E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(12): 1273-1278
Received: 11-10-2025
Accepted: 15-11-2025

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Correlation and path coefficient analysis studies in tomato germplasm (*Solanum lycopersicum* L.)

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i12q.4626

Abstract
Forty tomato genotypes were studied for correlation and path co-efficient analysis of yield and yield attributes in tomato (*Solanum lycopersicum* L.) at PG student research farm, College of Horticulture, Rajendranagar, SKLTSHU, Hyderabad, Telangana during *Kharif*, 2017. Fruit yield had positive and significant correlation with number of primary branches per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, Per cent fruit set, number of marketable fruits per plant, fruit length, fruit width, fruit weight, fruit yield per plant, ascorbic acid content, lycopene content and beta-carotene. Character association analysis among yield and yield contributing characters revealed that in most of cases the genotypic correlation coefficient was higher than the respective phenotypic correlation coefficients. Also, narrow difference between phenotypic and genotypic correlation coefficient was noticed for almost all the pairs of characters studied showing that masking or modifying effects of the environment was little indicating the presence of an inherent association among these characters. Path coefficient analysis of different yield and yield contributing traits revealed with plant height, number of primary branches per plant, days to 50% flowering, number of flowers per cluster, number of fruits per plant, per cent fruit set, number of marketable fruits per plant, fruit weight, fruit yield per plant, ascorbic acid content, lycopene content and beta-carotene exhibited positive direct effects on fruit yield. Hence, these characters play a major role in recombination breeding and suggested that direct selection based on these traits will be rewarded for crop improvement of tomato.

Keywords: Tomato, correlation, path coefficient analysis, fruit yield, *Solanum lycopersicum* L.

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important, popular and extensively used vegetable as fresh fruit and also in the form of processed product (Toor and Savage, 2005) [24]. The crop is widely grown all over the world. It is native to Peru- Ecuador region (Rick, 1969) [19]. Tomato is a rich source of vitamin A and vitamin C, minerals such as Ca, P and Fe and a strong antioxidant against cancer and heart diseases (Dhaliwal *et al*., 2003) [4]. Correlation and path coefficient analysis give an insight into the genetic variability present in populations. Correlation coefficient measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for generic improvement in yield. Yield is a complex trait with polygenic inheritance. By the use of regression analysis, each trait can be assigned appropriate weight to bring out rational improvement in yield. Path coefficient analysis measures the direct influence of one variable upon another and permits the separation of correlation coefficient into components of direct and indirect effects (Prashanth *et al*., 2008) [14]. Pidigam *et al*., 2019 [12] in yardlong bean; Sushma *et al*., 2020 [22] in tomato; Saisupriya *et al*., 2020 [20] in chilli; Rajashekar Reddy *et al*., 2018 [16, 18] in cluster bean; Naveen *et al*., 2017 [11] in tomato and Prasath *et al*., 2017 [13] in okra have reported good association among the yield and its attributes and due importance was given to the traits correlated with the yield, while exercising selections for crop improvement.
Keeping the above in view, the present research work has been undertaken in order to determine the nature of association, direct and indirect relationship between yield and yield contributing characters and relative contribution of each character towards yield in tomato through the correlation coefficient and the path coefficient analysis.

Materials and Methods

The experiment was conducted at PG student research farm, College of Horticulture, Rajendranagar, Hyderabad -500 030. Forty genotypes of tomato were grown in randomized block design in three replications during *Kharif*, 2017. Each germplasm line was grown in a plot of 1.8x 3.15 (5.67 Sq. meters) accommodating 21 plants, per plot 7 plants per row with spacing of 60 X 45 cm^2. All recommended cultural practices were followed to raise good crop stand and growth of the plants. Data were recorded for twenty one characters *viz*., plant height(cm), number of primary branches per plant, days to first flowering, days to 50% flowering, number of flower clusters per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, Per cent fruit set, number of marketable fruits per plant, days to first harvest, days to last harvest, fruit length(cm), fruit width(cm), fruit weight(g), fruit yield per plant(kg), yield per ha(t), total soluble solids (ºBrix), ascorbic acid(mg/100 g), lycopene content(mg/100 g) and beta-carotene(mg/100 g). Observations were recorded on five randomly selected competitive plants from each plot on twenty one yield and yield contributing components. The correlation coefficient analysis was carried out as per Al-jibouri *et al*., (1958) [2] and path coefficient analysis was done following the method outlined by Dewey and Lu (1959) [3].

