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Heritability Studies of Fruit Related Traits in *Solanum Lycopersicum* L. Germplasm

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Abstract

Studies were conducted for the estimation of variability in 20 tomato varieties/hybrids for fruit length, fruit width, pericarp thickness, fruit firmness at pink stage and fruit firmness at red stage. Analysis of variance revealed significant variation in tomato germplasm for all quality traits. Heritability estimates were higher for all the characters, whilst genetic advance was high only for fruit width and fruit length. Estimates of heritability and genetic advance for these traits suggest that direct selection may be more effective, and the plant material for other characters can be improved through hybridization and selective breeding.

Keywords: *Solanum lycopersicum*, variability, heritability, genetic advance, breeding

1. Introduction

Tomato (*Solanum lycopersicum* L.) 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 (Tigchelaar, 1986). 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 (Anonymous, 2006).

In Pakistan, very little efforts have been made for improving vegetable crops including tomato, because of their secondary importance in the crop husbandry (Shokat et al., 2011). 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 (Anonymous, 2011). 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 tones of tomato seeds worth 2.09 million US$ (Anonymous, 2006) while it was increased significantly to US$ 5.1 million in 2009 (Anonymous, 2011).

This expensive seed supply of tomato necessitates the vegetable breeders to breed varieties/hybrids having great yield potential under local environments. For this purpose,

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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 (Passam et al., 2007). In present study, a small sample of 20 tomato varieties/hybrids were examined to study variation in different fruit related traits and data analyzed to calculate heritability and genetic advance of those characters.

2. Materials and Methods

Twenty tomato genotypes containing two checks (Nagina and Riogrande) and 18 hybrids were (Table-1) grown in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during the year 2008-09. The nursery of plant material was raised on well prepared small beds and one month old healthy seedlings were transplanted in field using Randomized Complete Block Design with three replications. Each entry was sown in single row 6.5 meter long, with intra-row and inter-row spacing of 50 cm and 125 cm, respectively. Transplanting was done on one side of bed just after irrigation. Agronomic and plant protection practices were applied as and when required. Data was collected on fruits from ten random plants for fruit length (mm), fruit width (mm), fruit firmness at pink stage (kg/cm^2), fruit firmness at red stage (kg/cm^2) and pericarp thickness (mm) proposed by IPGRI, Italy (Anonymous, 1996). Analysis of variance technique was used to split the total variation into its components which were estimated using the method described by Bliss et al., (1973). Variance components were obtained by equating the mean square as given below:

$\delta^2 e = M_3$

$\delta^2 gy = M_2 - M_3/Y$

$\delta^2 g = M_1 - M_2/ry$

where $\delta^2 e$, $\delta^2 gy$ and $\delta^2 g$ are components of variance due to error, genotype * environment interaction and genotypes respectively. M_1, M_2 and M_3 are the observed values of mean squares for the genotypes, interaction and error, respectively (Fehr, 1987).

Heritability estimates genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and genetic advance (GA) were calculated using the following formulae (Singh & Choudhary, 1985).

$h^2_{\text{(b.s.)}} = Vg/ Vp$

$GCV = \sqrt{\delta^2 g} / \bar{U}$

$PCV = \sqrt{\delta^2 gy} / \bar{U}$

$GA = i\sqrt{Vp}H*100$

where “i” is the coefficient constant

3. Results

Analysis of variance revealed significant differences for all the characters ($P \leq 0.01$, Table-2). Statistical and genetic parameters for different characters are presented in the Table-3 that showed low coefficient of variability for fruit length (8.12%). Estimates of genotypic, phenotypic and environmental variances for fruit length were 66.98, 71.76 and 4.78 while genotypic, phenotypic and environmental coefficients of variability were 1.44, 1.53 and 0.10 respectively. Higher values of both broad sense heritability (0.93) and genetic advance (17.86) were observed for fruit length. However for fruit width, low coefficient of variability (6.53%) was recorded while genotypic, phenotypic and environmental variances were 86.72, 89.12 and 2.40 respectively. Similarly values of genotypic, phenotypic and environmental coefficients of variability for fruit width were 2.11, 2.17 and 0.06 respectively while higher estimates of broad sense heritability (0.97) and genetic advance (20.76) were recorded.

Low coefficient of variability (7.41%) was recorded for fruits firmness at pink stage. The genotypic, phenotypic and environmental variances for this character were 0.54, 0.59 and 0.05 while their coefficients of variability were 0.10, 0.11 and 0.01 respectively. Estimate of broad sense heritability (0.92) was high while genetic advance (1.89) was on the lower side. Coefficient of variability for fruit firmness was low (7.07%) at red stage. The genotypic, phenotypic and environmental variances were 0.36, 0.38 and 0.02 whilst coefficients of variability were 0.10, 0.11 and 0.01 respectively for this trait. High estimate of broad sense heritability (0.95) showed that fruit firmness is heritable character and expected genetic advance was 1.32. Coefficient of variability was low (4.52%) for pericarp thickness. The estimates of genotypic, phenotypic and environmental variances were 1.67, 1.69 and 0.02 while coefficients of variability for pericarp thickness were 0.30, 0.31 and 0.01 respectively. Estimate of broad sense heritability for pericarp thickness was high (0.99) signifying the expected genetic advance of 3.78.

