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# Inter-relationship for various components and path co-efficient analysis in tomato (*Solanum lycopersicum* L.)

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**ABSTRACT :** The correlation and path co-efficient studies were conducted for sixteen genotypes of tomato at Vegetable Research Farm, Department of Vegetable Science and Floriculture at C.S.K. Himachal Pradesh Agricultural University, Palampur during 2012 and 2013. Findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the character studied. Marketable yield had a positive and highly significant association with gross yield per plant, number of marketable fruits per plant, total fruits per plant, average fruit weight, number of nodes, plant height and TSS content. Strong association of these traits revealed that the selection based on these traits would ultimately improve the marketable yield and it is also suggested that hybridization of genotypes possessing combination of above characters will prove more useful for getting desired segregants. Path co-efficient analysis revealed that gross yield per plant, ascorbic acid, pericarp thickness and average fruit weight had the highest positive direct effect on fruit yield at phenotypic levels. Number of locules per fruit, total number of fruits per plant, fruit shape index, number of marketable fruits per plant and TSS content also had positive direct effects. Hence, it would be rewarding to lay stress on these characters in selection programme for increasing the marketable yield.

**KEY WORDS :** Correlation and path analysis, Tomato, Genotypes, Yield, Quality

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**T**omato is one of the most nutritive vegetables which is very rich in vitamin A and vitamin C, proteins, fats and carbohydrates, food energy calories as well as other essential minerals and food elements. It is also rich in medicinal value. Study of inter relationship among various characters in the form of correlation is one of the important aspects in the selection programme for the breeder to make an effective selection based on the correlated and uncorrelated response. The direct

selection for fruit yield is not sufficiently effective, as yield is polygenetically controlled and associated with number of related traits. Therefore, indirect selection is desirable for improvement of yield. A knowledge of association between yield and its component traits and inter relationship among themselves may provide information fruitful for planning an effective and successful breeding programme. The estimation of correlation indicates only the extent and nature of

association between yield and its components, but does not show the direct and indirect effects of different yield attributes on yield. Fruit yield is dependent on several characters which are mutually associated, these will in turn impair the true association existing between a component and fruit yield. A change in any one component is likely to disturb the whole network of cause and effect. Thus, each component has two paths of action *viz.*, the direct influence on fruit yield, indirect effects through components which are not revealed from correlation studies. Thus, the present investigation was initiated to study both correlation and path co-efficient analysis in different tomato genotypes.

### RESEARCH PROCEDURE

The experiment was carried out at the experimental farm of Department of Vegetable Science and Floriculture, C.S.K. Himachal Pradesh Krishi Vishvavidyalaya, Palampur during 2012 and 2013 in Randomized Block Design (RBD) replicated thrice inside the modified naturally ventilated polyhouse of the size 25m × 10m. The experimental material used for the present study comprised of 15 diverse bacterial wilt resistant hybrids of tomato developed at CSKHPKV Palampur with one check hybrid from private sector. The details of the hybrids along with their sources are presented in Table A.

Besides the application of vermicompost @ 5 tonnes per hectare, chemical fertilizers were applied as per recommendations for protected cultivation (50 kg each

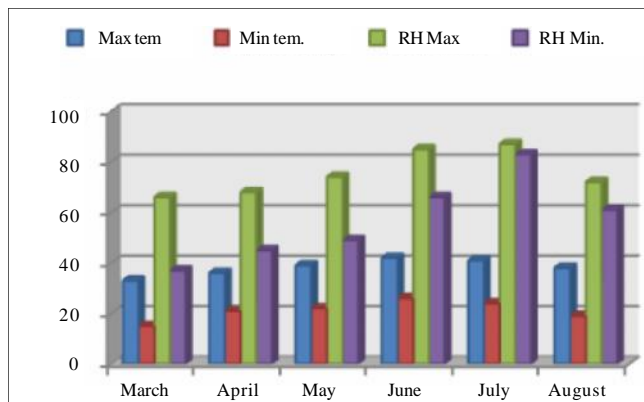


Fig. A : Weather data during cropping season in year 2012

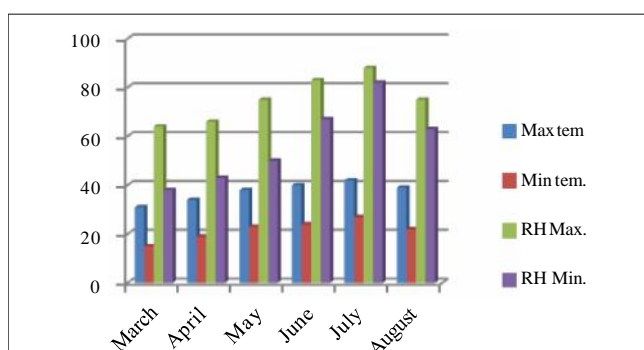


Fig. B : Weather data during cropping season in year 2013

of N, P and K per ha) through straight fertilizers. Whole of the vermicompost and chemical fertilizers were applied in pits before transplanting. The fertigation was given twice a week by applying liquid fertilizer (19:19:19) @ 2.2 g/m<sup>2</sup> of the effective area of polyhouse after third week of transplanting and was stopped 15 days before final harvest.

