Research Article

Evaluation of tomato accessions for quantitative and qualitative traits under agro climatic condition of Peshawar

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Abstract

The objective of this research was to screen the tomato accessions for quantitative and qualitative traits under agro climatic condition of Peshawar. 17 tomato accessions with a tomato commercial cultivar were evaluated in randomized complete block design with three replication at The University of Agriculture Peshawar, during kharif season 2016. Quantitative traits studied were juice pH, total soluble solids, days to flowering, plant height, fruits plant⁻¹, fruit weight and fruit yield plant⁻¹. While qualitative traits comprised plant growth type, canopy size, leaf type, flower inflorescence, fruit color, fruit shape and fruit firmness. Highly significant differences were observed among tomato accessions for all the quantitative traits studied except juice pH. While qualitative traits showed that maximum accessions had indeterminate growth habit (88.9%), Intermediate canopy size (55.6%), curled leaf type (66.7%), medium number of flowers inflorescence⁻¹ (55.6%), red fruit color (61.1%), deep globe fruits (26.7%) and soft fruit firmness (83.3%). Fruit yield plant⁻¹ showed significant positive correlation with juice pH ($r=0.580^{**}$), TSS ($r=0.500^{**}$), plant height ($r=0.420^{**}$), fruits plant⁻¹ ($r=0.410^{**}$) and fruit weight ($r=0.920^{**}$) except days to flowering ($r=-0.310^{**}$) which showed significant negative correlation with fruit yield plant⁻¹. Roma showed highest value of fruit juice pH (4.1), total soluble solids (6.1), fruit weight (54.2 g) and fruit yield plant⁻¹ (688.7 g). Therefore this study suggested that Roma and 31910 could be recommended as commercial cultivars under agro climatic condition of Peshawar and also could be used in future tomato breeding programs.

Keywords: Evaluation; Tomato accessions; Quantitative traits; Qualitative traits; Correlation

Introduction

Tomato (*Lycopersicon esculentum*) is a self-pollinated fruit berry and the second most important vegetable crop cultivated throughout the world [1]. It belongs to family

solanaceae with approximately 90 genera and 3,000-4,000 species, some of which are economically important such as potatoes, eggplants, peppers and tobacco [2, 3]. It originated from Central and South America.

It is one of the most important crops widely grown in tropical and temperate regions of the world. Tomato have three different types of growth habits namely; determinate, indeterminate and semi determinate [4].

Over the last century, tomato as a major horticultural vegetable crop has attained a tremendous popularity. It can be grown in most places all over the world, like growing in the field, greenhouses and net houses. In Pakistan tomato is grown both as Kharif and Rabi crop on an area of 1689 and 38549 hectares with an average production of 142113 and 423930 tons respectively. The Khyber Pakhtunkhwa (KPK) Province share for Kharif and Rabi crop is 9670 and 3582 hectares with 85754 and 41798 tons production [5].

Tomato is also known as protective food because of its special nutritive values [6]. The tomato fruit is moderately rich in Vitamin A and C and contains 93.8g water, 1.2g protein, 4.8g carbohydrate, 0.5mg carotene [7]. Yellow tomatoes have higher vitamin A content than red tomatoes, but red tomatoes contain lycopene, an anti-oxidant that may contribute to protection against carcinogenic substances. Red color of tomato fruits is the result of chlorophyll degradation as well as synthesis of lycopene and other carotenoids [8].

For sustainable genetic improvement of the crop systematic study and characterization of tomato germplasm is of great importance. For improved breeding program, evaluation is vital in order to know the genetic background and the breeding values of the available tomatoes [9]. Yield components and

morphological traits have been widely used in the evaluation of tomato crops. Therefore the current study was conducted to know about the genetic variability of quantitative and qualitative traits in tomato germplasm under agro climatic condition of Peshawar and to select the most promising tomato accessions for future breeding programs.

