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Participatory Evaluation of Tomato (*Lycopersicon esculentum* Mill.) Varieties Under Irrigation Condition at Abergelle Woreda, Ethiopia

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Abstract. Participatory on-farm evaluation of improved tomato varieties *namely;'Melka salsa, 'Roma VF'* and *'Kochero'* against the local variety was carried out in the 2019/20 irrigation season. The trial was laid on unreplicated simple plots using six farmers as replication at irrigation scheme of Saka kebele in Abergelle woreda. The experiment was intended to evaluate and demonstrate the performances of different tomato varieties for farmers, then to collect and assess their feedback. Based on the actual biological and farmers' preference data, the analysis result underscores the better performance of improved tomato varieties over the local variety by the most yield-related attributes. The average marketable fruit yields of *'Melka salsa, 'Roma VF', 'Kochero'*, and the local variety were 4.62, 3.88, 3.64, and 3.10 ton.ha^{-1}, respectively. The improved varieties had thus yielded an advantage of 72.38%, 37.14%, and 25.72% over the local variety in the given order. Among the improved tomato varieties, *'Melka salsa'* provided the highest fruit yield, and owing the highest score of overall preference attributes rank. *The medium-sized, oval-shaped, and tasty flashed 'Melka salsa' tomato fruit is most liked by farmers for its less perishability, better market demand and good taste.* The '*Melka salsa'* tomato variety is therefore suggested for up-scaling for similar agro-ecologies that have irrigation schemes and production potential. The biological scientists were also advised to consider the farmers' preference attributes and feedback as a backup for future tomato breeding studies.
Keywords: fruit shape; irrigation potential; late blight; preference attributes

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is an important edible and nutritious vegetable crop, ranked next to potato and sweet potato in the world (Nemeskéri et al., 2019). Tropical, sub-tropical and temperate agro-ecologies are favorable for tomato cultivation (Massimi, 2021). 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 and Amhara region is 8.5 and 4.5 ton.ha^{-1}, respectively (Getachew et al., 2019).

Wag-himira, among the potential zones of Amhara region, is one of the tomato producer areas using small irrigation schemes at the smallholder level (Binalfew et al., 2016). Considering the economic benefits stated, farmers need to grow tomato varieties having the merits of high yield and better performance to their local environment. Despite, irrigation can evade the risks of moisture stress, it is costly compared to rain-fed farming in terms of labor, input, and equipment (Zhou et al., 2017). In this costly practice, high-yielding vegetable varieties should be produced for the efficiency of small irrigation land that smallholder farmers owned (Gebisa et al., 2017).

Regional tomato production in Ethiopia is below the national average due to inadequate adaptable improved varieties (Binalfew et al., 2016). To solve this problem, researchers at dry-land agriculture research centers have adapted and recommended different improved tomato varieties ('*Melka salsa'*, *'Roma VF'* and '*Kochero')* for the lowland irrigation potential areas including Wag-himra zone (Benti et al., 2017).

Experience has shown that the recommended varieties were not adopted by farmers since they were merely on the basis of biological performance, giving less attention to farmers' desired traits (Mehadi et al., 2016). However, such preference traits are of course the building blocks for

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demand-driven variety adaptation (Mihiretu & Assefa, 2019).

The current participatory study was conducted at Saka irrigation scheme of Abergelle woreda to evaluate and demonstrate different improved tomato varieties against the locally available variety, then to select productive and socially acceptable variety for possible and enhanced tomato yield.

METHODS

Study area description

Saka kebele (Fig. 1) which has about 908.8 ha of irrigable land. It is located at 13°20′N and 38°58′E latitude and longitude, respectively in Abergelle woreda of Wag-himra zone, Ethiopia (Wubet et al., 2022). The woreda comprises about 17.29% of the irrigation potential of the zone, i.e. 16240 ha (Abeje et al., 2016). The annual temperature of the woreda is ranging between 23^{o}c and 43^{o}c, while the average annual rainfall varies between 250-750 mm (Mihiretu et al., 2019). Agroecologically, about 85% of the woreda is lowland having low and erratic annual rainfall distribution. The short rainy season is mainly characterized by late onset (starts in early July) and early offset (ends in late August) (Mihiretu et al., 2021).