### RESEARCH ANALYSIS AND REASONING

The major causes underlying association are either due to pleiotropic gene action or linkage or both. The phenotypic correlation includes genotypic and environmental effect, which provides information about total association between the observable characters. Genotypic correlation provided a measure of genetic association between the characters and normally used in selection, while environmental as well as genetic architecture of a genotype plays a great role in achieving higher yield combined with better quality. The genotypic and phenotypic correlation for fruit yield and its component in tomato for Env. I, II and over environments are

Sr. No.	Hybrids	Source
1.	BWR-5(F/R) × CLN 1314G	CSKHPKV, Palampur
2.	BWR-5(F/R) × Palam Pride	CSKHPKV, Palampur
3.	BWR-5(F/R) × 16-B	CSKHPKV, Palampur
4.	CLN 1314G × Palam Pride	CSKHPKV, Palampur
5.	1-2 × 16-B	CSKHPKV, Palampur
6.	1-2 × BBWR-21-3-16	CSKHPKV, Palampur
7.	12-1 × Palam Pride	CSKHPKV, Palampur
8.	15-2(H/R) × Palam Pride	CSKHPKV, Palampur
9.	15-2(H/R) × 16-B	CSKHPKV, Palampur
10.	15-2(H/R) × Hawaii-7998	CSKHPKV, Palampur
11.	BL 333-1×16-B	CSKHPKV, Palampur
12.	Hawaii-7998 × Palam Pride	CSKHPKV, Palampur
13.	Hawaii-7998 × Palam pink	CSKHPKV, Palampur
14.	BBWR-11-1 × BBWR-21-3-16	CSKHPKV, Palampur
15.	BBWR-21-3-16 × Palam Pride	CSKHPKV, Palampur
16.	Avtar (Check)	Nunhems Company

presented in Tables 1, 2, 3, 4 and 5, respectively and mostly significant correlations are discussed here.

At phenotypic level, marketable yield per plant was positively and significantly correlated with gross yield per plant, total number of fruits per plant, average fruit weight, number of nodes and plant height in Env. I whereas, in Env. II marketable yield per plant was significantly and positively correlated with gross yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight, number of nodes, plant height, TSS content and acidity. Over environments at phenotypic level, marketable yield per plant was positively and significantly correlated with gross yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight, number of nodes, plant height and TSS content.

Gross yield per plant in Env. I was positively and significantly correlated with marketable yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight, number of nodes and plant height at phenotypic level. On the other hand, days to first harvest and internodal length showed negative correlation with marketable yield per plant. Mehta and Asati (2008) also reported negative correlation of marketable yield with days to flowering, days to first harvest and fruiting. In Env. II gross yield per plant was positively and significantly associated with marketable yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight, number of nodes, plant height and TSS content. Over environments this trait showed positive and significant correlation with marketable yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight, number of nodes, plant height and TSS content. These results suggest that effective improvement in tomato yield can be achieved by selection for these traits. Bhutani and Kalloo (1989); Kant and Mani (2004) and Bilashini *et al.* (2011) have also reported positive association between number of fruits and yield.

Days to 50 per cent flowering had positive and significant correlation with days to first harvest and ascorbic acid over the environment. Negative significant correlation also existed for this trait with gross yield per plant, number of marketable fruits per plant, total number of fruits per plant, number of nodes, plant height, TSS content and marketable yield per plant.

Days to first harvest that this trait was significantly and positively correlated with internodal length and

negatively significantly correlated with gross yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight, number of nodes, plant height, TSS content and marketable yield per plant. Mehta and Asati (2008) also reported negative correlation of days to first harvest with number of fruits per plant and yield.

Number of marketable fruits per plant exhibited positive and significant correlation with total number of fruits per plant, average fruit weight, number of nodes, plant height, TSS content and marketable yield per plant. Kant and Mani (2004) and Ara *et al.* (2009) also reported positive and significant correlation of number of marketable fruits per plant with yield and plant height.

Similarly, the total number of fruits per plant had positive and significant association with number of marketable fruits per plant, average fruit weight, number of nodes, plant height, TSS content and marketable yield per plant. Average fruit weight was positively and significantly associated with number of nodes, plant height and marketable yield per plant. Fruit shape index had positive and significant association with pericarp thickness. Sidhu and Singh (1989) also reported positive correlation between fruit shape index and pericarp thickness. Pericarp thickness showed positive non significant correlation was found with internodal length and marketable yield per plant. Though number of locules per fruit did not show any significant correlation with other traits in both the environments but over environments it was found to be significantly and positively correlated with TSS content and acidity. Number of nodes exhibited positive and significant correlation with plant height, TSS content and marketable yield per plant. Internodal length showed negative and significant correlation with plant height, TSS content and marketable yield per plant while positive significant with ascorbic acid.

Plant height showed positive and significant association with marketable yield per plant and TSS content in Env. I at phenotypic level. Same results were observed for Env. II as it had positive and significant correlation with marketable yield per plant and TSS content. These observations are in agreement with Kumar *et al.* (2003) and Rani *et al.* (2010). Over environments also this trait had significant positive association with marketable yield per plant and TSS content.

TSS showed positive and significant correlation with acidity and marketable yield per plant while negative and significant association existed with ascorbic acid. Anitha

**Table 1: Estimates of phenotypic (P) and genotypic (G) correlation co-efficients for different pair of quantitative and quality traits in tomato in Environment I**