Results and Discussion

Correlation coefficient analysis

The knowledge of nature and magnitude of association between yield and its component traits is necessary for effective selection in advance generations. Correlations between pairs of characters are either due to linkage of genes or due to pleiotropic gene action. In the present study, correlations between twenty one characters were worked out in all possible combinations at phenotypic and genotypic levels presented in table 1. In general, the magnitude of genotypic correlation coefficients was higher than the corresponding values of the phenotypic correlation coefficients. This indicated a strong genetic association between these traits. Kumar *et al.* (2003) [9] also reported higher estimates of genotypic correlation than the corresponding phenotypic correlation coefficients between yield and yield components. A perusal of data in table 1 revealed that most important trait fruit yield per hectare showed high positive significant correlations with number of flowers per cluster (0.385 P, 0.399 G), fruit length (0.563 P, 0.600 G), fruit width (0.361 P, 0.384 G), fruit weight (0.924 P, 0.942 G), fruit yield per plant (0.998 P, 0.999 G) and negative significant correlations with number of primary branches per plant (-0.268 P, -0.282 G), number of fruits per plant (-0.247 P, -0.326 G), per cent of fruit set (-0.313 P, -0.639 G), number of marketable fruits per plant (-0.236 P, -0.267 G) and lycopene content (-0.500 P, -0.519 G) at both phenotypic and genotypic level. These finding results are in coincidence with number of flowers per cluster (Ahirwar *et al.*, 2013) [1], fruit length (Tiwari *et al.*, 2013) [23], fruit width (Reddy *et al.*, 2013) [18], fruit weight (Prassana *et al.*, 2005) [15] and yield per plant (Khan and Samadia, 2012) [7]. In respect of the crops, similar findings are obtained by Pidigam *et al*., 2019 [12] in yardlong bean; Sushma *et al*., 2020 [22] in tomato; Saisupriya *et al*., 2020 [20] in chilli; Rajashekar Reddy *et al*., 2018 [16, 18] in cluster bean; Naveen *et al*., 2017 [11] in tomato and Prasath *et al*., 2017 [13] in okra.

Yield is associated with a number of component traits that is controlled by a multi-facetted factor. It is the concern of the plant breeder and the ultimate factor on which selection programmes are to be envisaged. All changes in crop yield must be accompanied by a shift in one or more traits (Graffius, 1964) [5]. All the shift in the traits need not however, be expressed by changes in yield. This could be due to varying levels of positive or negative correlations between yield and its component traits and among the components themselves. The study of association between traits helps in the selection of genotypes and also proffers a way forward for a simultaneous selection scheme in more than one trait. It also means that the characters emerged as most important associates of fruit yield in tomato.

Path coefficient analysis

Path coefficient analysis is a tool to partition the observed correlation coefficient of yield components on yield into direct and indirect effects to provide clear picture of character associations for formulating effective selection strategy. The path coefficient studies presented in Table 2 revealed that for fruit yield per plant followed by fruit weight had high positive direct effects on fruit yield per hectare. Correlation between yield and yield components were partitioned into direct and indirect effects to know the particular factor responsible for that correlation.

Path coefficient analysis showed that the characters plant height, number of primary branches per plant, days to 50% flowering, number of flowers per cluster, number of fruits per plant, per cent fruit set, number of marketable fruits per plant, fruit weight, fruit yield per plant, ascorbic acid content, lycopene content and beta-carotene exhibited positive direct effects on fruit yield. This suggested that direct selection based on these traits will be rewarding for crop yield improvement. These results were conformity with Singh *et al*. (2004) [21] and Haydar *et al*. (2007) [6].