Materials and methods

The experiment was carried out at The University of Agriculture Peshawar in summer season 2016. 17 tomato accessions and a commercial variety were procured from National Agricultural Research Centre (NARC), Islamabad (Table 1). Those seeds were sown in plastic tubes on 17 March, 2016. After a week of seeding those accessions were transplanted to the field using randomized complete block design with three replication. Data were noted on five plants genotype⁻¹ for various qualitative and quantitative traits. Qualitative traits were measured according to International Plant Genetic Resources Institute descriptors list for tomato (Table 2) [10]. Quantitative traits studied were days to flowering, plant height, fruits plant⁻¹, fruit weight, fruit juice pH, Soluble Solids (TSS), fruit yield plant⁻¹.

Statistical analysis

Quantitative traits were subjected to Analysis of variance (ANOVA) according to [11]. Genotypes that showed significant differences were subjected to Least Significant Difference (LSD) test at 5% probability level. Correlation and frequency distribution of qualitative traits were analyzed using statistical package 'STATISTICA-V.8.1.

Table 1. List of 17 Tomato Accessions and a commercial Variety studied in the experiment

S. NO.	Accession #	S.NO	Accession #	S.NO	Accession #
1	31910	7	17882	13	17884
2	29471	8	17876	14	19900
3	17877	9	17876	15	19904
4	19903	10	6237	16	19293
5	17873	11	27726	17	19297
6	29448	12	19895	18	Roma

Table 2. Minimal descriptor list for tomato (IPGRI, 1996)

Plant characteristics	Score		Fruit characteristics	Score
Plant growth type			Fruit color	
Dwarf	1		white	1
Determinate	2		Green	2
Semi-determinate	3		Yellow	3
Indeterminate	4		Gold	4
Canopy size			Orange	5
Small	1		Pink	6
Indeterminate	2		Red	7
Large	3		Fruit shape	
Leaf type			Oblate	1
Rugose	1		Deep oblate	2
Potato leaf	2		Globe	3
Regular	3		Deep globe	4
Curled	4		Heart shaped	5
Flowers inflorescence¹			Cylindrical	6
Low	1		Pyriform	7
Medium	2		Fruit firmness	
High	3		Soft	1
Type of inflorescence			Medium	2
Simple	1		Hard	3
Forked	2			
Compound	3			

Results and discussion

Tomato juice pH

Data regarding total juice pH is presented in (Table 3). Analysis of variance revealed non-significant difference among tomato accessions for juice pH. Maximum value of juice pH was recorded for Roma (4.3) while minimum juice pH was noted for accession 29471 (3.9). The present results are in line with Ghasemi *et al.*, Henareh *et al.* and Olakojo *et al.* [12-14]. They also reported significant difference for juice pH in tomato genotypes. The juice pH was significantly ($P \leq 0.01$) positive correlated with total soluble solids, fruits plant⁻¹, fruit weight and fruit yield plant⁻¹, while with plant height it was non-significantly positive correlated. However juice pH had non-significant negative correlation with days to flowering (Table 4). Aoun *et al.* [15] also found that juice pH was significantly positive correlated with total soluble solids.

Total soluble solids (⁰Brix)

Statistically analyzed data showed significant differences ($P \leq 0.01$) among tomato accessions for total soluble solids. Maximum total soluble solids were recorded for accession 31910 (6) followed by Roma (6), while minimum total soluble solids was recorded for accession 19471 (3.5). These results are strengthened by the findings of Chernet *et al.* and Parkar and Maleekuu [16, 17]. Who also observed significant differences among tomato accessions for total soluble solids. Total soluble solids was significantly ($P \leq 0.01$) positive correlated with fruits plant⁻¹, fruit weight and fruit yield plant⁻¹. However total soluble solids was significantly ($P \leq 0.01$) negative correlated with days to flowering while the said trait was non-significantly positive correlated with plant height (Table 4). Our studied results are in close correspondence with Golani *et al.* [18]. Who also found positive correlation between TSS and fruit yield.

