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Original Research Article

Evaluation and Participatory Variety Selection of Tomato (*Lycopersicum esculentum* Mill.) for Yield and Related Traits

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Abstract: Tomato is one of the most important commercial and food vegetable crops in Ethiopia. Even though, the crop is dominantly cultivated in the rift valley area it also produced in the study area for local market. The crop is produced by the farmers by using varieties which the source is not known and poor in yield and low in disease tolerance. Hence, participatory variety selection through demonstration of four tomato varieties was conducted at Wondo Genet and Wondo woredas during 2020/2021. The experiment was conducted on station for researchers' data collection by replicating three times and non-replicated plot basis for farmers' evaluation. Four tomato varieties; Gelelima, Chali, ARP-d2 tomato and Melka salsa were used for evaluation purpose. The researcher data and farmers preferences were analyzed using SAS software and pair wise ranking respectively. The result showed that highest marketable fruit yield (49.83t ha^{-1}) was obtained from Gelelima and the lowest (39.10t ha^{-1}) was from the Melka salsa variety. Pair wise raking of farmers preference also, shown that Gelelima was the first and best variety according to their criterion at both locations. Therefore, based on the result obtained it is better and recommended to produce Gelelima tomato variety for the farmers of Wondo Genet and Wondo woreda and other similar agro-ecologies.

Keywords: Pairwise ranking, participatory, preferences, tomato, varieties.

INTRODUCTION

Tomato (*Lycopersicum esculentum* Mill.) is one of the most important edible and nutritious vegetable crops in the world (FAO, 2006). Tomato is a major vegetable crop, has gained in popularity over the last century and is now grown in almost every country of the world (Robertson and Labate, 2007). Tomatoes are consumed as either fresh fruit by themselves, in salads, as ingredients in many recipes, or in the form of various processed products such as paste, whole peeled tomatoes, diced products and various forms of juices and soups (Kole, 2007). It has major economic and dietary importance in all parts of the world. It is rich in nutrients such as vitamins, minerals, and antioxidants, which are important to well-balanced human diet (Srinivasan, 2010).

It is also one of the most important vegetable crops grown in Ethiopia. It is important cash crop grown by both small scale farmers and commercial growers for fresh market and processing industry (Lemma, 1992). In Ethiopia, beyond consumption, tomato bids better economic returns for many farmers mainly during the wet and rainy seasons (Priyankara *et al*., 2017). Its productivity fluctuates as per the farmers' local context, management practices, and the variety used. The average productivity of tomato in Ethiopia is 8.5 ton ha^{-1} (Getachew *et al.*, 2019).

Tomato productivity highly depends on the potential of the genotype used and timely availability of resources. Crop variety is one of the vital factors that influence yield. Tomato yield and quality have been reported to be under genetic control and hence do vary widely with cultivars (Oko-Ibom and Asiegbu, 2007). The use of appropriate variety may result in better growth and higher yield (Isah, 2014).

To improve technology generation, dissemination and adoption, and to benefit from the available improved technologies, different stakeholders (researchers, extension officers, farmers, consumers and traders) have to be part of the breeding process right from its beginning. This can be done through participatory

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plant breeding in the identification of priority traits, on-farm demonstrations, popularization and re-evaluation of the technologies (Ceccarelli and Grando, 2007). Participatory variety selection (PVS) is a powerful tool that involves farmers and other stakeholders to help breeding programs and to improve variety adoption (Sperling *et al*., 2001). It also assists plant breeders to develop technologies that fit into a specific production niche and the farmers' needs (Ceccarelli *et al.*, 2000). The conventional plant breeding scheme uses a narrow range of selection criteria that addresses issues related to yield, uniformity and stability. Traditional farmers, however, employ more diverse and complex selection criteria, revolving around stable crop performance over seasons and they grow a range of genotypes that meet their needs in very complex and heterogeneous environments (Ceccarelli and Grando, 2007). The farmers' preferences, as well as the socioeconomic aspects, are often ignored by the conventional breeding programs. Farmer participation in setting breeding goals and varietal evaluation will remain critical for enhancing adoption and genetic diversity. Participatory variety selection can speed up the selection and fast-track the dissemination processes. In addition, it will eliminate a number of unacceptable varieties and save money and time (Assefa *et al*., 2006). An adoption of these improved tomato technologies will provide an opportunity for improvement of nutritional status of farming community in the vicinity. It is also very important in creation of employment especially for jobless youths and woman in the production areas and it brings a diversification of farming and income source to the producers of respective districts. In order to provide the improved tomato varieties for the producers of Wondo genet (Sidama Region) and Wondo (West Arsi zone, Oromia region), four different improved tomato varieties were evaluated at the study areas by participating the farmers. Therefore, this study was carried out to evaluate and select different tomato varieties, suitable for the study areas and to identify the farmers' preference criteria for the varieties.