Traits	Days to first harvest	Gross yield per plant (kg)	Number of fruits per plant	Total number of fruits per plant	Average fruit weight (g)	Fruit shape index	Pericarp thickness (mm)	Number of locules per fruit	Number of nodes	Internodal length (cm)	Plant height (cm)	TSS content (%)	Acidity (%)	Ascorbic acid (mg/100g)	Marketable yield per plant (kg)
Days to 50 per cent flowering	P 0.288*	-0.249	-0.457*	-0.441*	0.127	-0.236	-0.101	0.052	-0.368*	0.093	-0.446*	-0.239	0.200	0.203	-0.263
	G 0.622*	-0.634*	-0.604*	-0.640*	0.008	-0.391*	-0.318*	0.061	-0.701*	3.655*	-0.653*	-0.515*	0.154	0.424*	-0.627*
Days to first harvest	P -0.738*	-0.738*	-0.775*	-0.772*	-0.279	0.139	0.078	-0.023	-0.714*	0.290*	-0.576*	-0.377*	-0.139	0.092	-0.727*
	G -0.954*	-0.954*	-0.883*	-0.878*	-0.561*	0.124	0.128	-0.125	-0.924*	3.196*	-0.641*	-0.481*	-0.102	0.120	-0.930*
Gross yield per plant	P 0.739*	0.739*	0.739*	0.757*	0.508*	0.041	0.083	-0.003	0.629*	-0.293*	0.464*	0.282	0.026	-0.230	0.984*
	G 0.975*	0.975*	0.949*	0.949*	0.869*	-0.021	0.124	0.066	1.057*	-3.402*	0.621*	0.457*	0.023	-0.193	1.003*
Number of marketable fruits per plant	P 0.968*	0.968*	0.968*	0.968*	0.374*	0.204	0.067	0.008	0.824*	-0.389*	0.652*	0.287*	-0.005	-0.360*	0.730*
	G 0.999*	0.999*	0.999*	0.999*	0.616*	0.220	0.120	0.028	1.036*	-3.870*	0.684*	0.418*	-0.014	-0.419*	0.939*
Total number of fruits per plant	P 0.386*	0.386*	0.386*	0.386*	0.154	0.087	0.087	0.021	0.837*	-0.408*	0.655*	0.225	-0.064	-0.351*	0.740*
	G 0.557*	0.557*	0.557*	0.557*	0.174	0.174	0.240	0.045	1.027*	-3.715*	0.683*	0.407*	-0.111	-0.441*	0.923*
Average fruit weight (g)	P -0.041	-0.041	-0.041	-0.041	-0.041	-0.103	-0.024	-0.003	0.435*	-0.196	0.323*	-0.082	0.045	0.031	0.536*
	G 0.452*	0.452*	0.452*	0.452*	0.187	0.187	0.452*	0.018	0.672*	-0.115	0.488*	0.269	0.216	0.055	0.867*
Fruit shape index	P 0.372*	0.372*	0.372*	0.372*	-0.380*	-0.103	0.372*	-0.380*	-0.008	-0.087	-0.121	-0.046	-0.072	-0.468*	0.046
	G 0.639*	0.639*	0.639*	0.639*	-0.434*	-0.103	0.639*	-0.434*	0.099	-1.942*	-0.125	0.030	-0.170	-0.576*	-0.022
Pericarp thickness (mm)	P -0.167	-0.167	-0.167	-0.167	0.187	0.187	0.187	0.187	-0.018	0.138	-0.032	-0.169	-0.178	-0.121	0.080
	G -0.509*	-0.509*	-0.509*	-0.509*	0.187	0.187	0.187	0.187	-0.643*	-0.643*	-0.075	-0.203	-0.194	-0.174	0.157
Number of locules per fruit	P 0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	-0.078	0.217	0.217	0.200	0.226	-0.273	0.0002
	G 0.572*	0.572*	0.572*	0.572*	0.094	0.094	0.572*	0.094	0.572*	0.572*	0.258	0.319*	0.483*	-0.235	0.037
Number of nodes	P -0.553*	-0.553*	-0.553*	-0.553*	-0.553*	-0.553*	-0.553*	-0.553*	-0.553*	-0.553*	0.723*	0.411*	0.004	-0.244	0.607*
	G -3.009*	-3.009*	-3.009*	-3.009*	0.822*	0.822*	0.822*	0.822*	0.822*	0.822*	0.822*	0.555*	0.054	-0.319*	1.024*
Internodal length (cm)	P -0.283	-0.283	-0.283	-0.283	-0.283	-0.283	-0.283	-0.283	-0.283	-0.283	-0.283	-0.293*	0.075	0.388*	-0.289*
	G -2.170*	-2.170*	-2.170*	-2.170*	-3.746*	-3.746*	-3.746*	-3.746*	-3.746*	-3.746*	-3.746*	-3.746*	0.561*	2.489*	-3.198*
Plant height (cm)	P 0.349*	0.349*	0.349*	0.349*	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.349*	0.111	-0.169	0.446*
	G 0.513*	0.513*	0.513*	0.513*	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.513*	0.137	-0.196	0.591*
TSS content (%)	P 0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240	-0.257	0.264
	G 0.296*	0.296*	0.296*	0.296*	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.296*	0.209	-0.209	0.412*
Acidity (%)	P 0.312*	0.312*	0.312*	0.312*	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.312*	0.006	0.312*	0.006
	G 0.372*	0.372*	0.372*	0.372*	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.372*	0.007	0.372*	-0.007
Ascorbic acid (mg/100g)	P -0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163
	G -0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163	-0.163

\* indicates significance of value at P=0.05



**Table 2 : Estimates of phenotypic (P) and genotypic (G) correlation co-efficients for different pair of quantitative and quality traits in tomato in Environment II**

