Research Article

Performance evaluation of tomato accessions across two locations of Khyber Pakhtunkhwa

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Abstract

Identification of adaptable and stable genotypes is an important aspect of applied crop breeding which can insure sustainable crop production. Adaptability studies in tomato is an essential part of breeding for adequate evaluation of genotypes accomplished through environments (years/locations). A set of forty tomato accessions of diverse origin were tested at Swabi and Haripur locations to assess their performance. The experiment was carried out in randomized complete block design with three replications. Data were recorded on 50% flowering, days to fruiting and yield per hectare. Genotype (G), environment (E) and GEI share in total sum of squares were also studied. Significant ($p \leq 0.01$) differences were observed among the accessions, environments (locations) and $G \times E$ interaction means for majority traits, which assured greater genetic variability among the accessions due to their divergent genetic make-up, as well as environments. On average, the accessions showed best performance in Swabi location than Haripur for yield and duration parameters. Overall, the promising accessions could be further explored for improvement in tomato fruit yield.

Keywords: Genotypes; Environments; Genotype-by-environment interaction

Introduction

Tomato (*Solanum lycopersicum* Mill.) is relatively a new addition to the world food crops, used in various forms both fresh and processed. Although tomato does not rank high in terms of caloric value, by virtue of volume consumed in its various forms such as cooked, salad, soup, preserves, pickles, ketchup sauces and many other products, it contributes substantially to dietary intake of

vitamin A, B, C and essential minerals [1]. Tomato being a tender perennial crop, it is susceptible to both frost as well as high temperature, and thus it is grown under varying environmental conditions. Since 1961, tomato production in the world has increased 291%, and during the year 2002 production reached 108 million metric tons. The share of Pakistan during 2005-06 in

tomato production was 4965.35 tones, fresh or chilled worth US\$ 0.829 million [2].

In Pakistan, very little efforts have been made for improving vegetable crops including tomato, because of their secondary importance in the crop husbandry [3]. Consequently, very few local varieties of tomato are available for cultivation and most of them are selections from the introduced germplasm. Furthermore, the available varieties are poor in quality traits, and therefore, are unable to get consumer's attraction. In Pakistan tomato is grown on an area of 44460 hectare with annual production of 491370 tones [4]. Amongst the several reasons of low production of tomato the two reasons appears to be reasonable, firstly locally developed varieties are not available and secondly the non-existence of local tomato seed industry. Almost the total seed supply of tomato requirement is fulfilled through import of hybrid seed, and during 2005-06 Pakistan imported 72.75 tons of tomato seeds worth 2.09 million US\$, while it was increased

significantly to US\$ 5.1 million in 2009 [5].

This expensive seed supply of tomato necessitates the vegetable breeders to breed varieties/hybrids having great yield potential under local environments. For this purpose, irrespective of the tools adopted during the breeding process, the breeder has to take two major steps: first to find and/or create genetic variation and secondly to select the best genotypes [4]. In present study, small samples of 40 tomato accessions were evaluated for their performance across two locations of Khyber Pakhtunkhawa.

Material and methods

The present investigation was conducted to categorize native and foreign tomato germplasms from diverse genetic sources. For morphological characterization tomato germplasm, consisting of 40 tomato genotypes, were acquired from national agriculture research center (NARC), Islamabad and federal Seed certification and registration department (FSC and RD), Islamabad, Pakistan in January, 2013 (Table 1).

Table 1. List of tomato accessions characterized various traits

S. No.	Accession No.	Source	S. No.	Accession No.	Source
1	Acc-06232	**NARC (Pakistan)	21	AVR-211	*AVRDC (Taiwan)
2	Acc-10572	NARC (Pakistan)	22	CLN-222	USA
3	Acc-10587	NARC (Pakistan)	23	CLN-232	USA
4	Acc-17867	NARC (Pakistan)	24	AVR-241	AVRDC (Taiwan)
5	Acc-17870	NARC (Pakistan)	25	AVR-251	AVRDC (Taiwan)
6	Acc-17872	NARC (Pakistan)	26	AVR-261	AVRDC (Taiwan)
7	Acc-17874	NARC (Pakistan)	27	CLN-272	USA
8	Acc-17877	NARC (Pakistan)	28	CLN-282	USA
9	Acc-17878	NARC (Pakistan)	29	CLN-292	USA
10	Acc-17879	NARC (Pakistan)	30	EUR-303	Holand
11	Acc-17882	NARC (Pakistan)	31	CLN-312	USA
12	Acc-17883	NARC (Pakistan)	32	AVR-321	AVRDC (Taiwan)
13	Acc-17889	NARC (Pakistan)	33	EUR-333	Holland
14	Acc-17890	NARC (Pakistan)	34	AVR-341	AVRDC (Taiwan)
15	Acc-19288	NARC (Pakistan)	35	CLN-352	USA
16	Acc-19289	NARC (Pakistan)	36	CLN-362	USA
17	Acc-19290	NARC (Pakistan)	37	STM- 1	Swabi (Pakistan)
18	Acc-19893	NARC (Pakistan)	38	STM- 2	Swabi (Pakistan)
19	Acc-19912	NARC (Pakistan)	39	STM-3	Swabi (Pakistan)
20	AVR-201	AVRDC (Taiwan)	40	Sahel	Syngenta