Plant height showed negligible positive direct effect at genotypic level (0.002) and negligible negative direct effect at phenotypic level (-0.001) on fruit yield per ha. Further, negligible indirect positive effect at genotypic level 0.0008 and negligible negative effect on fruit yield at phenotypic level -0.0005 was noticed through both days to first flowering and days to 50% flowering. Number of primary branches per plant observed negligible positive direct effect on fruit yield at genotypic level (0.0101) as well as at phenotypic level (0.0032). Further, negligible positive indirect effects on fruit yield were exhibited through days to first flowering at both genotypic and phenotypic level with values 0.0038 and 0.0010 respectively. Days to first flowering recorded negligible negative direct effect on fruit yield per ha at genotypic level (-0.0186) as well as negligible positive effect at phenotypic level (0.0097). At both genotypic and phenotypic level, days to 50% flowering exhibited negligible positive direct effect on fruit yield (0.0106 and -0.0105 respectively). Number of flower clusters per plant recorded negligible negative direct effect on fruit yield at genotypic level (-0.0166) as well as at phenotypic level (-0.0206). Number of flowers per cluster showed negligible positive direct effect on fruit yield at genotypic level (0.0015) and phenotypic level (0.0143) respectively. At both genotypic and phenotypic level, number of fruits per cluster observed negligible negative direct effect on fruit yield (-0.0278 and -0.0150 respectively). Number of fruits per plant recorded negligible positive direct effect at genotypic level (0.1599) as well as at phenotypic level (0.0731) on fruit yield. Per cent fruit set showed negligible positive direct effect on fruit yield at genotypic level (0.0173) and phenotypic level (0.0060) respectively. At both genotypic and phenotypic level, number of marketable fruits per plant exhibited negligible positive direct effect (0.0484 and 0.0061) respectively on fruit yield. Days to first harvest showed negligible negative direct

Table 1: Phenotypic (P) and genotypic (G) correlation coefficients among yield and yield attributes in forty genotypes of tomato