Table 3. Mean performance of quantitative traits of tomato accessions evaluated under the agro climatic conditions of Peshawar

Accession	Fruit juice PH	Fruit TSS (°Brix)	Days to flowering	Plant height (cm)	Fruits plant ⁻¹	Fruit weight(gm)	Fruit yield plant ⁻¹ (gm plant ⁻¹)
6237	4.1	6.0a	38c	45.7i	12.7d	5.2k	70.5h
17873	4.1	6.0a	47b	43.2k	20.3b	8.1j	165.8e
17876	4.1	5.5b	47b	48.3h	8.1g	36.1c	274.2cd
17877	4.0	4.0d	38c	30.5l	9.5f	17.1f	163.1e
17882	4.1	5.5b	47b	20.3o	8.1g	17.2f	140.1f
17884	4.0	4.0d	51a	101.6b	11.4e	22.2d	254.9d
19293	4.1	4.5c	53a	35.56k	8.1g	5.2k	42.5i
19297	4.1	4.5c	53a	30.5l	9.5f	4.2l	40.3i
19843	4.0	4.0d	51a	63.5f	6.2i	5.2k	42.5i
19895	4.1	5.5b	47b	30.3l	22.96a	12.2i	280.9c
19900	4.1	5.5b	38c	106.7a	9.5f	2.2n	21.2i
19903	4.0	4.0d	38c	25.4m	8.1g	3.1m	24.6 i
19904	4.1	4.0d	47b	76.2d	7.2h	15.2h	110.7g
27726	4.1	5.5b	47b	55.9g	17.26c	15.2h	263.1cd
29448	4.1	5.5b	47b	22.9n	10.6e	16.2g	173.14e
29471	3.9	3.5e	47b	71.1e	6.2 i	21.1e	130.6 fg
31910	4.1	6.0a	38c	86.4c	13.5d	44.2b	488.2b
Roma	4.3	6.1a	38c	101.6b	13.4d	54.2a	688.7a
Mean	4.1	5.0	45	55.3l	11.3	16.9	187.5
LSD _(0.05)	0.41	0.29	2.57	0.94	0.63	0.42	17.31

Table 4. Correlation among quantitative traits in tomato accessions evaluated under the agro climatic conditions of Peshawar

Traits	Juice pH	Total soluble solids	Days to flowering	Plant height	Fruits plant ⁻¹	Fruit weight
Total soluble solids	0.750**					
Days to flowering	-0.200	-0.350**				
Plant height	0.150	0.030	-0.230			
Fruits plant ⁻¹	0.370**	0.610**	-0.090	-0.060		
Fruit weight	0.430**	0.340*	-0.280*	0.440**	0.080	
Fruit yield plant ⁻¹	0.580**	0.500**	-0.310*	0.420**	0.410**	0.920**

Days to flowering

Analysis of variance revealed significant difference ($P \leq 0.01$) among tomato accessions for days to flowering (Table 5). Mean data showed that maximum days to flowering were recorded for accession 19293 (53), while minimum days to flowering were recorded for accession 31910 (38) followed by 19903 and Roma (38). Our findings are in agreement with Ullah *et al.* [19]. Days to flowering was significantly ($P \leq 0.05$) negative correlated with total soluble solids, fruit weight and fruit yield plant⁻¹. Whereas days to flowering was non-significantly

negative correlated with juice pH, plant height and fruits plant⁻¹ (Table 4).

Plant height (cm)

Statistical analysis revealed significant difference ($P \leq 0.01$) among tomato accessions for plant height. Maximum plant height was recorded for accession 19900 (106.7 cm) followed by Roma and 17884 (101.6 cm), while minimum plant height was recorded for accession 17882 (20.3 cm). Similar findings were also reported by Ambule *et al.* and Iqbal *et al.* [20, 21]. Plant height was significantly ($P \leq 0.01$) positive correlated with fruit weight and fruit yield

plant⁻¹. However non-significantly positive correlated with juice pH and total soluble solids. Plant height was non-significant negative correlated with days to flowering

and fruits plant⁻¹ (Table 4). Izge *et al.* [22] also found significant positive correlation between plant height and fruit yield plant⁻¹.

