

Genetic Architecture and Association of Fruit Yield and Quality Traits in Tomato (*Solanum Lycopersicum* L.)

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Abstract Information regarding genetic base, nature and strength of association and effect of different yield component and quality traits on final yield is prerequisite of a crop improvement program. Twenty one genotypes of tomato were sown in triplicated complete randomized design to access this information. All traits showed considerable genetic variation with variable environmental influence. Additive gene action was involved in expression of days to 50% flowering, vine length, number of fruits per plant and fruit weight. Dominance played major role for number of fruit clusters per plant and lycopene contents. Number of fruit clusters per plant, number of fruits per plant, fruit weight, fruit firmness and lycopene contents had strong positive association with fresh fruit yield per plant at genotypic level. Number of fruit clusters per plant had maximum direct effect on fresh fruit yield followed by fruit weight, number of fruits per plant and days to 50% flowering. It was concluded that number of fruits per plant is more important for varietal development while for hybrid breeding, number of fruit clusters per plant should be main concern along with fruit firmness and lycopene contents.

Keywords *Solanum Lycopersicum* L., Genotypic Correlation, Direct/Indirect Effects, Gene Action, Fruit Quality

1. Introduction

The cultivated tomato (*Solanum lycopersicum* L.) is a tender perennial crop and is being grown in a variety of climatic conditions. The adoption of tomato in various environments and methods of production and versatility in its uses is attributed to wealth of genetic variation existing in this genus. And this genetic variability could easily be exploited because of the tomato flowering behavior. Therefore it had led to wide developments of uncountable number of open pollinated varieties and hybrids having specific characteristics and special uses round the world. It contributes substantially to dietary intake of vitamin A, B, C and essential minerals (Tigchelaar, [1]). In Pakistan, very

little efforts have been made on the improvement of vegetable crops including tomato because of their secondary importance in the crop husbandry. Consequently, in tomato very few local varieties are available for cultivation and most of them are selections from introduced germplasm and absolutely no local hybrid have been brought to the market yet. Furthermore, the available varieties are poor in quality traits and therefore, are unable to get farmer's and consumer's attraction due to certain inferior traits and these need to be replaced with newly evolved improved varieties and hybrids with attractive quality traits good yield potential. Investigation of genetic base of various fruit yield and quality parameters and their association helps to develop suitable breeding strategy. Considering all these facts, the present study was conducted to understand genetic base of various fruit yield and quality traits, their nature and strength of association and their direct and indirect effects on fresh fruit yield.

2. Materials and Methods

The present trial was conducted at research farm of Vegetable Research Institute, Faisalabad, Pakistan during 2012-13 located between 73°-74° East longitude and 30°-31.5° North latitude. Twenty one genotypes of tomato were grown in triplicated randomized complete block design (RCBD). Thirty days old healthy seedlings were transplanted in plot size of 6.50 × 1.25 m with plant spacing of 50 cm. Standard agronomic practices were performed throughout the cropping season.

Observations of days to 50% flowering (DTF) were recorded on plot basis. Five guarded plants were tagged in each plot for further data collection. Vine length was measured manually from each tagged plant and mean value was used in data analysis. Observations for number of fruit clusters per plant (FC/P), number of fruits per plant (F/P) and fresh fruit yield per plant were recorded for each tagged plant separately. Ten fruits (at horticultural maturity) were selected from each tagged plant and data was recorded for fruit weight (FW), fruit firmness (FF), Pericarp thickness (PT), total soluble solids (TSS) and lycopene contents (LC).

Analysis of variance was used to check significance of differences among genotypes for all traits following Steel *et al.* [2]. Genotypic and phenotypic components of variations were computed following Burton and Devane [3]. Broad sense heritability and genetic advance was computed using formula given by Falconer and Mackay [4]. 5% selection intensity (2.06) was used in estimation of genetic advance. Phenotypic and Genotypic correlation coefficients were estimated using formula given by Kown and Torrie [5]. Path analysis for estimating direct and indirect effects of traits in yield was performed using formula given by Dewey and Lu [6].