S. No.	Character		PH (cm)	NPB/PL	DFF	D50%F	NFC/PL	NF/C	NFR/C	NFR/PL	PF	NMF/P	DFH	DLH	FL (cm)	FW (cm)	FWT (g)	FY/P (kg)	TSS (^{0}Brix)	ABA (mg/ 100 g)	LC (mg/ 100 g)	BC (mg/ 100 g)	FY/H
1	PH (cm)	P	1.0000	0.148	0.351	0.344	-0.077	-0.212*	0.139	0.111	-0.071	0.115	-0.048	0.075	0.005	0.035	-0.103	-0.135	-0.254**	-0.014	0.005	-0.010	-0.1281
		G	1.0000	0.151	0.418	0.400	-0.100	-0.242	0.155	0.132	-0.099	0.119	-0.045	0.093	0.013	0.033	-0.109	-0.137	-0.279	-0.073	0.009	-0.013	-0.1275
2	NPB/PL	P		1.000	0.330	0.321	0.038	-0.285**	0.242**	0.234**	-0.024	0.321	0.108	0.131	-0.252**	-0.295**	-0.270**	-0.273**	-0.219*	-0.199*	0.291**	0.013	-0.2680**
		G		1.000	0.373	0.350	0.028	-0.321	0.281	0.259	-0.109	0.354	0.128	0.128	-0.283	-0.337	-0.282	-0.289	0.230	-0.327	0.316	0.036	-0.2827**
3	DFF	P			1.000	0.966	0.071	-0.388	0.464	0.405	0.092	0.398	0.235**	0.385	-0.188*	-0.157	-0.222*	-0.177	0.219	-0.199	0.291**	0.257**	-0.1744
		G			1.000	1.013	0.128	-0.483	0.556	0.464	-0.066	0.472	0.282	0.437	-0.219	-0.191	-0.247	0.204	-0.046	-0.215	0.333	-0.280	-0.2001*
4	D50%F	P				1.000	0.092	-0.404	0.457	0.406	-0.035	0.414	0.225*	0.401	-0.189*	-0.139	-0.232*	-0.190*	-0.061	-0.144	0.309	-0.259**	-0.1875*
		G				1.000	0.111	-0.481	0.586	0.470	-0.086	0.456	0.286	0.448	-0.215	-0.163	-0.255	-0.214	-0.072	-0.201	0.350	-0.274	-0.2108*
5	NFC/PL	P					1.000	-0.064	0.020	0.516	-0.082	0.475	-0.134	0.062	-0.259**	-0.230*	-0.211*	-0.006	-0.017	-0.035	0.035	0.171	-0.0262
		G					1.000	-0.047	0.196	0.577	-0.225	0.578	-0.173	0.075	-0.330	-0.335	-0.263	-0.061	-0.023	-0.035	0.019	0.238	-0.0814
6	NF/C	P						1.000	-0.065	-0.149	0.097	-0.231*	-0.163	-0.198*	0.165	0.066	0.313	0.381	-0.200*	-0.135	-0.208*	0.233*	0.3856**
		G						1.000	-0.120	-0.184	0.239	-0.248	-0.172	-0.216	0.192	0.065	0.330	0.399	-0.216	-0.178	-0.215	0.242	0.3992**
7	NFR/C	P							1.000	0.691	0.134	0.573	0.036	0.386	-0.286**	-0.247**	-0.190*	0.002	-0.061	-0.125	0.182*	-0.055	0.0042
		G							1.000	0.747	0.080	0.736	0.020	0.456	-0.347	-0.269	-0.212	-0.024	-0.073	-0.207	0.229	-0.080	-0.0254
8	NFR/PL	P								1.000	0.179	0.857	-0.071	0.323	-0.639	-0.563	-0.563	-0.235**	0.155	-0.134	0.267**	0.093	-0.2477**
		G								1.000	0.178	0.975	-0.097	0.356	-0.716	-0.622	-0.597	-0.313	0.162	-0.192	0.289	0.094	-0.3266**
9	%FS	P									1.000	0.112	0.120	0.162	-0.179*	-0.019	-0.355	-0.316	0.140	-0.088	0.190*	0.103	-0.3139**
		G									1.000	0.153	0.220	0.295	-0.328	-0.036	-0.624	-0.633	0.210	-0.198	0.350	0.205	-0.6395**
10	NMF/P	P										1.000	-0.111	0.393	-0.603	-0.545	-0.498	-0.228*	0.153	-0.089	0.280**	0.175	-0.2367**
		G										1.000	-0.113	0.433	-0.685	-0.619	-0.537	-0.256	0.160	-0.146	0.298	0.199	-0.2671**
11	DFH	P											1.000	0.329	-0.043	0.010	-0.066	-0.168	0.023	-0.119	0.136	-0.314	-0.1603
		G											1.000	0.359	-0.052	0.037	-0.069	-0.185	0.007	-0.127	0.144	-0.371	-0.1739
12	DLH	P												1.000	-0.213*	-0.068	-0.255**	-0.209*	-0.038	-0.069	0.214*	-0.024	-0.2084*
		G												1.000	-0.227	-0.074	-0.264	-0.225	-0.049	-0.056	0.222	-0.371	-0.2237*
13	FL(cm)	P													1.000	0.782	0.740	0.555	-0.204*	0.188*	-0.478	-0.163	0.5633**
		G													1.000	0.851	0.779	0.590	-0.217	0.232	-0.498	-0.1723	0.6006**
14	FW(cm)	P														1.000	0.559	0.352	-0.198*	0.154	0.302	-0.130	0.3616**
		G														1.000	0.584	0.374	-0.218	0.165	-0.312	-0.131	0.3849**
15	FWT(g)	P															1.000	0.352	-0.198	0.154	-0.302	-0.130	0.9244**
		G															1.000	0.935	-0.200	0.228	-0.532	-0.067	0.9421**
16	FY/P(kg)	P																1.000	0.998	0.164	-0.504	0.036	0.9980**
		G																1.000	-0.126	0.198	-0.525	0.037	0.9992**
17	TSS (^{0}Brix)	P																	1.000	0.046	0.047	-0.032	-0.1322
		G																	1.000	0.057	0.053	-0.0386	-0.1380
18	ABA(mg/ 100 g)	P																		1.000	-0.329	-0.0104	0.1694
		G																		1.000	-0.399	-0.006	0.2073*
19	LC (mg/ 100 g)	P																			1.000	0.257**	-0.5005**
		G																			1.000	0.268	-0.5197**
20	BC (mg/ 100 g)	P																				1.000	0.0360
		G																				1.000	0.0356
21	FY/H	P																					1.000

		G																				1.000

*Significant at 5 per cent level; ** Significant at 1 per cent level

PH - Plant height (cm), NPB/PL- Number of primary branches per plant, DFF - Days to first flowering, D50%F- Days to 50 percent flowering, NFC/PL - Number of flower clusters per plant, NF/C- Number of flowers per cluster, NFR/C- Number of fruits per cluster, NFR/PL- Number of fruits per plant, PF- Per cent fruitset, NMF/P- Number of marketable fruits per plant, DFH- Days to first harvest, DLH - Days to last harvest, FL - Fruit length (cm), FW- Fruit width(cm), FWT - Fruit weight (g), FY/P- Fruit yield per plant(kg), FY/H- Fruit yield per hectare(t), TSS - Total soluble solids (ºBrix), ASA- Ascorbic acid(mg/100 g), LC- Lycopene content (mg/100 g) and BC- Beta-carotene (mg/100 g).