Traits	Days to first harvest	Gross yield per plant (kg)	Number of fruits per plant	Total number of fruits per plant	Average fruit weight (g)	Fruit shape index	Pericarp thickness (mm)	Number of locules per fruit	Number of nodes	Internodal length (cm)	Plant height (cm)	TSS content (%)	Acidity (%)	Ascorbic acid (mg/100g)	Marketable yield per plant (kg)
Days to 50 per cent flowering	P 0.569*	-0.515*	-0.651*	-0.650*	-0.113	-0.081	-0.157	0.147	-0.647*	0.056	-0.504*	-0.314*	-0.118	0.254	-0.550*
	G 0.821*	-0.942*	-1.044*	-1.035*	-0.395*	-0.036	-0.244	0.078	-1.122*	-2.164*	-0.739*	-0.534*	-0.152	0.331*	-1.098*
Days to first harvest	P -0.605*	-0.647*	-0.610*	-0.610*	-0.318*	0.029	0.050	0.065	-0.697*	0.289*	-0.755*	-0.417*	-0.185	0.170	-0.589*
	G -0.742*	-0.824*	-0.818*	-0.818*	-0.456*	0.051	-0.015	0.030	-0.913*	-1.671*	-0.824*	-0.662*	-0.258	0.226	-0.888*
Gross yield per plant	P 0.619*	0.619*	0.639*	0.639*	0.418*	-0.169	-0.056	-0.044	0.600*	-0.304*	0.506*	0.294*	0.233	-0.091	0.925*
	G 0.855*	0.855*	0.838*	0.838*	0.678*	-0.324*	0.073	-0.113	0.879*	0.798*	0.615*	0.292*	0.270	0.035	0.941*
Number of marketable fruits per plant	P 0.984*	0.984*	0.984*	0.984*	0.234	0.088	0.036	-0.048	0.809*	-0.290*	0.606*	0.367*	0.182	-0.354*	0.658*
	G 1.001*	1.001*	1.001*	1.001*	0.438*	0.149	-0.094	-0.043	1.028*	1.636*	0.677*	0.458*	0.178	-0.407*	0.987*
Total number of fruits per plant	P 0.195	0.064	0.104	0.104	0.195	0.064	-0.014	-0.021	0.774*	-0.304*	0.587*	0.361*	0.187	-0.362*	0.674*
	G 0.413*	0.413*	0.413*	0.413*	0.413*	0.104	-0.181	-0.039	1.035*	1.564*	0.674*	0.426*	0.166	-0.397*	0.958*
Average fruit weight (g)	P 0.018	0.029	0.029	0.029	0.330*	0.286*	0.338*	-0.185	0.253	-0.219	0.199	0.120	0.043	0.129	0.438*
	G 0.286*	0.286*	0.286*	0.286*	0.286*	0.286*	0.286*	-0.373*	-0.058	-0.060	-0.136	-0.086	-0.104	0.096	0.733*
Fruit shape index	P 0.029	0.029	0.029	0.029	0.330*	0.286*	0.338*	-0.290*	0.459*	0.559*	0.289*	0.491*	0.296*	0.096	0.733*
	G 0.338*	0.338*	0.338*	0.338*	0.338*	0.286*	0.338*	-0.446*	0.020	0.248	-0.146	-0.101	-0.226	-0.576*	-0.245
Pericarp thickness (mm)	P -0.183	-0.356*	-0.356*	-0.356*	0.075	0.075	0.075	-0.068	0.150	-0.010	-0.031	-0.140	-0.419*	-0.055	0.153
	G -0.356*	-0.356*	-0.356*	-0.356*	-0.356*	-0.356*	-0.356*	0.020	0.075	-0.080	0.173	0.245	0.281	-0.226	-0.039
Number of locules per fruit	P 0.106	0.106	0.106	0.106	0.068	0.068	0.068	0.106	0.106	0.068	0.203	0.424*	0.416*	-0.189	-0.072
	G 0.322	0.322	0.322	0.322	0.322	0.322	0.322	-0.322	0.075	-0.322	0.755*	0.507*	0.177	-0.234	0.649*
Number of nodes	P 1.586*	1.586*	1.586*	1.586*	0.841*	0.841*	0.841*	0.841*	0.841*	1.586*	0.841*	0.631*	0.265	-0.388*	1.025*
	G 0.841*	0.841*	0.841*	0.841*	0.841*	0.841*	0.841*	0.841*	0.841*	0.841*	0.841*	0.631*	0.265	-0.388*	1.025*
Internodal length (cm)	P -0.208*	-0.208*	-0.208*	-0.208*	-0.208*	-0.208*	-0.208*	-0.208*	-0.208*	-0.208*	-0.208*	-0.320*	-0.045	0.369*	-0.400*
	G 0.885*	0.885*	0.885*	0.885*	0.885*	0.885*	0.885*	0.885*	0.885*	0.885*	0.885*	1.720*	0.395*	-0.977*	0.929*
Plant height (cm)	P 0.374*	0.374*	0.374*	0.374*	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.374*	0.121	-0.137	0.503*
	G 0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.374*	0.121	-0.137	0.503*
TSS content (%)	P 0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	0.363*	-0.162	0.389*
	G 0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	0.427*	-0.138	0.477*
Acidity (%)	P 0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.213	0.289*
	G 0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.291*	0.320*
Ascorbic acid (mg/100g)	P -0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109	-0.109
	G -0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004

\* indicates significance of value at P=0.05

**Table 3 : Pooled over estimates of phenotypic (P) and genotypic (G) correlation co-efficients for different pair of quantitative and quality traits in tomato**

