	_	_	_
FY	**-0.43**	**-0.25**	**-0.04**	**0.30****	**0.74**	**0.36**	**0.21**	**0.42**	_	_	_
MY	**-0.47**	**-0.30**	**-0.05**	**0.29****	**0.77****	**0.32**	**0.19****	**0.44**	**0.99****	_	_
UMY	**0.61**	**0.53**	**0.17**	**-0.11**	**-0.70**	**0.07**	**0.06**	**-0.45**	**-0.61***	**-0.68****	_

Pearson correlation (r) of fruit yield with other characters showed highly significant positive correlation with number of primary branches (r=**0.30****), marketable yield (r=0.99) and non-significantly positive correlation with fruit number per plant (r=0.74), single fruit weight (r=0.36), fruit width (r=0.21) and fruit length (r=0.42) (Table 4) this means that improving of those characters are improving the fruit yield. This result was agreed with the findings of Regassa *et al.* (2012) reported fruit yield per plant was highly positive significant correlation with marketable yield and number of primary branches. Also fruit yield per hector was negatively non-significant with characters' days to 50% flowering (r=-0.43), days to first harvest (r=-0.25) and plant height (r=-0.04) which was agreed with the findings of Eshteshabul *et al.* (2010).

Fruit number per plant was showed positive correlation with characters' plant height (r=0.02), number of primary branches (r=0.24), single fruit weight (r=0.15) and fruit width (r=0.26) while fruit number per plant had positive correlation with fruit yield and marketable yield, improving of these characters is improving of fruit number per plant which was disagreed with the findings of Regassa *et al.* (2012) for single fruit weight who reported number of fruit per plant was showed negative correlation with single fruit weight.

Marketable yield was highly significant and positive correlation with number of primary braches (r=**0.29****), fruit number per plant (r=**0.77****), fruit width (r=**0.19****) and fruit yield (r=**0.99****) which agreed with the findings of (Palada and Allison 2001; Znidarcic et al.,2003; Lemma, 2002) for the character's number of primary branches. Also marketable yield showed non-significant and positive correlation with single fruit weight (r=0.32)and fruit length (r=0.44) and non-significant and negative correlation with characters' days to 50% flowering (r=-0.47), days to first harvest (r=-0.3) and plant height (r=-0.05).

Conclusion and Recommendation

Five tomato varieties were grown in east Wollega zone, Wayu Tukaworeda under irrigation in 2020/21 for their adaptability study and evaluation for their higher yield. Tomato was growing at the study area by the farmers for consumption and commercial purposes for longer period of time, but the farmers were using the local varieties of tomato buying from the market which causes for the decrease of the yield from year to year.To increases production and productivity of the crop appropriate varieties has to be looked for beside agronomic and plant protection activities. In the present study, variety ARP d2 variety and Melka shola were found superior in economic yield (marketable yield) and other parameters that it was recommended for further popularization in east Wollega, Wayu Tuka district under irrigation.

Since the experiment is one site one season experiment, further studies using combination of locations and seasons is required to generate more reliable information on performance of varieties across location and year.

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