Table 2: Phenotypic (P) and genotypic (G) path coefficients indicating direct and indirect effects of components characters on fruit yield in forty genotypes of tomato

S. No.	Character		Plant height (cm)	Number of primary branches per plant	Days to first flowering	Days to 50% flowering	Number of flower clusters per plant	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Per cent fruit sett	Number of marketable fruits per plant
1	Plant height (cm)	P	-0.0013	-0.0002	-0.0005	-0.0005	-0.0001	-0.0003	0.0002	-0.0001	-0.001	-0.0002
		G	0.0020	0.0003	0.0008	0.0008	-0.0002	-0.0005	0.0003	0.0003	-0.0002	0.0002
2	Number of primary branches per plant	P	0.0005	0.0032	0.0010	0.0010	0.0001	-0.0009	0.0008	0.0007	-0.0001	0.0010
		G	0.0015	0.0101	0.0038	0.0035	0.0003	-0.0032	0.0028	0.0026	-0.0011	0.0036
3	Days to first flowering	P	0.0034	0.0032	0.0097	0.0094	0.0007	-0.0038	0.0045	0.0039	-0.0009	0.0039
		G	-0.0078	-0.0069	-0.0186	-0.0188	-0.0024	0.0090	-0.0103	-0.0086	0.0012	-0.0088
4	Days to 50% flowering	P	-0.0036	-0.0034	-0.0101	-0.0105	-0.0010	0.0042	-0.0048	-0.0042	0.0004	-0.0043
		G	0.0042	0.0037	0.0107	0.0106	0.0012	-0.0051	0.0062	0.0050	-0.0009	0.0048
5	Number of flower clusters per plant	P	0.0016	-0.0008	-0.0015	-0.0019	-0.0206	0.0013	-0.0004	-0.0107	0.0017	-0.0098
		G	0.0017	-0.0005	-0.0021	-0.0019	-0.0166	0.0008	-0.0033	-0.0096	0.0037	-0.0096
6	Number of flowers per cluster	P	-0.0030	-0.0041	-0.0055	-0.0058	-0.0009	0.0143	-0.0009	-0.0021	0.0014	-0.0033
		G	-0.0004	-0.0005	-0.0007	-0.0007	-0.0001	0.0015	-0.0002	-0.0003	0.0003	-0.0004
7	Number of fruits per cluster	P	-0.0021	-0.0036	-0.0070	-0.0069	-0.0003	-0.0010	-0.0150	-0.0104	-0.0020	-0.0086
		G	-0.0043	-0.0078	0.0155	0.0163	-0.0055	0.0034	-0.0278	-0.0208	-0.0022	-0.0205
8	Number of fruits per plant	P	0.0081	0.0172	0.0296	0.0297	0.0377	-0.0110	0.0505	0.0731	0.0131	0.0627
		G	0.0211	0.0415	0.0743	0.0753	0.0923	-0.0294	0.1195	0.1599	0.0285	0.1559
9	Per cent fruit set	P	-0.0004	-0.0001	-0.0006	-0.0002	-0.0005	0.0006	0.0008	0.0011	0.0060	0.0007
		G	-0.0017	-0.0019	-0.0011	-0.0015	-0.0039	0.0041	0.0014	0.0031	0.0173	0.0026
10	Number of marketable fruits per plant	P	0.0007	0.0020	0.0024	0.0025	0.0029	-0.0014	0.0035	0.0053	0.0007	0.0061
		G	-0.0058	-0.0171	-0.0228	-0.0221	-0.0280	0.0120	-0.0357	-0.0472	-0.0074	0.0484
11	Days to first harvest	P	-0.0001	0.0001	0.0003	0.0003	-0.0002	-0.0002	0.0000	-0.0001	0.0002	-0.0002
		G	0.0000	-0.0001	-0.0002	-0.0002	0.0001	0.0001	0.0000	0.0001	-0.0002	0.0001
12	Days to last harvest	P	-0.0002	-0.0003	-0.0010	-0.0010	-0.0002	0.0005	-0.0010	-0.0008	-0.0004	-0.0010
		G	0.0003	0.0005	0.0014	0.0015	0.0002	-0.0007	0.0015	0.0012	0.0010	0.0014
13	Fruit length (cm)	P	0.0000	0.0003	0.0003	0.0003	0.0004	-0.0002	0.0004	0.0009	0.0002	0.0008
		G	0.0001	-0.0023	-0.0018	-0.0018	-0.0027	0.0016	-0.0028	-0.0058	-0.0027	-0.0056
14	Fruit width (cm)	P	-0.0002	0.0016	0.0008	0.0007	0.0012	-0.0004	0.0013	0.0030	0.0001	0.0029
		G	-0.0010	0.0104	0.0059	0.0050	0.0104	-0.0020	0.0083	0.0192	0.0011	0.0191
15	Fruit weight (g)	P	-0.0203	-0.0530	-0.0437	-0.0456	-0.0415	0.0615	-0.0374	-0.1104	-0.0697	-0.0977
		G	-0.0339	-0.0878	-0.0769	-0.0795	-0.0818	0.1028	-0.0662	-0.1858	-0.1942	-0.1674
16	Fruit yield/plant (kg)	P	-0.1131	-0.2287	-0.1488	-0.1591	-0.0054	0.3197	0.0017	-0.1969	-0.2647	-0.1910
		G	-0.1053	-0.2216	-0.1565	-0.1647	-0.0471	0.3064	-0.0190	-0.2403	-0.4858	-0.1968
17	Total soluble solids (ºBrix)	P	0.0021	-0.0018	0.0004	0.0005	0.0001	0.0017	0.0005	-0.0013	-0.0012	-0.0013
		G	0.0029	-0.0024	0.0005	0.0007	0.0002	0.0022	0.0008	-0.0017	-0.0022	-0.0016
18	Ascorbic acid (mg/100 g)	P	-0.0001	-0.0020	-0.0012	-0.0014	-0.0004	-0.0013	-0.0012	-0.0013	-0.0009	-0.0009
		G	-0.0012	-0.0054	-0.0035	-0.0033	-0.0006	-0.0029	-0.0034	-0.0032	-0.0032	-0.0024