Table 5. Mean squares of quantitative traits of tomato evaluated under agro climatic condition of Peshawar

Traits	Replication df=2	Accessions df=17	Error df=34	Coefficient of variation (%)
Juice Ph	0.16	0.02 ^{ns}	0.06	5.85
Total soluble solids	0.02	2.27**	0.03	3.39
Days to flowering	6.22	83.37**	2.22	3.30
Plant height	1.46	2547.99**	0.30	0.99
No of fruit plant ⁻¹	0.22	67.48**	0.13	3.24
fruits weight	0.06	642.05**	0.06	1.45
Fruit yield plant ⁻¹	169.90	90419.60**	101.00	5.36

ns = non-significant, ** = significant at 1% probability level

Fruits plant⁻¹

Statistically analyzed data showed that there were significant difference ($P \leq 0.01$) among tomato accessions for fruits palnt⁻¹. Greater fruits palnt⁻¹ were recorded for accession 19895 (22.96), while less fruits palnt⁻¹ were recorded for accession 29471 (6.2). These results are supported by the findings of Saeed *et al.* and Henareh *et al.* [13, 23]. Fruits plant⁻¹ was significantly ($P \leq 0.01$) positive correlated with juice pH, total soluble solids and fruit yield plant⁻¹. However fruits plant⁻¹ was non-significantly positive correlated with fruit weight. Fruits per plant was non-significantly negative correlated with days to flowering and plant height (Table 4). Tiwari *et al.* [24], also reported positive correlation between fruits plant⁻¹ and fruit yield plant⁻¹ and specified that fruit yield increases with fruits plant⁻¹.

Fruit weight (gm)

Analysis of variance revealed significant difference ($P \leq 0.01$) among tomato accessions for fruit weight. The mean data showed that maximum fruit weight was recorded for Roma (54.2 g) followed by accession 31910 (44.2g). While minimum fruit weight was noted for accession 19900 (2.2g). Similar diversity in tomato for fruit weight has been reported by Weller *et al.* and

Reddy and Reddy [25, 26]. Fruit weight was significantly ($P \leq 0.01$) positive correlated with juice pH, total soluble solids, plant height and fruit yield plant⁻¹. Similarly Fruit weight was significantly ($P \leq 0.01$) negative correlated with days to flowering and non-significantly positive correlated with fruits plant⁻¹ (Table 4). Our findings are in correspondence with Golani *et al.* [18], who also found that fruit weight was significantly positive correlated with fruit yield.

Fruit yield plant⁻¹(gm plant⁻¹)

Statistical analysis of the data showed significant difference ($P \leq 0.01$) among tomato accessions for fruit yield plant⁻¹. The mean comparison showed that maximum fruit yield plant⁻¹ was obtained from Roma (688.70) followed by accession 31910 (488.20 g). While the minimum fruit yield plant⁻¹ were obtained from accession 19900 (21.2 g). Our results are in agreement with the findings of Mukul *et al.* and Mohanty [27, 28]. Fruit yield plant⁻¹ was significantly ($P \leq 0.01$) positive correlated with juice pH, total soluble solids, plant height, fruits plant⁻¹ and fruit weight. However fruit yield plant⁻¹ was significantly ($P \leq 0.05$) negative correlated with days to flowering (Table 4). Kumar *et al.* and Denton *et al.* [29, 30] also reported positive phenotypic correlation of fruit yield

plant⁻¹ with TSS, plant height, fruits plant⁻¹ and fruit weight.

Descriptive statistics of qualitative traits of tomato accessions

Qualitative traits viz plant growth type, canopy size, leaf type, flowers inflorescence⁻¹ and inflorescence types were recorded following IPGRI descriptor list for tomato and there results are presented in (Table 6). Frequency distribution of plant growth type showed that out of 18 tomato genotypes 16 were indeterminate with a percentage of 88.9, while two were determinate with a percentage of 11.1%. Canopy size showed that a total of 18 genotypes five have large canopy size with a percentage of 27.8%. On other hand 10 genotypes with 55.8% were intermediate and three genotypes with 16.7% have small canopy size. Leaf type showed that 12 genotypes with 66.7% exhibited curled leaf type while, 6 genotypes with 33.3% revealed regular leaf type. Flowers per inflorescence showed that out of 18 genotypes 10 with a percentage of 55.6% were noted medium, followed by high with 5 genotypes with percentage of 27.8% and three were observed low with percentage of (16.7%). Type of inflorescence revealed that