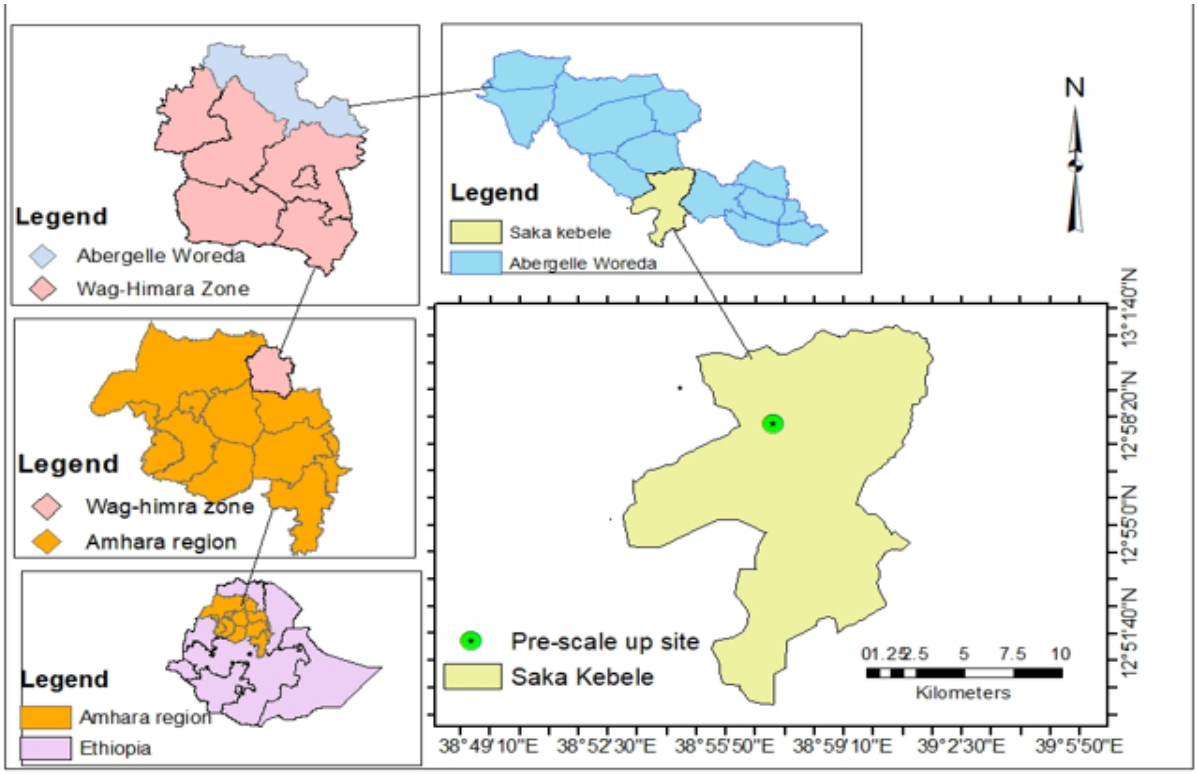

Fig.1. Irrigation scheme at Saka kebele, Abergelle woreda

Treatments and experimental design

The study was conducted under irrigation through a participatory approach. Ten farmers (with their spouses) were selected to establish a farmers' research and extension group (FREG). The farmers were given training about trial management and their roles as a participant. Sample plots from six farmers were randomly identified to host the experiment. Tomato seedlings were raised using well-prepared beds at Saka nursery site, having an area of 5m^2 and 15cm height from the soil surface. The beds were watered at two days intervals until germination, then twice per week (Shibru, 2016). The experiment consists of four tomato varieties of which three are improved *('Kochoro, Melka Salsa, Roma VF')* while the remaining one is the farmers' (Abergelle local) variety. Treatments were laid out in

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simple plots using farmers as replications. The seedlings were warily transplanted to experimental plots having an area of 100m^2 each. In total, 320 plants per plot were planted at 100 x 30cm spacing of rows and plants, respectively (Mehadi et al., 2016). Package components comprising watering, weeding, fertilizer application, staking, and harvesting at the stage of mature green were carried out uniformly for all treatments (Srinivasa et al., 2016). Furrow irrigation on weekly basis was used for watering the plots.