19	Lycopene content (mg/100 g)	P	0.0000	0.0024	0.0024		0.0025	0.0003	-0.0017	0.0015	0.0022	0.0016	0.0023
		G	0.0001	0.0048	0.0051		0.0053	0.0003	-0.0033	0.0035	0.0044	0.0053	0.0045
20	Beta-carotene (mg/100 g)	P	-0.0001	0.0001	-0.0016		-0.0016	0.0011	0.0014	-0.0003	0.0006	0.0006	0.0011
		G	-0.0001	0.0004	-0.0029		-0.0028	0.0024	0.0025	-0.0008	0.0010	0.0021	0.0020
S. No.	**Character**		**Days to first harvest**	**Days to last harvest**	**Fruit length (cm)**	**Fruit width (cm)**	**Fruit weight (g)**	**Fruit yield/ plant (kg)**	**Total soluble solids (ºBrix)**	**Ascorbic acid (mg/100 g)**	**Lycopene content (mg/100 g)**	**Beta-carotene (mg/100 g)**	**Correlation coefficient**
1	Plant height (cm)	P	0.0001	-0.0001	0.0000	0.0000	0.0001	0.0002	0.0003	0.0000	0.0000	0.0000	-0.1281
		G	-0.0001	0.0002	0.0000	0.0001	-0.0002	-0.0003	-0.0006	-0.0001	0.0000	0.0000	-0.1275
2	Number of primary branches per plant	P	0.0003	0.0004	-0.0008	-0.0009	-0.0009	-0.0009	0.0007	-0.0006	0.0009	0.0000	-0.2680**
		G	0.0013	0.0014	-0.0029	-0.0034	-0.0028	-0.0029	0.0023	-0.0033	0.0032	0.0004	-0.2827**
3	Days to first flowering	P	0.0023	0.0037	-0.0018	-0.0015	-0.0022	0.0038	-0.0005	-0.0012	0.0028	-0.0025	-0.1744
		G	-0.0053	-0.0081	0.0041	0.0036	0.0046	0.0038	0.0009	0.0040	-0.0062	0.0052	-0.2001*
4	Days to 50% flowering	P	-0.0024	-0.0042	0.0020	0.0015	0.0024	0.0020	0.0006	0.0015	-0.0032	0.0027	-0.1875*
		G	0.0030	0.0047	-0.0023	-0.0017	-0.0027	-0.0023	-0.0008	-0.0021	0.0037	-0.0029	-0.2108*
5	Number of flower clusters per plant	P	0.0028	-0.0013	0.0053	0.0047	0.0044	0.0001	0.0004	0.0007	-0.0007	-0.0035	-0.0262
		G	0.0029	-0.0012	0.0055	0.0056	0.0044	0.0010	0.0004	0.0006	-0.0003	-0.0040	-0.0814
6	Number of flowers per cluster	P	-0.0023	-0.0028	0.0024	0.0009	0.0045	0.0054	-0.0029	-0.0019	-0.0030	0.0033	0.3856**
		G	-0.0003	-0.0003	0.0003	0.0001	0.0005	0.0006	-0.0003	-0.0003	-0.0003	0.0004	0.3992**
7	Number of fruits per cluster	P	-0.0006	-0.0058	0.0043	0.0037	0.0029	0.0000	0.0009	0.0019	-0.0027	0.0008	0.0042
		G	-0.0022	-0.0205	0.0097	0.0075	0.0059	0.0006	0.0020	0.0058	-0.0064	0.0022	-0.0254
8	Number fruits per plant	P	0.0627	-0.0052	0.0236	-0.0468	-0.0412	-0.0172	0.0113	-0.0098	0.0195	0.0069	-0.2477**
		G	-0.0155	0.0569	-0.1145	-0.0996	-0.0955	-0.0501	0.0260	-0.0308	0.0462	0.0152	-0.3266**