3. Results and Discussion

Analysis of variance (Table 1) revealed significant differences among genotypes for all traits under study. Phenotypic variances were slightly greater than genotypic variances for all traits which implies that all these traits are prone to environmental variations (Gosh *et al.* [7]). However small values of environmental variances for all traits except vine length and number of fruits per plant showed that major portion of variations observed was genetic in nature. High heritability estimates for days to 50% flowering, vine length, number of fruit cluster per plant, number of fruits per plant and fruit weight suggested that these traits could be improved through direct selection on phenotypic basis (Haydaret *al.* [8]). Fruit firmness, pericarp thickness, total soluble salts and lycopene contents had medium to low heritability. These traits with low heritability could be improved through recurrent selection (Cramer and Wehner [9]). Medium to high estimates of genetic advance coupled with high heritability for days to 50% flowering, vine length, number of fruits per plant and fruit weight suggested involvement of additive gene action in expression of these traits. These traits should be considered in selection procedure for varietal development (Bharti *et al.* [10] and Singhet *al.* [11]). Non additive genes are involved in expression of number of fruit clusters per plant and lycopene contents indicated by medium high heritability and low genetic advance. These traits could be improved effectively through hybrid breeding. Medium to low heritability along with low genetic advance was observed for fruit firmness, pericarp thickness, total soluble salts and fruit yield per plant (Hidayatullahet *al.* [12]). This implies to complex genetic base involved in expression of these traits along with considerable environmental influence. Hence direct selection for these traits solely on phenotypic basis is not feasible. Genotypic and phenotypic correlations among various morphological and fruit quality traits of tomato are presented in Table 2. Small differences between genotypic and phenotypic values was observed which implies that this

association had strong genetic base. Number of fruits per plant had strong positive association with number of fruit clusters per plant and negative association with fruit weight and pericarp thickness at both genotypic and phenotypic level (Bucksethet *al.* [13]). Hence simultaneous improvement in number of fruits per plant and fruit weight is challenging. However pericarp thickness was positively associated with fruit weight and fruit firmness while negatively correlated to total soluble salts. Hence pericarp thickness and fruit firmness may be considered as direct selection criteria for fruit shelf life. Positive correlation between pericarp thickness and shelf life had been reported by Bucksethet *al.* [13]. Lycopene contents are negatively correlated to total soluble salts at genotypic level. Fruit yield per plant had strong positive correlation with number of fruit clusters per plant, number of fruits per plant, fruit weight, fruit firmness and lycopene contents while negative correlation with pericarp thickness and total soluble salts (Bucksethet *al.* [13] and Agonget *al.* [14]). This implies that side by side improvement of fresh fruit yield and fruit shelf life is challenging if number of fruits per plant and number of fruit clusters per plant are considered as selection criteria. Plant breeder had to compromise on a specific level of fruit quality and fruit yield to develop an economically accepted cultivar. Lycopene contents, which is an important fruit quality character, showed no direct correlation with any morphological fruit character, hence indirect selection for high lycopene contents is challenging. However fruits with high TSS value also had low lycopene contents as revealed by their significant negative correlation at genotypic level. Also lycopene contents are prone to environmental variations due to medium heritability and low genetic advance.

Number of fruit clusters per plant had maximum direct effect on fresh fruit yield followed by fruit weight, number of fruits per plant and days to 50% flowering (Fig. 1) (Dhankaret *al.* [15] and Prashanthe *al.* [16]). Total soluble salts had high negative direct effect on yield per plant. However total soluble salts had positive indirect effect on yield through number of fruits per plant and number of fruit clusters per plant (Table 3). Number of fruits per plant had more pronounced effect on fresh fruit yield per plant through number of fruit cluster per plant. Thus direct selection for fruit cluster per plant and fruit per plant is more rewarding as compared to fruit weight. Positive effect of pericarp thickness on fruit yield was diluted due to negative effects through number of fruit clusters per plant and number of fruits per plant. Number of fruits per plant should be given preference over fruit clusters per plant for varietal development while for hybrid breeding fruit clusters per plant should be considered along with fruit firmness and lycopene contents. Residual effects (R) were negligible which implies little influence of other traits, not included in this study, on fruit yield and quality of tomato.