Data collection and analysis

The quantitative biological data such as bunch number per plant, fruit number per bunch, days to maturity, disease score, fruit weight, and marketable fruit yield were collected at the plot and farmers' level. Descriptive statistics like mean, frequency, and percentages were employed to analyze such agronomic records. The change of yield (Eq. 1) was calculated to indicate the improved varieties' yield advantage over the local variety (Mihiretu, 2019). One-way ANOVA, followed by Tukey (HSD) post-statistical test was used to analyze the mean variation among and within treatments, respectively. Because the ANOVA result does not indicate the differences within treatments and their magnitude. If the assumption of equal variance is satisfied, Tukey (HSD) test is the most common (Kebede et al., 2021).

$$\Delta Y = \frac{Ys-Yb}{Yb} \text{ x } 100 \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where, ΔY: change of yield, Ys: yield of improved variety, Yb: local variety yield

Since all treatments were under improved management (uniform), their production costs were constant hence economic data were not collected. However, to assess the farmers' preferences and overall perception of varieties, the agreed parameters such as marketable fruit yield, earliness, fruit size, fruit shape, fruit taste and tolerance to disease (late blight), and marketability were collected (Mehadi et al., 2016). The parameters compared each other pair-wisely to give a weighted rank, thereby constructing a weighted matrix ranking table (Mihiretu et al., 2019). In the table, the varieties are compared to each other and counted to provide scores for each variety. The products (scores×weights) were then aggregated for final selection. Finally, to harmonize results from the quantitative data (actual measured) and qualitative data (farmers' preference), Spearman's (Eq. 2) rank correlation was used. For this reason that it shows the degree of coincidence between farmers' preference rank and the rank of the measured value (Mihiretu & Assefa, 2019).

$$r_s = 1 - \frac{6\sum d^2}{n\,(n^2-1)} \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where, d: rank differences assigned for similar phenomenon, n: number of ranked phenomena

RESULTS AND DISCUSSION

Performances of yield and yield-related traits

Results of the experiment revealed that except for the number of bunches per plant, there was a statistically significant ($p \leq 0.05$) difference among tomato varieties in all yield and yield-related traits (Table 2). This finding is therefore in line with Desalegn et al. (2016) who stated that there was insignificant variation in the number of branches per plant among the different tomato varieties. Besides, the number of fruits per plant was considerably different between the varieties, thus the highest fruit number per plant (28.48) was recorded from Melka salsa while the lowest (17.83) was obtained from the local tomato variety ($p \leq 0.05$). Likewise, there was substantial variance among the varieties' fruit weight, hence, '*Melka salsa'* had the highest fruit weight (58.24g), followed by *Roma VF* (57.12g) and *Kochoro* (40.05g) varieties (Table 1). The most common disease, considered as the potential production constraint for tomato varieties in the study area is late blight. The experimental tomato varieties were entirely exposed and were susceptible to the disease with the highest

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severity range, i.e., 2.02 to 4.82. The local tomato variety was thus found to be highly susceptible to the disease, whereas '*Melka salsa'* was moderately resistant to other varieties. In terms of days to maturity, however, varieties *'Kochoro'* followed by *'Melka salsa'* were earlier maturing than *'Roma VF'* and the local variety though there was no significant difference between the two early and late maturing varieties (Table 3).

Statistically significant ($p \leq 0.05$) yield variance between tomato varieties was also observed in the study. The highest marketable yield (4.62 ton.ha^{-1}) was obtained from the *'Melka salsa'* variety followed by the *'Roma VF'* variety (3.88 ton.ha^{-1}), but the lowest yield was obtained from the local variety (3.10 ton.ha^{-1}). This result is in line with the finding of Yeshiwas et al. (2016) who underlined the existence of a positive correlation between the number of fruits per plant and the yield of the varieties. However, yields from the improved tomato varieties were better, accordingly, *Melka salsa, Roma VF,* and *Kochoro* varieties had a yield advantage of 72.38%, 37.14%, and 25.72% over the local tomato variety, respectively. As can be seen in table 3, the Tukey-HSD test shows that among varieties, '*Melka salsa'* was best performing tomato variety in most yield and yield-related traits at less than and/or equal to a 5% significance level.

Table 1. Performances of different tomato varieties for yield and yield-related traits

Parameters	Varieties			
	Melka Salsa	Roma VF	Kochoro	Local
Disease (late blight) score (1-9)	2.02	4.65	3.68	4.82
Bunch number per plant	9.42	9.15	9.06	8.62
Fruit number per bunch	28.48	23.62	20.14	17.83
Days to maturity	118.4	128.6	112.8	124.2
Fruit weight (gm)	58.24	57.12	40.05	33.86
Marketable fruit yield (ton ha^{-1})	4.62	3.88	3.64	3.10
Yield advantage (%)	72.38	37.14	25.72	-