9	Per cent fruit set	P	0.0007	0.0010	-0.0011	-0.0001	-0.0021	-0.0019	0.0008	-0.0005	0.0011	0.0006	-0.3139**
		G	0.0038	0.0051	-0.0057	-0.0006	-0.0108	-0.0110	0.0036	-0.0034	0.0061	0.0036	-0.6395**
10	Number of marketable fruits per plant	P	-0.0007	0.0024	-0.0037	-0.0033	-0.0031	-0.0014	0.0009	-0.0006	0.0017	0.0011	-0.2367**
		G	0.0055	-0.0210	0.0332	0.0300	0.0260	0.0124	-0.0078	0.0071	-0.0145	-0.0096	-0.2671**
11	Days to first harvest	P	0.0013	0.0004	-0.0001	0.0000	-0.0001	-0.0002	0.0000	-0.0002	0.0002	0.0002	-0.1603
		G	-0.0008	-0.0003	0.0000	0.0000	0.0001	0.0002	0.0000	0.0001	-0.0001	0.0003	-0.1739
12	Days to last harvest	P	-0.0008	-0.0026	0.0005	0.0002	0.0007	0.0005	0.0001	0.0002	-0.0006	0.0001	-0.2084*
		G	0.0012	0.0033	-0.0007	-0.0002	-0.0009	-0.0007	-0.0002	-0.0002	0.0007	0.0000	-0.2237*
13	Fruit length (cm)	P	0.0001	0.0003	-0.0014	-0.0011	-0.0010	-0.0008	0.0003	-0.0003	0.0007	0.0002	0.5633**
		G	-0.0004	-0.0018	0.0081	0.0069	0.0063	0.0048	-0.0018	0.0019	-0.0040	-0.0014	0.6006**
14	Fruit width (cm)	P	-0.0001	0.0004	-0.0042	-0.0054	-0.0030	-0.0019	0.0011	-0.0008	0.0016	0.0007	0.3616**
		G	-0.0012	0.0023	-0.0262	-0.0308	-0.0180	-0.0115	0.0067	-0.0051	0.0096	0.0040	0.3849**
15	Fruit weight (g)	P	-0.0130	-0.0500	0.1451	0.1096	0.1960	0.1799	-0.0389	0.0365	-0.1023	-0.0131	0.9244**
		G	-0.0215	-0.0824	0.2427	0.1818	0.3112	0.2910	0.0067	-0.0051	0.0096	0.0040	0.9421**
16	Fruit yield/plant (kg)	P	-0.1407	-0.1751	0.4649	0.2946	0.7681	0.8371	-0.0999	0.1378	-0.4226	0.0307	0.9980**
		G	-0.1422	-0.1726	0.4526	0.2869	0.7170	0.7666	-0.0972	0.1525	-0.4025	0.0287	0.9992**
17	Total soluble solids (ºBrix)	P	-0.0002	0.0003	0.0017	0.0016	0.0016	0.0010	-0.0083	-0.0004	-0.0004	0.0003	-0.1322
		G	-0.0001	0.0005	0.0022	0.0022	0.0021	0.0013	-0.0103	-0.0006	-0.0005	0.0004	-0.1380
18	Ascorbic acid (mg/100 g)	P	-0.0012	-0.0007	0.0019	0.0015	0.0018	0.0016	0.0005	0.0099	-0.0033	-0.0001	0.1694
		G	-0.0021	-0.0009	0.0038	0.0027	0.0037	0.0033	0.0009	0.0164	-0.0065	-0.0001	0.2073*
19	Lycopene content (mg/100 g)	P	0.0011	0.0017	-0.0039	-0.0025	-0.0042	-0.0041	0.0004	-0.0027	0.0081	0.0021	-0.5005**
		G	0.0022	0.0034	-0.0076	-0.0047	-0.0081	-0.0080	0.0008	-0.0061	0.0152	0.0041	-0.5197**
20	Beta-carotene (mg/100 g)	P	-0.0019	-0.0001	-0.0010	-0.0008	-0.0004	0.0002	-0.0002	-0.0001	0.0016	0.0062	0.0360
		G	-0.0038	-0.0001	-0.0018	-0.0013	-0.0007	0.0004	-0.0004	-0.0001	0.0027	0.0102	0.0356