AVRDC = Asian Vegetable Research and Development Center, NARC = National Agriculture Research Center

Nursery preparation

Sowing of the accessions was done at Agriculture Research Farm, University of Haripur, in February 2013 for raising nursery seedlings. For sowing different soils like sandy, light, well drained and high in organic matter were selected by keeping a row to row distance of 10 cm and plant-to-plant distance of 5 cm.

Transplantation

Transplantation of the seedlings was carried out into well prepared field plots rich in organic matter after 4 weeks from the nursery at the evening time so to reduce the risk of transplant shock. Each field plot was composed of 4 rows of 1 meter with a row to row distance of 120 cm and a plant to plant space of 40 cm.

Field management

FYMs [(@ 15 tones per hectare) and NPK (@ 100:80:60 kg per hectare)] was applied at the time of seed bed preparation, followed by irrigation. Total amount of organic manure, P₂O₅, K₂O and 1/3 N was applied at the time of seed bed preparation and the rest of nitrogen was side dressed in two splits i.e., 20 days after transplantation and at pre-flowering stage. Furadon granules were also applied to the soil before transplantation to

avoid any insect attack on young plantlets. In order to keep the block weed free, mechanical weeding was done from transplantation till harvest. Earthing up and supporting and training with vertical strings was done after 15th day of transplantations.

Traits measurement and statistical analysis

Data were recorded on days to 50% flowering, days to fruiting and yield per hectare. Data were subjected to analysis of variance (ANOVA) according to Steel & Dickey [6]. After getting the significant variations among genotypes performance for various parameters, the means for each trait were further separated and compared by using the least significant difference (LSD) test at 5% level of probability.

Results and discussion

Pooled analysis of variance across two locations revealed significant ($p < 0.01$) differences among genotypes, environment and genotype $\times$ environment interaction for days to 50% flowering and yield per hectare; however environment and genotype $\times$ environment interaction was non-significant for days to fruiting (Table 2). Similar results were out lined by Panthee *et al.* [7].

Table 2. Mean square values of ANOVA for yield and yield related traits of 40 Accessions across two location of Khyber Pakhtunkhwa

Parameters	Mean squares			CV (%)
	Locations	Genotypes	G $\times$ L	
d.f.	1	39	39	
Days to germination	0.33750**	6.19135**	1.10673**	3.45
Days to 50% Flowering	49.504**	59.849**	16.111**	1.49
Days to Fruiting	42.504**	36.668**	18.12**	3.26
Yield per Plot	8.0656**	4.4246**	3.1279**	6.41

**, Significant at $p \leq 0.01$

Days to 50 % flowering

Category wise comparison for mean ranges at both locations were Acc-17889 (41.00) to STM-2 (52.00) days in indigenous group, EUR-333 (46.00) to EUR-303 (53.00) days

in European, AVR-241 (43.17) to AVR-261 (50.84 days) in Taiwan and CLN-282 (43.50 days) to CLN-312 (54.67 days) days in American germplasm. Mean values for locations based on 40 tomato genotypes for

days to 50% flowering was 47.37 and 48.27 days under Haripur and Swabi environment, respectively, indicating a net difference of 0.92 days between two tested environments (Table 3). Similarly Ghosh *et al.* [8] reported a wide range of variation for days to initial flowering in tomato. Wider variation in respect to days to first flowering was also reported by Prema *et al.* [9] among six cherry tomato lines. This scenario was manifested in Tropimech which has shorter

days to flowering and performs better than the other genotypes in terms of yield. Similar results have been reported by Dhankhar & Dhankhar [10]. Comparison between the environments showed that genotype EUR-312 revealed maximum (54.67 days) in Haripur environment followed by the same genotype in Swabi location; however, lowest (42.33 days) were observed in Swabi.