MATERIALS AND METHODS

Description of the Study Area

Tomato producing woredas was selected in southern Ethiopia which is Wondo Genet from Sidama region and Wondo woreda from Oromia region which have slightly different agro-ecologies and get the access to central markets. Wondo genet is located in Sidama region at the elevation of 1780 m.a.s.l with the minimum and maximum temperature of 12.02°C -26.72°C and 1128 ml average annual rain fall, respectively. Wondo is located in West Arsi zone of Oromia region state. The agro-ecology of both woredas is almost similar since they are located in similar belts.

Varieties used for evaluation purpose

Four varieties ARP-d2 tomato, Gelelima, Chali and Melka Salsa were received from Melkassa agricultural research center for evaluation and participatory variety selection purpose.

Field Establishment and Management

The experiment was carried out as replicated for researcher data collection and non-replicated trial at farmer's farm for farmers' evaluation. The trial was arranged in a randomized complete block design (RCBD) with three replications on research station. The treatments were randomly assigned to each plot. The experimental plot had an area of $12m^2$ (3m length x 4m width) and space between replications and plots were 1.5m and 1.5m, respectively. The space between rows and plants were 100cm and 30cm respectively. Plants in the middle rows of the net plot were used as the sampling unit for data analysis. All field management activities were done as required as per recommendations.

Farmers' Selection and Participatory Evaluation of the Varieties

In this study, two groups of tomato growers having 30 members (15= from Wondo Genet and 15= from Wondo) were selected from the two woredas with the help of development agents. Training was given to the farmers to create general awareness about the experiment. Group discussion and debates were made to observe and clear contradictory ideas on issue like farmers' preferences, criteria for evaluation and characteristics of good tomato varieties. Evaluation criteria were set by farmers' prior to evaluation as; growth habit, fruit size and fruit shape, fruit yield, market preference and tolerance to disease. According to the farmers, good tomato varieties should have the following characteristics; vigorous and uniform, free from disease, higher in yield, and medium to large fruit size with oval shape. Therefore, the varieties were evaluated by the farmers using these criterions and analyzed using pair wise and matrix ranking (Boef and Thijssen, 2007).

Researchers Data Collection

Data on growth parameters, yield and yield components consisting of plant height (cm), number of primary branches, days to 50% flowering, number of fruit cluster per plant, marketable fruit yield t ha-1, average fruit length (cm), average fruit equatorial diameter (cm), disease severity score and farmers' preference were recorded.

Plant height (cm): Heights of five randomly selected plants from the ground level to the apex grown in net plot area using rules were measured at maturity stage.

Number of primary branches per plant: The primary branches of five randomly selected plants in net plot area were counted at the maturity stage.

Number of fruit per plant: The numbers of fruit per plant in five randomly selected plants were counted and recorded while fruit picking at each harvesting cycle and summed up.

Fruit length (cm): The length of five randomly selected fruits at each harvest was measured using caliper.

Fruit diameter (cm): The central diameter of five randomly selected fruits at each harvest was measured using caliper and the mean values were taken for analysis.

Marketable fruit yield (t): Fruits free from any visible damages (diseased, insect pest, physiologically and mechanically) were considered as marketable fruit yield and converted to hectare.

Statistical Analysis

The mean values of all parameters (for researchers data) were subjected to analysis of variance (ANOVA) using SAS software (Allison, 2012), version 9.4. Least significant difference (LSD) procedure was used to compare differences between treatment means.