Traits	Days to first harvest	Gross yield per plant (kg)	Number of marketable fruits per plant	Total number of fruits per plant	Average fruit weight (g)	Fruit shape index	Pericarp thickness (mm)	Number of locules per fruit	Internodal length (cm)	Plant height (cm)	TSS content (%)	Acidity (%)	Ascorbic acid (mg/100g)	Marketable yield per plant (kg)
Days to 50 per cent flowering	P 0.415*	-0.375*	-0.548*	-0.539*	0.012	-0.169	-0.126	0.097	0.077	-0.473*	-0.270*	0.063	0.227*	-0.394*
Days to first harvest	G 0.924*	-0.765*	-0.868*	-0.888*	-0.268*	-0.286*	-0.299*	0.075	1.085*	-0.746*	-0.498*	0.047	0.379*	-0.839*
Gross yield per plant	P	-0.673*	-0.713*	-0.693*	-0.298*	0.090	0.065	0.020	0.289*	-0.661*	-0.393*	-0.159	0.129	-0.663*
	G	-0.929*	-0.890*	-0.894*	-0.462*	0.105	0.066	-0.035	1.007*	-0.775*	-0.591*	-0.209*	0.175	-0.913*
Number of marketable fruits per plant	P		0.678*	0.697*	0.462*	-0.056	0.018	-0.024	-0.298*	0.485*	0.286*	0.121	-0.160	0.954*
	G		0.893*	0.893*	0.774*	-0.154	0.077	-0.026	-0.766*	0.614*	0.344*	0.161	-0.094	0.991*
Total number of fruits per plant	P			0.976*	0.303*	0.150	0.053	-0.021	-0.341*	0.629*	0.321*	0.081	-0.357*	0.694*
	G			1.000*	0.493*	0.182	0.031	-0.019	-1.034*	0.671*	0.410*	0.074	-0.401*	0.907*
Average fruit weight (g)	P				0.289*	0.112	0.039	-0.001	-0.358*	0.621*	0.284*	0.052	-0.357*	0.707*
	G				0.458*	0.140	0.048	-0.003	-1.011*	0.672*	0.392*	0.023	-0.406*	0.909*
Fruit shape index	P				-0.013	-0.029	-0.033	-0.098	-0.206*	0.260*	0.009	0.044	0.080	0.488*
	G						0.235*	-0.165	-0.283*	0.372*	0.294*	0.196	0.085	0.766*
Pericarp thickness (mm)	P						0.335*	-0.375*	-0.075	-0.127	-0.062	-0.085	-0.442*	-0.006
	G						0.421*	-0.429*	-0.348*	-0.133	-0.035	-0.158	-0.553*	-0.092
Number of locules per fruit	P							-0.174	0.171	-0.034	-0.140	-0.190	-0.113	0.075
	G							-0.346*	0.063	-0.046	-0.154	-0.260*	-0.121	0.128
Number of nodes	P							0.070	-0.078	0.194	0.218*	0.250*	-0.249*	-0.019
	G							0.090	0.030	0.224*	0.342*	0.404*	-0.230*	-0.026
Internodal length (cm)	P								-0.445*	0.739*	0.451*	0.082	-0.239*	0.627*
	G								-0.983*	0.813*	0.557*	0.134	-0.329*	0.938*
Plant height (cm)	P									-0.248*	-0.304*	0.024	0.378*	-0.339*
	G									-0.611*	-1.019*	-0.016	0.732*	-0.801*
TSS content (%)	P										0.358*	0.115	-0.153	0.473*
	G										0.464*	0.135	-0.174	0.592*
Acidity (%)	P											0.290*	-0.213*	0.317*
	G											0.339*	-0.185	0.408*
Ascorbic acid (mg/100g)	P												0.266*	0.131
	G												0.325*	0.155
	P													-0.163
	G													-0.111

\*indicates significance of value at P =0.05

**Table 4: Estimates of direct and indirect effects of different traits on marketable yield per plant at phenotypic (P) and genotypic (G) levels in Environment I**

Traits		Days to 50 per cent flowering	Days to first harvest	Gross yield per plant (kg)	Number of marketable fruits per plant	Total number of fruits per plant	Average fruit weight (g)	Fruit shape index	Pericarp thickness (mm)	Number of locules per fruit	Internodal length (cm)	Plant height (cm)	TSS content (%)	Acidity (%)	Ascorbic acid (mg per 100g)
Days to 50 per cent flowering	P	-0.043	-0.012	0.011	0.020	0.019	-0.005	0.010	0.004	-0.002	0.016	0.019	0.010	-0.009	-0.009