Phenotypic Residual effect =0.053; Genotypic Residual effect=0.021; Diagonal (under lined) values indicate direct effects

effect on fruit yield per plant at genotypic level (-0.0008) and negligible positive direct effect at phenotypic level (0.0013). Days to last harvest observed negligible positive direct effect on fruit yield at genotypic level (0.0033) and negligible negative direct effect at phenotypic level (-0.0026). Fruit length exhibited negligible positive direct effect at genotypic level (0.0081) and negligible negative direct effect at phenotypic level (-0.0041) on fruit yield. At both genotypic and phenotypic level, fruit width recorded negligible negative direct effect on fruit yield (-0.0308 and -0.0054) respectively. Fruit weight exhibited high positive direct effect on fruit yield at genotypic level (0.3112) as well as at phenotypic level (0.1960). Total soluble solids observed negligible negative direct effect at genotypic level (-0.0103) and phenotypic level (-0.0083) on fruit yield per plant. Ascorbic acid showed negligible positive direct effect on fruit yield at genotypic level (0.0164) as well as at phenotypic level (0.0099). At both genotypic and phenotypic level, lycopene content recorded negligible positive direct effect on fruit yield (0.0164 and 0.0099) respectively. Beta-carotene showed negligible positive direct effect at genotypic level (0.0102) and at phenotypic level (0.0062) on fruit yield per ha. These findings are in conformity with the results of Ahirwar *et al*., (2013) [1] for plant height, Khapte and Jansirani (2014) [8] for number of fruits per plant, Manna and Paul (2012) [10] for fruit weight and Ramana *et al.*, (2007) [17] for fruit yield per plant in tomato.

Hence, it could be concluded that in tomato yield per hectare was positively and significantly correlated with number of flowers per cluster, fruit length, fruit width, fruit weight, fruit yield per plant, ascorbic acid and beta-carotene. In path coefficient analysis the highest positive direct effect was noted in fruit weight followed by number of fruits yield per plant. So, the traits like; fruit weight and fruits yield per plant showed positive correlation with yield as well as they have positive direct effect on yield. Hence these traits can be used as selection indices in tomato to bring about the improvement in yield and exploited when selecting for high fruit yields in tomato.

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