RESULTS AND DISCUSSION

Researchers Evaluation

Under field condition plant height (cm), number of branches per plant, average fruit weight (g), number of fruits per plant, fruit diameter(cm), fresh fruit yield per plant (kg/ha), and marketable fresh fruit yield per hectare (ton) were measured.

The results of this study revealed that, most of growth, yield and yield related traits were affected by the varieties except number of branches and fruit diameter (Table 1). As indicated in Table 1 plant height showed statistically highly significant difference among varieties. The highest plant height (72.28cm) was recorded from variety Gelelima which is statically similar with by variety Melka salsa whereas the lowest plant height (59.37cm) was recorded from variety chali (Table 1). The difference in plant height among the varieties might be because of genetic difference among the varieties. This result was in agreement with the finding of Isah (2014) who reported the variation in plant height in four tomato varieties that might be occurred due to genetic difference. The maximum fruit numbers per plant (36.91) and fruit diameter (5.81 cm) were recorded from Melka salsa and ARP-d2 tomato varieties while the lowest fruit numbers per plant (26.43) and fruit diameter (4.63 cm) were recorded from ARP-d2 tomato and Melka salsa varieties respectively. This might be due to the reality that varieties can have different genetic makeup that makes them different. The current finding goes in line with the finding reported by (Hossain *et al*., 2014). They observed different fruit diameter and fruit number ranges while evaluating different tomato varieties.

Analysis of variance also showed that single fruit weight was affected by the varieties (Table 1). The highest single fruit weight (106.96g) was obtained from ARP-d2 tomato variety while, the lowest single fruit weight (73.17g) was obtained from Melka salsa variety. Also, fruit number per plant and fruit diameter was influenced by the varieties. The highest fruit number per plant (36.91) and fruit diameter (5.81) were recorded from Melka salsa and ARP-d2 tomato varieties respectively. Whereas, the lowest fruit number per plant (26.43) and fruit diameter (4.63) were recorded from ARP-d2 tomato and Melka salsa varieties respectively. The difference might come from genetic difference of the varieties which contribute to the difference in each trait. Several authors (Eshteshabul *et al*., 2010; Abrar *et al*., 2011) reported that the mean number of fruits per plant lay between 4.46 and 98.30. The higher the number of fruits per cluster the more fruit yield is expected, although fruit size also determines the yield estimation (Pandey, 2006).

Similarly yield per plant and per hectare was influenced by the varieties. The highest yield per plant (2.32kg) was recorded from variety Galelima which is stastically similar with variety ARP-d2 tomato and Chali while, the lowest (1.81kg) was recorded from Melka salsa variety. The highest marketable yield per hectare (49.83t) was obtained from Galelima variety which is stastically similar with ARP-d2 tomato variety. The lowest total yield per hectare (39.10t) was obtained from Melka salsa variety. Genetic difference/variation in each variety contributed to the yield difference among them. Marketable fruit yield is the major determinant factor for selection of a particular tomato variety, as it affects commercialization and thus income generation of the farmers (Pandey, 2006).

Table 1: Combined mean performance of tomato varieties for selected parameters during 2020/21

Varieties	Plant height (cm)	Branch number per plant	Fruit number per plant	Fruit Diameter (cm)	Fruit length (cm)	Fruit weight (g)	Yield per plant (kg)	Yield per ha (tha^{-1})
ARP-d2 tomato	62.48^{b}	4.94	26.43^{b}	5.81^{a}	7.06	106.96^{a}	2.12^{ab}	45.63^{ab}
Chali	59.37^{b}	5.46	28.32^{ab}	4.83^{c}	6.80	86.50^{b}	1.97^{ab}	41.28^{b}
Galelima	72.28^{a}	5.23	33.03^{ab}	5.32^{b}	7.23	88.03^{b}	2.32^{a}	49.83^{a}
Melka Salsa	68.98^{a}	5.16	36.91^{a}	4.63^{c}	6.65	73.17^{c}	1.81^{b}	39.10^{b}
$LSD_{0.05}$	5.20	ns	8.33	0.28	ns	6.49	0.34	7.60
CV (%)	7.60	27.83	25.68	5.30	7.99	7.04	16.08	16.62