Table 3. Days to 50% flowering, days to fruiting and yield per hectare (tons) comparison of 40 Accessions across two locations of Khyber Pakhtunkhwa

Days to 50% flowering			Days to fruiting			Yield per hectare (tons)			
Accessions	Haripur	Swabi	Mean	Haripur	Swabi	Mean	Haripur	Swabi	Mean
Europe	49.67	50.17	49.92	19.67	20.33	20.00	33.10201	20.57801	26.84001
EUR-303	53.33	53.67	53.50ab	23.33	23.00	23.17b	33.01929	17.76045	25.38987e/k
EUR-333	46.00	46.67	46.34kl	16.00	17.67	16.84n/p	33.18474	23.39556	28.29015c/f
Indigenous	47.43	47.96	47.70	17.81	18.13	17.97	24.78620	30.05211	27.41916
Acc-06232	50.33	50.67	50.50c/f	20.33	20.67	20.50c/g	22.54043	16.75183	19.64613n
Acc-10572	46.33	49.67	48.00h/j	16.33	20.67	18.50k/m	25.56827	25.13373	25.35100e/k
Acc-10587	45.33	50.67	48.00h/j	15.33	20.67	18.00l/n	26.41743	28.72768	27.57256c/h
Acc-17867	42.33	43.00	42.67o	14.00	15.33	14.67rs	24.57162	34.38272	29.47717cd
Acc-17870	51.67	47.33	49.50e/h	21.67	17.33	19.50f/k	26.37357	31.76151	29.06754c/e
Acc-17872	43.00	45.67	44.34mn	14.33	16.33	15.33qr	21.62749	28.79545	25.21147e/k
Acc-17874	50.00	48.67	49.34e/h	20.00	18.67	19.34g/k	20.06871	33.46380	26.76626d/i
Acc-17877	53.00	43.00	48.00h/j	23.00	14.67	18.84j/l	24.94038	30.79076	27.86557c/g
Acc-17878	47.67	44.33	46.00kl	17.67	15.33	16.50o/q	21.08331	52.14517	36.61424b
Acc-17879	46.00	51.33	48.67g/j	16.00	20.67	18.34k/m	24.61746	23.87993	24.24870g/m
Acc-17882	51.33	49.33	50.33d/f	21.33	18.33	19.83e/j	25.45665	27.13502	26.29584d/j
Acc-17883	52.67	48.00	50.34d/f	22.67	18.00	20.34c/h	27.24266	29.55291	28.39779 c/f
Acc-17889	40.33	41.67	41.00p	13.33	14.33	13.83s	28.85924	30.58545	29.72235 cd
Acc-17890	45.00	47.00	46.00kl	15.00	16.33	15.67p/r	22.84740	32.00270	27.42505 c/h
Acc-19288	47.00	52.33	49.67e/g	17.00	21.33	19.17h/l	20.50525	27.35429	23.92977h/m

Acc-19289	43.67	45.00	44.34mn	15.00	16.33	15.67p/r	20.54113	28.96688	24.75401 f/l
Acc-19290	48.67	52.33	50.50c/f	18.67	22.67	20.67c/f	20.35176	26.20414	23.27795i/n
Acc-19893	51.67	51.33	51.50cd	21.67	16.67	19.17h/l	24.80085	32.95750	28.87918c/e
Acc-19912	46.33	51.00	48.67g/j	16.33	21.67	19.00i/l	27.23070	28.00012	27.61541c/h
Sahel	43.33	44.67	44.00m/o	14.67	14.67	14.67rs	42.96993	48.85021	45.91007a
STM-1	48.33	46.67	47.50i/k	18.33	16.67	17.50m/o	18.87272	25.14768	22.01020k/n
STM-2	51.33	52.67	52.00bc	21.33	21.67	21.50c	25.38688	27.42605	26.40647d/j
STM-3	45.67	46.67	46.17kl	15.67	18.00	16.84n/p	27.20877	21.18298	24.19588g/m
Taiwan	45.43	48.05	46.74	16.14	19.14	17.64	29.28325	28.60580	28.94453
AVR-201	48.33	52.67	50.50c/f	18.33	22.00	20.17d/i	33.03524	29.25990	31.14757c
AVR-211	45.33	47.00	46.17kl	15.33	22.67	19.00i/l	27.19881	25.10383	26.15132d/j
AVR-241	43.00	43.33	43.17no	14.33	20.67	17.50m/o	33.42792	44.09615	38.76204b
AVR-251	45.67	52.33	49.00f/i	16.00	15.00	15.50qr	32.19805	21.08730	26.64268d/j
AVR-261	50.67	51.00	50.84c/e	20.67	21.67	21.17cd	30.89442	40.18925	35.54184b
AVR-321	43.33	44.67	44.00m/o	14.67	15.67	15.17r	27.82471	18.37838	23.10155i/n
AVR-341	41.67	45.33	43.50no	13.67	16.33	15.00rs	20.40359	22.12582	21.26471l/n
USA	48.29	48.92	48.61	18.38	18.88	18.63	25.97890	25.52567	25.75229
CLN-222	46.00	44.67	45.34lm	16.00	17.00	16.50o/q	34.72956	25.07991	29.90474cd
CLN-232	49.67	49.33	49.50e/h	19.67	15.33	17.50m/o	31.51832	27.67720	29.59776cd
CLN-272	52.00	51.00	51.50cd	22.00	20.00	21.00c/e	21.85074	23.68459	22.76767j/n
CLN-282	44.33	42.67	43.50no	15.00	14.67	14.84rs	25.66196	29.08448	27.37322c/h
CLN-292	47.00	47.67	47.34jk	17.00	18.00	17.50m/o	17.49534	23.99355	20.74445mn
CLN-312	55.00	54.33	54.67a	25.00	24.33	24.67a	20.65674	19.20959	19.93317n
CLN-352	45.67	52.33	49.00f/i	15.67	22.33	19.00i/l	37.90690	24.52178	31.21434c
CLN-362	46.67	49.33	48.00h/j	16.67	19.33	18.00l/n	18.01161	30.95422	24.48292f/m