	G	-0.186	-0.116	0.118	0.113	0.119	-0.001	0.073	0.059	-0.011	0.130	0.122	0.096	-0.029	-0.079
Days to first harvest	P	-0.020	-0.070	0.052	0.055	0.054	0.020	-0.010	-0.005	0.002	0.050	0.041	0.026	0.010	-0.006
	G	0.134	0.215	-0.205	-0.190	-0.189	-0.121	0.027	0.028	-0.027	-0.199	-0.138	-0.103	-0.022	0.026
Gross yield per plant (kg)	P	-0.233	-0.692	0.938	0.693	0.710	0.476	0.039	0.077	-0.003	0.590	0.435	0.265	0.024	-0.216
	G	-0.723	-1.088	0.140	1.112	1.082	0.991	-0.024	0.142	0.075	1.206	0.708	0.521	0.026	-0.220
Number of marketable fruits per plant	P	-0.059	-0.100	0.096	0.129	0.125	0.048	0.026	0.009	0.001	0.107	0.084	0.037	-0.0007	-0.047
	G	-0.132	-0.192	0.212	0.218	0.217	0.134	0.048	0.026	0.006	0.226	0.149	0.091	-0.003	-0.091
Total number of fruits per plant	P	0.049	0.086	-0.084	-0.108	-0.111	-0.043	-0.017	-0.010	-0.002	-0.093	-0.073	-0.025	0.007	0.039
	G	0.204	0.280	-0.302	-0.318	-0.319	-0.178	-0.056	-0.077	-0.014	-0.327	1.184	-0.130	0.036	0.141
Average fruit weight (g)	P	0.011	-0.024	0.044	0.033	0.034	0.875	-0.004	-0.002	-0.0003	0.038	0.028	-0.007	0.004	0.003
	G	0.0000	-0.002	0.003	0.002	0.002	0.004	-0.0004	0.002	0.001	0.003	0.002	0.001	0.0009	0.0002
Fruit shape index	P	-0.011	0.007	0.002	0.010	0.007	-0.002	0.048	0.018	-0.018	-0.0004	-0.006	-0.002	-0.003	-0.022
	G	0.106	-0.033	0.006	-0.060	-0.047	0.028	-0.271	-0.173	0.118	-0.027	0.034	-0.008	0.046	0.156
Pericarp thickness (mm)	P	-0.0004	0.0003	0.0003	0.0002	0.0003	-0.0001	0.001	0.004	-0.0006	-0.0001	-0.0001	-0.0006	-0.0007	-0.0004
	G	-0.010	0.004	0.004	0.004	0.007	0.014	0.019	0.030	-0.015	0.006	-0.020	-0.006	-0.006	-0.005
Number of locules per fruit	P	0.003	-0.001	-0.0002	0.0005	0.001	-0.0002	-0.024	-0.011	0.063	0.004	0.014	0.013	0.014	-0.017
	G	-0.008	0.017	-0.009	-0.004	-0.006	-0.002	0.058	0.068	-0.133	-0.013	-0.076	-0.043	-0.064	0.031
Number of nodes	P	0.036	0.070	-0.061	-0.081	-0.082	-0.042	0.0007	0.002	-0.006	-0.098	0.054	-0.040	-0.0004	0.024
	G	-0.069	-0.090	0.104	0.101	0.100	0.066	0.010	0.018	0.009	0.098	0.080	0.054	0.005	-0.031
Internodal length (cm)	P	-0.004	-0.011	0.011	0.015	0.015	0.007	0.003	-0.005	0.003	0.021	0.011	0.011	-0.003	-0.015
	G	-0.011	-0.010	0.011	0.012	0.011	0.0004	0.006	0.002	-0.002	0.009	0.007	0.012	-0.002	-0.008
Plant height (cm)	P	0.011	0.014	-0.011	-0.016	-0.016	-0.008	0.003	0.0008	-0.005	-0.018	0.007	-0.025	-0.009	0.004
	G	0.084	0.082	-0.079	-0.088	-0.087	-0.062	0.016	0.010	-0.033	-0.105	0.278	-0.128	-0.066	0.025
TSS content (%)	P	-0.005	-0.007	0.005	0.005	0.004	-0.002	-0.0009	-0.003	0.004	0.008	0.007	0.019	0.005	-0.005
	G	0.036	0.034	-0.032	-0.030	-0.029	-0.019	-0.002	0.014	-0.023	-0.039	0.265	-0.036	-0.071	0.015
Acidity (%)	P	-0.012	0.009	-0.002	0.0003	0.004	-0.003	0.004	0.011	-0.014	-0.0002	-0.005	-0.007	-0.015	-0.019
	G	0.016	-0.010	0.002	-0.001	-0.011	0.022	-0.017	-0.020	0.050	0.005	0.058	0.014	0.030	0.038
Ascorbic acid (mg/100g)	P	0.015	0.007	-0.017	-0.026	-0.026	0.002	-0.034	-0.009	-0.020	-0.018	0.028	-0.019	0.023	0.073
	G	-0.068	-0.019	0.031	0.067	0.071	-0.009	0.093	0.028	0.038	0.051	-0.400	0.034	-0.060	-0.161
Correlation coefficients	P	-0.263	-0.727*	0.984*	0.730*	0.740*	0.536*	0.046	0.080	0.0002	0.607*	-0.289*	0.264	0.006	-0.214
	G	-0.627*	-0.930*	1.003*	0.939*	0.923*	0.867*	-0.022	0.157	0.037	1.024*	-3.198*	0.412*	-0.007	-0.163