out of 18 genotypes 17 showed simple inflorescence with percentage of 94.4% while one genotype showed compound inflorescence with percentage of 5.6%. Fruit character of qualitative nature with individual classes like exterior color of mature fruit, fruit shape and fruit firmness results are presented in (Table 7). Frequency distribution of fruit color showed the predominance of red color for five genotypes with 27.8%, followed by orange in 11 genotypes (61.1%), pink in one genotype (5.6%) and gold in one genotype (5.6%). Fruit shape of four genotypes (22.2%) was found to be flattened, two genotypes (11.1%) were slightly flattened, three genotypes (16.7%) were globe, five genotypes (27.8%) were deep globe, only one genotype (5.6%) were heart shaped, one were cylindrical (5.6%) and two genotypes (11.1%) were Pyriform. Fruit firmness of 15 genotypes (83.3%) have soft fruit and 3 genotypes (16.7%) had medium fruits firmness. Similar findings were also observed earlier by Grandillo *et al.* [31]. They also reported significant variation among tomato accessions for qualitative traits.

Table 6. Frequency distribution of qualitative morphological characters of tomato germplasm tested under agro climatic condition of Peshawar

Plant characteristics	Frequency	Percent
Plant growth type		
Dwarf	0	0.00
Determinate	2	11.1
Semi-determinate	0	0.00
Indeterminate	16	88.9
Canopy size		
Small	3	16.7
Indeterminate	10	55.6
Large	5	27.8
Leaf type		
Rugose	0	0.00
Potato leaf	0	0.00
Regular	6	33.3
Curled	12	66.7
Flowers inflorescence⁻¹		
Low	3	16.7
Medium	10	55.6

High	5	27.8
Type of inflorescence		
Simple	17	94.4
Forked	0	0.00
Compound	1	5.6

Table 7. Fruit characters of tomato germplasm tested under agro climatic condition of Peshawar

Fruit characteristics	Frequency	Percent
Fruit color		
white	0	0.00
Green	0	0.00
Yellow	0	0.00
Gold	1	5.6
Orange	11	27.8
Pink	1	5.6
Red	5	61.1
Fruit shape		
Oblate	4	22.2
Deep oblate	2	11.1
Globe	3	16.7
Deep globe	5	27.8
Heart shaped	1	5.6
Cylindrical	1	5.6
Pyriform	2	11.1
Fruit firmness		
Soft	15	83.3
Medium	3	16.7
Hard	0	0.00

Conclusions

Analysis of variance showed significant difference among the tomato accession for all the studied traits except juice pH which showed non-significant differences among tomato accessions. Maximum fruit yield plant⁻¹ was recorded for Roma (688.70) followed by accession 31910 (488.20 g). While minimum fruit yield plant⁻¹ was noted for accession 19900 (21.2 g). Qualitative results revealed that maximum accessions have indeterminate growth habit, Intermediate canopy size, curled leaf type, medium number of flowers inflorescence⁻¹, red fruit color, deep globe fruits and soft fruit firmness. Fruit yield plant⁻¹ showed significant positive correlation with juice pH (r=0.580**), TSS (r=0.500**), plant height (r=0.420**), fruits plant⁻¹ (r=0.410**) and fruit weight (r=0.920**) except days to flowering (r=-0.310**) which showed

significant negative correlation with fruit yield plant⁻¹. Roma performed better followed by accession (31910). Therefore it is suggested that these two tomato genotypes could be used in future tomato breeding programs.

Authors' contributions

Conceived and designed the experiments: N Ara, Performed the experiments: N Samad, Analyzed the data: S Ali, Contributed reagents/ materials/ analysis tools: Manzoor, S Fahad and Q Hussain, Wrote the paper: A Sohail.

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