Farmers' Preference

Farmers' perception on the performance of tomato varieties were tested at Wondo Genet and Wondo districts and analyzed using matrix and pair wise ranking. As a result, the majority of participant farmers in the districts have good interest to produce improved tomato varieties. The evaluated varieties preformed well as the farmers criterion. The performance of the varieties and farmers preference was similar in both districts. After discussions and debates farmers ranked the varieties based on their preference and degree of satisfaction by giving the values 1-5 (Boef and Thijssen, 2007). Matrix ranking result showed that overall mean for all performance indicators/preference criteria at Wondo Genet district were higher for Gelelima (5.43) followed by ARP-d2 tomato (3.86) Table 2. Similarly, the overall mean for performance indicators at Wondo district were higher for Gelelima (5.29), which is followed by ARP-d2 tomato (4.14) Table 2. The least preferred and with low performance variety according to farmers' preference criteria was Melka salsa and Chali varieties.

Also, the farmers got chance to compare the varieties to each other based on the identified preference criteria. Using pair-wise ranking, participants/farmers' preference toward the varieties was summarized according to Boef and Thijssen (2007). The result showed that Gelelima was the most preferred varieties followed by ARP-d2 tomato (Table 3). Farmers indicated that Gelelima was selected due to its higher yield potential, good fruit size and moderately tolerant to disease. Also the variety was preferred since it has good fruit shape for its high marketability. The farmers gave lowest rank for Melka salsa due to its small fruit size and susceptible to disease compared to the other varieties. During the evaluation, farmers indicated that their preference matched with researchers' selection criteria for fruit size, marketability and higher yield.

Table 2: Farmers preference for tomato varieties at Wondo Genet (n=15) and Wondo woredas (n=15)

Criteria for selection	Wondo Genet				Wondo			
	Chali	Melka Salsa	Gelilema	ARP-d2 tomato	Chali	Melka Salsa	Gelilema	ARP-d2 tomato
Disease resistance	3	2	8	2	4	4	4	3
Growth habit	4	3	4	4	2	3	7	3
Fruit shape (oval)	3	4	5	3	2	5	6	2
High yielder	3	2	5	5	2	1	5	7
Fruit size (large)	3	3	5	4	3	2	5	5
Fruit uniformity	3	4	4	4	3	4	4	4
Market preference	2	1	7	5	3	1	6	5
Total preference	21	19	38	27	19	20	37	29
Overall mean	3	2.71	5.43	3.86	2.71	2.86	5.29	4.14
Overall rank	**3**	**4**	**1**	**2**	**4**	**3**	**1**	**2**

Rank: 5= very good, 4= good, 3= average, 2= poor and 1 = very poor.

Table 3: Pair wise ranking on the overall preference of farmers toward different tomato varieties at both locations respectively

	Chali	Melka Salsa	Gelilema	ARP-d2 tomato	Total score
Chali					0
Melka Salsa	Melka Salsa				1
Gelilema	Gelilema	Gelilema			3
ARP-d2 tomato	ARP-d2 tomato	ARP-d2 tomato	Gelilema		2

CONCLUSIONS

The study was conducted to identify the best performing varieties for good yield and economic return, and to recommend the best variety with better fruit quality and tolerant to disease and insect pests for farmers in the study area by incorporating the farmers' preference criterion. The result from researchers experiment indicated that Gelelima was high yielder and tolerant to disease than other varieties. Similarly, it the most preferred tomato variety by the farmers at Wondo Genet and Wondo woredas. Chali and Melka salsa varieties were low yielder and least preferred variety since their fruit size is small compared to Gelelima and ARP-d2 tomato varieties. Researchers variety evaluation and farmers variety selection was almost indicated similar result. Hence, planting of the Gelelima tomato variety had yield advantage and it is advisable to use this variety for the production of marketable fruit yields in the study areas. So, the researcher recommends Gelelima variety for both location and similar agro ecologies to get better yield and good fruit quality. Since the varieties are updated, recently released improved tomato varieties should be adapted to the areas and better variety should be selected and delivered to the users.

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