Residual effect at phenotypic level (P)=0.1536 Residual effect at genotypic level (G)=SQR(T(-1.0115))

\*indicates significance of value at P=0.05 Level; Bold values indicates direct effects



**Table 5: Pooled over estimates of direct and indirect effects of different traits on marketable yield per plant at phenotypic (P) and genotypic (G) levels**

Traits	Days to 50 per cent flowering	Days to first harvest	Gross yield per plant (kg)	Number of marketable fruits per plant	Total number of fruits per plant	Average fruit weight (g)	Fruit shape index	Pericarp thickness (mm)	Number of locules per fruit	Number of nodes	Internodal length (cm)	Plant height (cm)	TSS content (%)	Acidity (%)	Ascorbic acid (mg per 100g)
Days to 50 per cent flowering	P -0.045	-0.019	0.017	0.025	0.024	-0.001	0.008	0.006	-0.004	0.022	-0.003	0.021	0.012	-0.003	-0.010
	G 0.007	0.007	-0.005	-0.006	-0.006	-0.002	-0.002	-0.002	0.001	-0.007	0.008	-0.005	-0.004	0.0003	0.003
Days to first harvest	P -0.011	-0.027	0.018	0.019	0.019	0.008	-0.002	-0.002	-0.001	0.019	-0.008	0.018	0.011	0.004	-0.004
	G -0.168	-0.182	0.169	0.162	0.163	0.084	-0.019	-0.012	0.007	0.173	-0.183	0.141	0.08	0.038	-0.032
Gross yield per plant (kg)	P -0.317	-0.570	0.847	0.575	0.591	0.391	-0.048	0.015	-0.021	0.521	-0.252	0.411	0.242	0.103	-0.136
	G -0.770	-0.935	1.007	0.899	0.899	0.780	-0.155	0.078	-0.026	0.918	-0.772	0.618	0.347	0.162	-0.095
Number of marketable fruits per plant	P -0.022	-0.029	0.028	0.041	0.040	0.012	0.006	0.002	-0.001	0.033	-0.014	0.026	0.013	0.003	-0.015
	G -0.203	-0.208	0.209	0.234	0.234	0.115	0.043	0.007	-0.004	0.231	-0.242	0.157	0.096	0.017	-0.094
Total number of fruits per plant	P -0.030	-0.039	0.039	0.055	0.056	0.016	0.006	0.002	0.0000	0.045	-0.020	0.035	0.016	0.003	-0.020
	G -0.001	-0.001	0.001	0.234	0.001	0.001	0.0002	0.0001	0.0000	0.001	-0.001	0.001	0.0004	0.0000	-0.0004
Average fruit weight (g)	P 0.001	-0.022	0.034	0.022	0.021	0.073	-0.001	-0.002	-0.007	0.025	-0.015	0.019	0.001	0.003	0.006
	G -0.002	-0.003	0.005	0.001	0.003	0.006	-0.0002	0.001	-0.001	0.003	-0.002	0.002	0.002	0.001	0.001
Fruit shape index	P -0.009	0.005	-0.003	0.008	0.006	-0.001	0.054	0.018	-0.020	-0.002	-0.004	-0.007	-0.003	-0.005	-0.024
	G -0.123	0.045	-0.066	0.003	0.060	-0.012	0.429	0.181	-0.184	0.020	-0.150	-0.057	-0.015	-0.068	-0.237
Pericarp thickness (mm)	P -0.009	0.005	0.001	0.004	0.003	-0.002	0.025	0.074	-0.013	-0.003	0.013	-0.003	-0.010	-0.014	-0.008
	G -0.009	0.002	0.002	0.078	0.001	0.007	0.013	0.030	-0.010	0.003	0.002	-0.001	-0.005	-0.008	-0.004
Number of locules per fruit	P 0.007	0.001	-0.002	-0.001	-0.0001	-0.007	-0.026	-0.012	0.068	0.005	-0.005	0.013	0.015	0.017	-0.017
	G 0.033	-0.015	-0.011	0.001	-0.001	-0.072	-0.188	-0.151	0.437	0.040	0.013	0.098	0.150	0.177	-0.101
Number of nodes	P 0.015	0.021	-0.018	-0.024	-0.024	-0.010	0.001	0.001	-0.002	-0.029	0.013	-0.022	-0.013	-0.002	0.007
	G 0.174	0.179	-0.172	-0.008	-0.187	-0.100	-0.009	-0.019	-0.017	-0.188	0.185	-0.153	-0.105	-0.025	0.062
Internodal length(cm)	P -0.006	-0.022	0.022	0.026	0.027	0.016	0.006	-0.013	0.006	0.033	-0.075	0.019	0.023	-0.002	-0.028
	G 0.018	0.016	-0.012	-0.017	-0.016	-0.005	-0.006	0.001	0.001	-0.016	0.016	-0.010	-0.017	-0.0003	0.012
Plant height (cm)	P 0.030	0.041	-0.030	-0.039	-0.039	-0.016	0.008	0.002	-0.012	-0.046	0.016	-0.063	-0.023	-0.007	0.010
	G 0.089	0.093	-0.074	-0.080	-0.081	-0.045	0.016	0.006	-0.027	-0.098	0.073	-0.120	-0.056	-0.016	0.021
TSS content (%)	P -0.015	-0.022	0.016	0.018	0.016	0.001	-0.004	-0.008	0.012	0.025	-0.017	0.020	0.056	0.016	-0.012
	G -0.049	-0.058	0.034	0.040	0.039	0.029	-0.003	-0.015	0.034	0.055	-0.100	0.046	0.098	0.033	-0.018
Acidity (%)	P -0.007	0.002	-0.001	-0.001	-0.001	-0.0004	0.001	0.002	-0.003	-0.001	-0.0002	-0.001	-0.003	-0.010	-0.003
	G -0.014	0.065	-0.050	-0.023	-0.007	-0.061	0.049	0.081	-0.125	-0.042	0.005	-0.042	-0.105	-0.310	-0.101
Ascorbic acid (mg/100g)	P 0.021	0.012	-0.014	-0.032	-0.032	0.007	-0.040	-0.010	-0.023	-0.022	0.034	-0.014	-0.019	0.024	0.091
	G 0.179	0.083	-0.044	-0.190	-0.192	0.040	-0.261	-0.057	-0.109	-0.156	0.346	-0.082	-0.087	0.154	0.472
Correlation co-efficients	P -0.394*	-0.663*	0.954*	0.694*	0.708*	0.488*	-0.007	0.075	-0.019	0.627*	-0.339*	0.473*	0.317*	0.131	-0.163
	G -0.839*	-0.913*	0.991*	0.907*	0.909*	0.766*	-0.093	0.128	-0.026	0.938*	-0.801*	0.592*	0.408*	0.156	-0.111

Residual effect at phenotypic level (P)=0.2624 Residual effect at genotypic level(G)=SQRT(1-1.0072)

\*Indicates significance of value at P=0.05 Level; Bold values indicates Direct effects



*et al.* (2007) and *Ara et al.* (2009) also reported positive correlation of TSS with acidity.

Acidity was positively and significantly correlated with ascorbic acid. This is in conformity to the findings of *Rani et al.* (2010). The inconsistent findings with respect to some traits to those of earlier researchers may be the consequence of protected environment and different genotypes used in the present investigation.

Findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the character studied. Hence, on the basis of correlation studies the selection for gross yield per plant, marketable fruits per plant, total number of fruits per plant, average fruit weight, number of nodes, plant height and TSS content will be effective for isolating plant with higher yield in tomato.

At phenotypic level in Env. I, highest direct positive effects of various traits on marketable yield per plant could be arranged in the following descending order: gross yield

per plant, average fruit weight, number of marketable fruits per plant, ascorbic acid, number of locules per fruit, fruit shape index, TSS content and pericarp thickness. At genotypic level in Env. I, the estimates of direct effects indicated that number of marketable fruits per plant, days to first harvest, gross yield per plant, acidity, number of nodes, pericarp thickness and average fruit weight had positive direct effect on marketable yield per plant while internodal length, TSS content, plant height, number of locules per fruit, ascorbic acid, days to 50 per cent flowering, fruit shape index and total number of fruits per plant had negative direct effects on marketable yield per plant.