4. Discussion

For the development of potential plant material of *Solanum lycopersicum* L. through selection and breeding, availability of variation in the desired characters is imperative for vegetable breeder. In present study, simple analysis of variance for fruit length, fruit width, pericarp thickness, fruit firmness at pink stage and fruit firmness at red stage revealed significant variability. These results indicated that variation in these fruit characters may involve an additive genetic component as described by Hayman (1954) and thus based upon the significant amount of variation. The observed variation would be helpful for the development of desired plant material in tomato. However, a continuous study for the genetic basis of variation is essential.

Heritability was calculated using the genotypic and phenotypic coefficient of variation which was high for all the characters. Similarly, high genetic advance was noted for fruit length and fruit width as reported by Rehman et al., (2002), Kale et al., (1988), Saleem et al., (2009) and Rajan (2012). Direct selection for these parameters may be practiced without any further hybridization (Saleem et al., 2011). Fruit firmness is an important parameter regarding the internal quality of tomato fruit (Marcic et al., 2011). High estimate of broad sense heritability and moderate genetic advance was calculated for fruit firmness at pink and red stage. Both these characters might be improved through hybridization. Although estimates of heritability for all the characters appeared to be inflated, which is encouraging for a breeder but the characters exhibited high estimates of broad sense heritability with low genetic advance, direct selection of these characters may mislead as suggested by Frageria & Kohli (1997) and Kamruzzahan et al., (2000). Pericarp thickness is one of the most important traits regarding the shelf life of tomato in which high heritability and low genetic advance was calculated. These results support the findings of Al-Aysh et al., (2012), Rajan (2012) that pericarp thickness may further be improved through hybridization (Rajan, 2012; Pradeepkumar et al., 2001). The information obtained in present study is from limited tomato germplasm; therefore results cannot be generalized for whole of the tomato *(Solanum lycopersicum)* species. Evaluation of large number of accessions/hybrids is suggested in future to substantiate the information reported here.

Table 1. List of varieties/hybrids of *Solanum lycopersicum* L.

Sr. No.	Genotypes	Organization Name
1	Nagina	Ayub Agricultural Research Institute (AARI), Faisalabad
2	Advanta 1211	Imperial Chemical Industries for Life Sciences, Pakistan
3	Advanta 1208	Imperial Chemical Industries for Life Sciences, Pakistan
4	Money Maker (Auriga)	Auriga, Pakistan
5	Sitara 6001	Sitara Seeds, Pakistan
6	Advanta 1203	Imperial Chemical Industries for Life Sciences, Pakistan
7	Riogrande	Ayub Agricultural Research Institute (AARI), Faisalabad
8	Advanta 1204	Imperial Chemical Industries for Life Sciences, Pakistan
9	Sitara TS-7	Sitara Seeds, Pakistan
10	Sitara 607	Sitara Seeds, Pakistan
11	Advanta 1209	Imperial Chemical Industries for Life Sciences, Pakistan
12	Advanta 1207	Imperial Chemical Industries for Life Sciences, Pakistan
13	Advanta 1210	Imperial Chemical Industries for Life Sciences, Pakistan
14	Kanzo	Kanzo Seeds, Pakistan
15	D-44-48	Ayub Agricultural Research Institute (AARI), Faisalabad
16	Advanta 1205	Imperial Chemical Industries for Life Sciences, Pakistan
17	Advanta 1202	Imperial Chemical Industries for Life Sciences, Pakistan
18	Advanta 1206	Imperial Chemical Industries for Life Sciences, Pakistan
19	Tomato Cherry	United Distributors Karachi, Pakistan
20	QF Red	United Distributors Karachi, Pakistan

Table 2. Analysis of variance of fruit related characters

Genetic parameters	FL	FW	FFP	FFR	PT
Replication mean square	14.92	17.44	0.02	0.01	0.005
Genotypic mean square	215.28	267.37	1.76	1.14	5.08
Genotypic F. value	15.02	37.06	12.08	20.47	82.78

Table 3. Variability and heritability of fruit related characters

Genetic parameters	FL	FW	FFP	FFR	PT
Coefficient of variability (%)	8.12	6.53	7.41	7.07	4.52
Genotypic variance	66.98	86.72	0.54	0.36	1.67
Phenotypic variance	71.76	89.12	0.59	0.38	1.69
Genotypic coefficient of variation	1.44	2.11	0.10	0.10	0.30
Phenotypic coefficient of variation	1.53	2.17	0.11	0.11	0.31
Broad sense heritability	0.93	0.97	0.92	0.95	0.99
Genetic advance	17.86	20.76	1.89	1.32	3.78

* FW = Fruit width, FFP = Fruit firmness at pink stage, FL = Fruit length FFR = Fruit firmness at red stage and PT = pericarp thickness

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