Table 1. Estimation of component of variances for various yield components and fruit quality traits of Tomato

Character	DTF	VL	FC/P	F/P	FW	FF	PT	TSS	LC	FY/P
Population Mean	87.92	103.43	7.25	63.48	42.65	3.91	5.64	4.29	0.045	2.00
Genotypic MS (df = 20)	23.86**	493.09**	2.90**	1547.47**	103.81**	1.14**	2.91**	0.82**	6.42 E-4**	0.82**
Genotypic variance (σ^2G)	7.41	157.08	0.95	513.37	33.75	0.25	0.73	0.21	1.95 E-4	0.27
Phenotypic variance (σ^2P)	9.04	178.93	0.99	520.72	36.31	0.63	1.45	0.40	2.52 E-4	0.29
Environmental variance (σ^2E)	1.63	21.85	0.04	7.35	2.56	0.38	0.72	0.19	0.57 E-4	0.02
Genotypic coefficient of variability (GCV)	3.10	12.12	13.46	35.69	13.62	12.88	15.17	10.73	31.18	25.78
Phenotypic coefficient of variability (PCV)	3.42	12.94	13.76	35.95	14.13	20.37	21.32	14.68	35.48	26.71
Broad sense heritability (HBS)	0.82	0.88	0.96	0.98	0.93	0.40	0.51	0.53	0.77	0.93
Genetic advance (GA)	5.08	24.25	1.97	46.07	11.54	0.65	1.27	0.69	0.03	1.03

** indicates significant at 1% level of significance, DTF = Days to 50% flowering, VL = Vine length (cm), FC/P = Number of fruit clusters per plant, F/P = Number of fruits per plant, FW = Fruit weight (g), FF = Fruit Firmness (Kg/cm²), PT = Pericarp Thickness (mm), TSS = Total soluble salts (%), LC = Lycopene contents (g/100g), Y/P = Yield per plant (Kg)

Table 2. Estimation of genotypic and phenotypic correlation coefficients for various yield components and fruit quality traits of Tomato

Character		DTF	VL	FC/P	F/P	FW	FF	PT	TSS	LC	Y/P
DTF	G	1									
	P	1									
VL	G	-0.25	1								
	P	-0.21	1								
FC/P	G	-0.38	-0.30	1							
	P	-0.33	-0.28	1							
F/P	G	-0.29	-0.24	0.90**	1						
	P	-0.26	-0.22	0.84**	1						
FW	G	-0.14	0.29	-0.41	-0.53*	1					
	P	-0.12	0.26	-0.40	-0.51*	1					
FF	G	-0.28	-0.24	0.21	-0.03	0.13	1				
	P	-0.21	-0.08	0.15	0.06	0.08	1				
PT	G	0.21	-0.32	-0.30	-0.51*	0.07*	0.71**	1			
	P	0.08	0.02	-0.26	-0.37	0.10	0.38	1			
TSS	G	0.25	-0.31	0.32	0.42	-0.43	-0.75**	-0.25**	1		
	P	0.18	-0.23	0.23	0.31	-0.33	-0.27	-0.20	1		
LC	G	-0.17	-0.11	0.01	0.004	-0.35	0.12	-0.11	-0.49*	1	
	P	-0.09	-0.12	0.02	-0.01	-0.03	0.01	-0.07	-0.31	1	
Y/P	G	-0.22	-0.21	0.60**	0.50*	0.11*	0.50*	-0.22*	-0.14*	0.16*	1
	P	-0.21	-0.20	0.58**	0.49*	0.10*	0.33*	-0.20*	-0.07*	0.12*	1

** indicates significant at 1% level of significance, * indicates significant at 5% level of significance, G = Genotypic correlation coefficient, P = Phenotypic correlation coefficient