In Env. II at phenotypic level, highest direct positive effects of various traits on marketable yield in descending order were gross yield per plant, total number of fruits per plant, pericarp thickness, number of nodes, ascorbic acid, acidity, average fruit weight, fruit shape index, TSS content, number of locules per fruit and days to first harvest. At genotypic level, estimates of direct effects indicated that number of marketable fruits per plant, gross

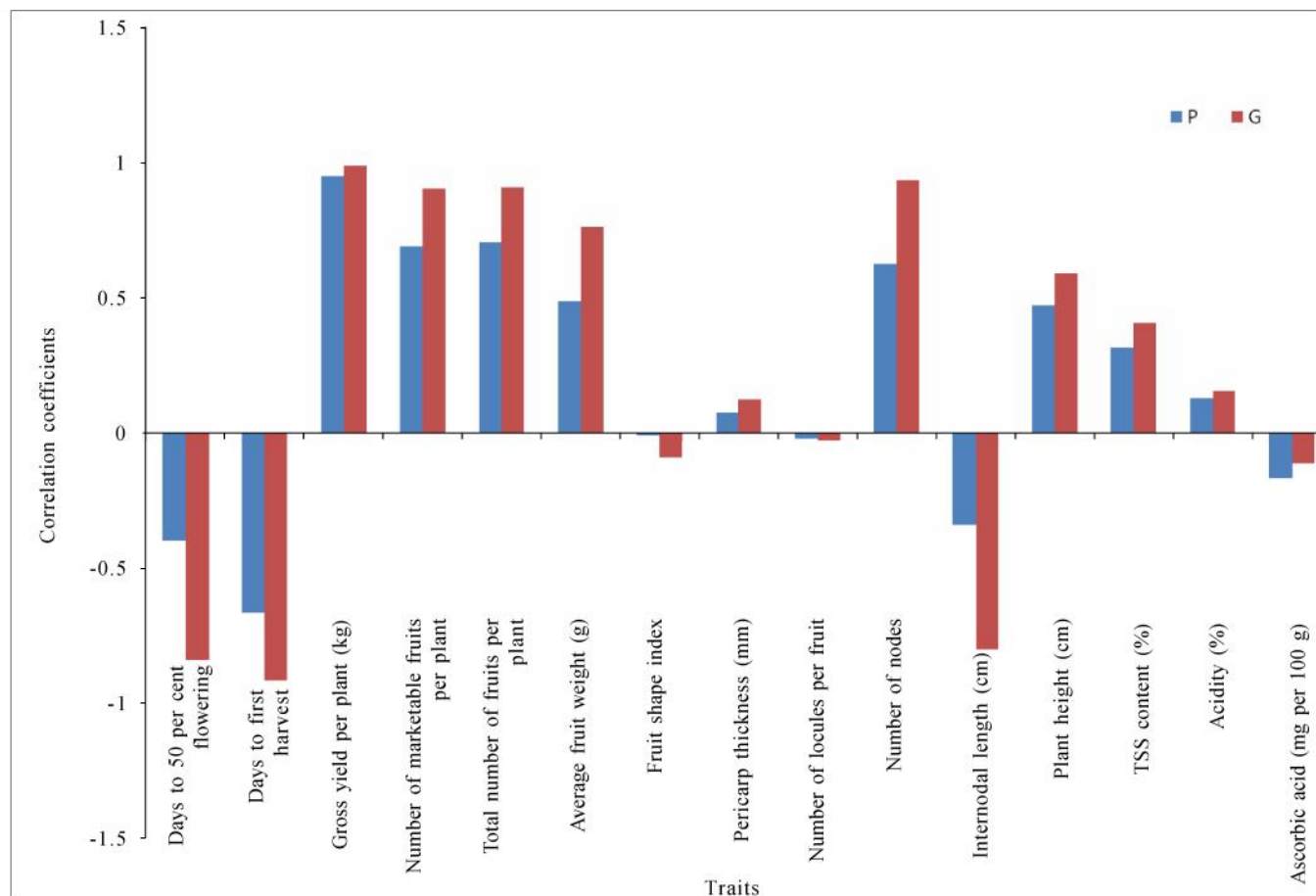


Fig. 1 : Genotypic and phenotypic correlation co-efficient in tomato

yield per plant, days to first harvest, plant height, TSS content, acidity and internodal length had positive direct effect on marketable yield per plant while average fruit weight, fruit shape index, pericarp thickness, ascorbic acid, number of locules per fruit, number of nodes, days to 50 per cent flowering and total number of fruits per plant had negative direct effect.

Over environments, at phenotypic level direct positive effects of various traits on marketable yield in descending order were gross yield per plant, ascorbic acid, pericarp thickness, average fruit weight, number of locules per fruit, total number of fruits per plant, TSS content, fruit shape index and number of marketable fruits per plant. At genotypic level, estimates of direct effects revealed that gross yield per plant, ascorbic acid, number of locules per fruit, fruit shape index, number of marketable fruits per plant, TSS content, pericarp thickness, internodal length, days to 50 per cent flowering, average fruit weight and total number of fruits per plant had positive direct effects on marketable yield per plant. Negative direct effects were exhibited by plant height, days to first harvest, number of nodes and acidity.

Pooled over path co-efficient analysis exhibited appreciable amount of direct effect of gross yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight, fruit shape index, pericarp thickness, number of locules per fruit, TSS content and ascorbic acid on marketable yield per plant at phenotypic level. The direct effect of remaining components of traits either negligible or negative as that of days to 50 per cent flowering, days to first harvest, number of nodes, internodal length, plant height and acidity. Directly or indirectly all characters showed positive effect on marketable yield per plant, which is in confirmation to the finding of Hidayatullah *et al.* (2008) who also reported that number of fruits per plant exhibited positive as well as high direct effect.

The characters showing high direct effect on marketable yield per plant indicated that direct selection for these traits might be effective and there is possibility of improving marketable yield per plant through selection based on these characters. Similar results have also been reported by Haydar *et al.* (2007); Anitha *et al.* (2007); Hidayatullah *et al.* (2008) and Ara *et al.* (2009). These findings strongly confirm the role of the characters like gross yield per plant, number of marketable fruits per plant, total number of fruits per plant, average fruit weight,

fruit shape index, pericarp thickness, number of locules per fruit, TSS content and ascorbic acid in selecting a superior type of yield per plant.

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