Preference traits and evaluation of different tomato varieties

Better performing improved varieties correspondingly need to fulfill the farmers' preferences for future use. The FREG members (20 farmers) as a group set out seven weighted selection criteria to compare and rank tomato varieties, i.e., marketable fruit yield, earliness, fruit size, fruit shape, fruit taste and tolerance to disease (late blight), and marketability. The weighted matrix ranking result exhibited that a variety with lowest sum was farmers' first choice, and vice-versa (Benti et al., 2017). The farmers preferred '*Melka salsa'*, *'Roma VF'*, *'Kochoro'*, and local tomato varieties as their 1st, 2nd, 3rd, and 4th choices based on the overall preference criteria (Table 4). The farmers specified that *'Melka salsa'* selected for its higher yield, relatively better resistance to late blight, fruit size, shape and taste. This result was against the finding of Yeshiwas et al. (2016) indicated that the fruit size of '*Melka salsa'* was small and even susceptible to late blight. The difference was observed maybe due to the dissimilarity in experimental location and season. The medium-sized, oval-shaped, and tasty flashed fruits of *'Melka salsa'* variety liked by farmers for less perishability, taste and greater market demand. The correlation among measured ranks and the farmers' preference ranks of different tomato varieties for tolerance to disease, earliness (days to maturity), fruit size, and marketable fruit yield revealed that 10%, 100%, 90%,

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and 100% coincidence, respectively (Table 5). The average (75%) coincidence of actual values and the farmers' ranks in this study underscores the acceptance of *'Melka salsa'* over other competing tomato varieties in the area. Because, Spearman's correlation theory revealed that ≥50% degree of coincidence between measured and farmers' ranks for overall preference traits is acceptable (Mihiretu and Assefa, 2019).

Table 2. Mean performances of yield and yield related traits of different tomato varieties

Parameters	Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Marketable fruit yield (ton ha^{-1})	Treatments	15.32	3	5.450	36.333***	0.001
	Errors	2.21	20	0.150		
	Total	17.53	23			
Number of bunches per plant	Treatments	10.29	3	3.066	1.685	0.167
	Errors	25.95	20	1.820		
	Total	36.14	23			
Days of maturity	Treatments	14915.22	3	4605.42	2089.57***	0.000
	Errors	50.84	20	2.204		
	Total	14966.06	23			
Tolerance to disease (late blight)	Treatments	12.05	3	3.510	11.396**	0.049
	Errors	1.57	20	0.308		
	Total	13.62	23			
Fruit number per bunch	Treatments	28.14	3	9.049	4.297**	0.014
	Errors	40.15	20	2.106		
	Total	68.29	23			
Fruit weight (gm)	Treatments	145.50	3	48.50	15.292***	0.002
	Errors	63.43	20	3.171		
	Total	208.93	23			

Note: ***, **, * implies the level significance at 1, 5 and 10%, respectively

Table 3. Post hoc analysis to identify well performing tomato varieties for yield and related traits

Parameters	Pair of varieties	Mean Difference	Std. Error	Tukey-HSD Sig.
Marketable fruit yield (ton ha^{-1})	M – R	2.146**	0.168	0.014
	M – K	2.103***	0.168	0.006
	M – L	2.083***	0.168	0.000
	R – K	0.067	0.168	0.984
	R – L	1.667**	0.168	0.014
	K – L	1.540***	0.168	0.000
Number of bunches per plant	M – R	2.36	0.563	0.368
	M – K	1.232	0.563	0.146
	M – L	1.708**	0.563	0.018
	R – K	1.132	0.563	0.236
	R – L	1.417	0.563	0.093
	K – L	1.548	0.563	0.184

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Days of maturity	M – R	42.167**	0.285	0.029
	M – K	-45.176**	0.285	0.013
	M – L	-45.176**	0.285	0.012
	R – K	-45.012**	0.285	0.023
	R – L	40.142	0.285	0.100
	K – L	42.40***	0.285	0.000
Tolerance to disease (late blight)	M – R	1.323**	0.181	0.012
	M – K	0.567	0.181	0.914
	M – L	1.467***	0.181	0.000
	R – K	0.903***	0.181	0.000
	R – L	1.007	0.181	0.902
	K – L	0.719***	0.181	0.000
Fruit number per bunch	M – R	-2.030**	0.748	0.049
	M – K	-2.400**	0.748	0.016
	M – L	.617***	0.748	0.004
	R – K	1.900***	0.748	0.006
	R – L	2.917***	0.748	0.001
	K – L	1.017**	0.748	0.038
Fruit weight (g)	M – R	23. 050	1.360	0.150
	M – K	44.00***	1.360	0.000
	M – L	42.833***	1.360	0.000
	R – K	44.500***	1.360	0.000
	R – L	43.343***	1.360	0.000
	K – L	1.617	1.360	0.208