Days to fruiting

Mean values for tomato accessions for days to fruiting were 17.72 and 18.57 days under Haripur and Swabi environment, respectively, indicating a net difference of 0.85 days between two tested environments (Table 3). This character showed wide range

of variation provides ample scope for selecting the desirable genotypes. Minimum numbers of days to fruiting (13.83 days) were observed for genotype Acc-17889 followed by Sahel and Acc-17867 (14.67 days), CLN-282 (14.84 days) and AVR-321 (15.17 days). These genotypes were early

maturing by taking less days to maturity. Whereas, maximum value of (24.67 days) was observed for CLN-312 followed by EUR-303 (23.17 days), STM-2 (21.50 days) and AVR-261 (21.17 days). These were grouped in late maturing. Similar trend was also observed by Sunnadagudi [11] in tomato. Comparison between the environments showed that genotype EUR-303 revealed maximum number of days to fruiting (23.33 days) in Haripur environment. However, in Swabi the genotype CLN-312 revealed maximum days to fruiting with a mean value of 24.33. Category wise, over all mean across two locations ranged between Acc-17889 (13.83) to STM-2 (21.50 days) for indigenous group, EUR-333 (16.84) to EUR-303 (23.17 days) for European, AVR-341 (15.00) to AVR-261 (21.17 days) for Taiwan and CLN-282 (14.84) to CLN-312 (24.67 days) for American germplasm.

Yield hectare⁻¹ (tons)

Mean values of 40 tomato genotypes for yield per hectare was 26.22 and 28.42 tons per hectare under Haripur and Swabi environment, respectively, indicating a net difference of 2.20 tons between two tested environments (Table 3). Maximum value of 45.91 tons per hectare were observed in Sahel followed by AVR-241 (38.76), Acc-17878 (36.61), AVR-261 (35.54) and CLN-352 (31.21) whereas, minimum (19.65 tons) was observed for Acc-06232 followed by CLN-312 (19.93), CLN-292 (20.74), AVR-341 (21.26) and STM-1 (22.01) for yield per hectare (Table 3). A wide range of yield/ha (27.91 to 75.55 t/ha) was also reported in six cherry tomato lines by Ingale [12]. Comparison between the environments showed that genotype Acc-17878 revealed maximum (52.14 tons) yield per hectare in Swabi environment followed by the Sahel genotype in the same location with an average yield of 48.85 tons per hectare; however, minimum (17.49 tons) yield per

hectare was observed in Swabi. Indigenous, European, Taiwan and USA group ranged from 19.64 ton (Acc-06232) to 36.61 ton (Acc-17878), 25.38 ton (EUR-303) to 28.29 ton (EUR-333), 21.26 ton (AVR-341) to 38.76 ton (AVR-241) and 19.93 ton (CLN-292) to 29.90 tons (CLN-222), respectively. Fruit yield is the final products of various characters and here it was considered to be the resultant variable while the rest of the variables were casual variables. Each character influence fruit yield by its direct and indirect contributions with other characters. An aggregate residual factor that includes all other factors affecting fruit yield and not yet accounted was treated as independent of the rest of factors considered.

Conclusions

Based on two-location studies, it was concluded that environments in combination with genotypes play principal role in phenotypic manifestation of the various traits followed by $G \times E$ interaction. Overall, accession Sahel followed by STM-3 and AVR-321 showed best performance and found more adaptive to the existing environmental conditions of Swabi. These accessions could be grown for improvement in fruit yield of tomato.

Authors' contributions

Conceived and designed the experiments: I Hussain, Performed the Experiments: N Ali & A Ali, Analyzed the Data: A Farid, Contributed reagents/ materials/ analysis tools: SM Khan, I Hussain, N Ali and A Ali, Wrote the paper: SA Khan, A Khan, SM Khan & H Raza.

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