Table 3. Estimation of direct and indirect effects of various yield components and fruit quality traits of Tomato on fruit yield per plant

Character	DTF	VL	FC/P	F/P	FW	FF	PT	TSS	LC	Y/P
DTF	0.289	0.042	-0.261	-0.122	-0.07	0.025	0.006	-0.138	0.008	-0.22
VL	-0.071	-0.171	-0.202	-0.103	0.142	0.021	-0.001	0.170	0.006	-0.21
FC/P	-0.110	0.051	0.685	0.379	-0.199	-0.019	-0.009	-0.176	-0.0003	0.60**
F/P	-0.082	0.041	0.610	0.427	-0.259	0.002	-0.015	-0.231	0.00	0.50*
FW	-0.040	-0.050	-0.281	-0.227	0.486	-0.012	0.002	0.233	0.002	0.11*
FF	-0.082	0.041	0.145	-0.012	0.064	-0.089	0.021	0.412	-0.006	0.50*
PT	0.061	0.005	-0.205	-0.217	0.032	-0.063	0.029	0.137	0.006	-0.22*
TSS	0.073	0.053	0.221	0.181	-0.207	0.067	-0.007	-0.546	0.025	-0.14*
LC	-0.048	0.019	0.004	0.0002	-0.017	-0.011	-0.003	0.270	-0.051	0.16*

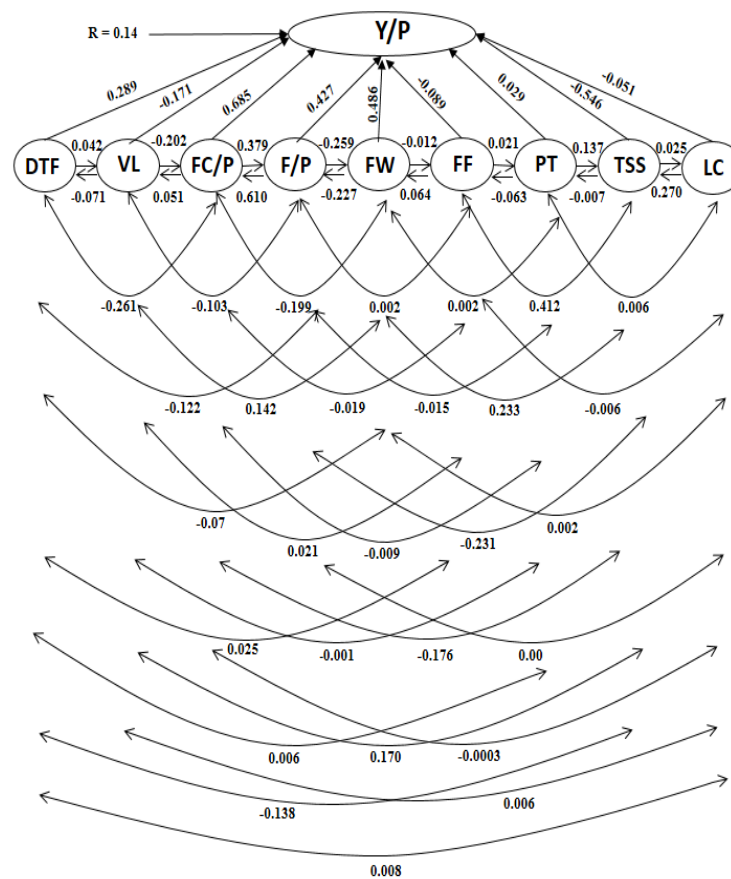


Figure 1. Path diagram of direct/indirect effects of yield components and fruit quality traits on fresh fruit yield of tomato.

4. Conclusion

Considerable genetic variation exists in tomato for efficient yield and quality improvement. Different selection criteria should be followed for hybrid and varietal development. Indirect selection for lycopene contents through morphological markers is challenging. Number of fruits per plant is more important for varietal development while for hybrid breeding, number of fruit clusters per plant should be main concern along with fruit firmness and lycopene contents.

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