Note: ***, ** implies significance levels at 1 and 5%, respectively; M, R, K and L stand for Melka Salsa, Roma VF, Kochoro and Local tomato varieties

Table 4. The farmers preference traits and evaluation rank of different tomato varieties

Weighted parameters		M	R	K	L
Earliness (days to maturity)	S	2.00	4.00	1.00	3.00
	W	2.00	2.00	2.00	2.00
	S×W	4.00	8.00	2.00	6.00
Marketable fruit yield	S	1.00	2.00	3.00	4.00
	W	1.00	1.00	1.00	1.00
	S×W	1.00	2.00	3.00	4.00
Tolerance to disease (late blight)	S	1.00	1.00	1.00	2.00
	W	3.00	3.00	3.00	3.00
	S×W	3.00	3.00	3.00	6.00
Fruit size	S	1.00	1.00	2.00	2.00
	W	6.00	6.00	6.00	6.00
	S×W	3.00	6.00	12.0	12.0
Fruit shape	S	1.00	1.00	1.00	2.00
	W	7.00	7.00	7.00	7.00
	S×W	7.00	7.00	7.00	14.0

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Fruit taste	S	1.00	3.00	2.00	3.00
	W	4.00	4.00	4.00	4.00
	S×W	4.00	12.0	8.00	12.0
Marketability	S	1.00	2.00	3.00	3.00
	W	5.00	5.00	5.00	5.00
	S×W	5.00	10.0	15.0	15.0
	$\sum(S * W)$	27.0	48.0	50.0	69.0
	Ranks	1.00	2.00	3.00	4.00

Note: Ranks 1, 2, 3, 4 stand for Excellent, Best, Fair, and Worst performances, respectively; S: score, W: weight; M, R, K, and L stand for Melka Salsa, Roma VF, Kochoro, and Local tomato varieties

Table 5. Correlation between measured and farmers' preference ranks for different tomato varieties

Parameters	Ranks	M	R	K	L
Tolerance to disease (late blight)	Actual	1	3	2	4
	Farmers	1	1	1	2
	d^2	$(1-1)^2$	$(3-1)^2$	$(2-1)^2$	$(4-2)^2$
	r_s = 0.1 (10%)				
Earliness (days to maturity)	Actual	2	4	1	3
	Farmers	2	4	1	3
	d^2	$(2-2)^2$	$(4-4)^2$	$(1-1)^2$	$(3-3)^2$
	r_s = 1.0 (100%)				
Fruit size	Actual	1	2	3	4
	Farmers	1	2	3	3
	d^2	$(1-1)^2$	$(2-2)^2$	$(3-3)^2$	$(4-3)^2$
	r_s = 0.9 (90%)				
Marketable fruit yield	Actual	1	2	3	4
	Farmers	1	2	3	4
	d^2	$(1-1)^2$	$(2-2)^2$	$(3-3)^2$	$(4-4)^2$
	r_s = 1.0 (100%)				

Note: rs = correlation coefficient, d = rank difference among alike phenomenon, n = ranked number of the phenomenon; M, R, K, and L stands for Melka Salsa, Roma VF, Kochoro, and Local tomato varieties

CONCLUSION

The overall mean marketable fruit yields of improved tomato varieties significantly out-yielded the local tomato variety under similar production practices. Among improved tomato varieties, the variety named *'Melka salsa'* provided the highest fruit yield, plus the highest score of overall preference attributes rank. The farmers thus perceived the greater yield potential of *'Melka salsa'* improved tomato variety, and fully promised to use the variety in the future. The medium-sized, oval-shaped, and tasty flashed fruits of *'Melka salsa'* tomato variety were liked by farmers for its less perishability and better market demand. Therefore, *'Melka salsa'* tomato variety is recommended for scale-wide diffusion in the study area and similar agro-ecologies with irrigation scheme and potential. The public agricultural extension wing and other concerned organizations working on horticulture development in the study area are hence responsible for distributing this improved tomato variety for interested

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farmers. Besides, biological scientists should take the farmers' preference attributes and feedback as a backup for future breeding and adaptation studies on tomato varieties.

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Declaration of interest

The authors have no conflict of interest

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