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CORRELATION AND PATH ANALYSIS STUDIES IN TOMATO (*Lycopersicon esculentum* Mill.)

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ABSTRACT

Thirteen genotypes of tomato were evaluated under semi-arid and subtropical climatic conditions in the Research Farm and Laboratory of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during spring-summer season of the year 2017-18. Analysis of variance studies indicated a significant difference among all the genotypes for all the characters under study. High heritability coupled with high genetic advance as percent of mean was observed for marketable yield, days to 50% flowering, plant height at 90 days after transplanting, number of fruits per plant, number of branches per plant, total soluble solids and number of locules per fruit. The total yield per plant had positive and highly significant correlation with number of branches per plant, number of flowers per cluster, number of trusses per plant, number of fruits per truss , number of fruits per plant, average fruit weight, number of locules per fruit, ascorbic acid and days to first harvest. It indicated that the improvement in these traits leads to increase in total yield. The highly positive direct effect on total yield was shown by the characters leaf area index, number of flowers per cluster, number of trusses per plant, number of fruits per truss, polar diameter of fruit, pericarp thickness of fruit, total soluble solids, chlorophyll a:b ratio and days to first harvest, suggested that direct selection based on these characters would result in higher breeding efficiency for improving the yield in tomato.

Key words : *Heritability, genetic advance and correlation*

Tomato is one of the most important and widely grown vegetable crops, belongs to a family Solanaceae. In many countries, it ranks second importance to potato. Wider adoptability, high yield potential and usage of varieties in fresh and processed food industries increases its importance to all over the world. Due to its nutritional value, protects the human body from several ailments. Potentiality of this crop made its need for an improvement and to develop varieties suitable for cultivation under specific agro climatic conditions. Plant productivity requires the consideration of both yield and quality parameters for breeding programme.

Prime objective of the breeder is to improve the plant characters both qualitatively and quantitatively. Hence, adequate knowledge of genetics for various traits is essential to obtaining desirable results. Selection of new parents for higher degree of heterosis is of prime importance. Heritability denotes the proportion of phenotypic variation due to genotype. An effective breeding programme involves the improvement of both yield and quality parameters

Breeding programme aim at plant production requires not only of yield but also its direct and indirect effect of its components. Yield is the combined effect of all its individual components. Yield and quality both are important components of breeder. Therefore, it is important to know the relationship between various components that affects the yield and quality. Correlation studies between the different quantitative characters' gives the degree of relationship between these components. Direct and indirect contributions of various components towards total yield can be made understand by path co-efficient techniques.

MATERIALS AND METHODS

The experiment was carried out at Research Farm and Laboratory of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during a spring-summer season of the year 2018. The experimental material comprised of 13 genetically diverse genotypes of tomato *viz.,* 16/TODVAR-1 to 16/TODVAR-12 (IIVR, Varanasi) and Sel-7 (Hisar, Haryana). These genotypes were grown in Randomized Block Design with 3 replications and 60 x 45 cm spacings. Observations were recorded for plant height, number branches, days to 50% flowering, number of trusses per plant, number of flowers per cluster, number of fruits per truss, number of fruits per plant, leaf area index, marketable yield, average fruit weight, equatorial and polar diameter of fruit, number of locules per fruit, pericarp thickness of fruit, total soluble solids, acidity, ascorbic acid content, chlorophyll a:b ratio, test weight of seed and days to first harvest. Heritability in broad sense was calculated as the ratio of genotypic variance to the phenotypic variance and it was expressed in percentage (1). Genetic advance as per cent mean of each character was worked out by adopting the following formula given by (2). The correlation coefficients among all possible character combinations at phenotypic (rp) and genotypic (rg) level were estimated by employing the formulae given by (3). The path coefficient analysis was performed as per the formula and adopted by Deway and Lu (4).

Table-1 : Estimation of variability, heritability and expected genetic advance for 22 characters.

Sr. No.	Characters	Heritability in broad sense (h^2b) in %	Genetic advance as % of mean
1.	Plant height at 60 DAT (cm)	84.16	25.27
2.	Plant height at 90 DAT (cm)	97.75	18.52
3.	Plant height at 120 DAT (cm)	96.82	24.55
4.	Number of branches per plant	96.81	47.72
5.	Days to 50% flowering	97.80	17.43
6.	Leaf area index	81.48	8.35
7.	Number of flowers per cluster	93.49	10.77
8.	Number of trusses per plant	89.47	12.06
9.	Number of fruits per truss	92.42	16.65
10.	Number of fruits per plant	97.29	24.96
11.	Days to first harvest	82.43	4.25
12.	Average fruit weight (g)	89.71	7.74
13.	Marketable yield (q/ha)	98.08	18.72
14.	Polar diameter (cm)	34.66	3.42
15.	Equatorial diameter (cm)	93.55	15.63
16.	Number of locules per fruit	93.68	15.64
17.	Pericarp thickness (mm)	87.78	29.77
18.	Total soluble solids (%)	96.74	12.35
19.	Acidity (%)	87.50	28.53
20.	Ascorbic acid(mg/100g)	92.38	13.56
21.	Chlorophyll a:b ratio	74.79	7.68
22.	Test weight (g)	84.83	6.74

RESULTS AND DISCUSSION

The observational data were recorded as per the materials and methods discussed in the previous chapter. The experimental data for different characters were arranged and analyzed by following the Randomized Block Design. The results obtained are presented under the following headings :

Components of variation and estimates of genetic parameters : The high estimates of heritability (broad sense) were noticed in almost all characters like marketable yield (98.08%), days to 50% flowering (97.80%), plant height at 90 DAT (97.75%), number of fruits per plant (97.29%), plant height at 120 DAT (96.82%), number of branches per plant (96.81%), total soluble solids (96.74%), number of locules per fruit (93.68%) equatorial diameter of fruit (93.55%), number of flowers per cluster (93.49%) number of fruits per truss (92.42%), ascorbic acid (92.38%), average fruit weight (89.71%), number of trusses per plant (89.47%), pericarp thickness (87.78%), acidity (87.50%),test weight of seed (84.83%), plant height at 60 DAT (84.16%), days to first harvest (82.43%), leaf area index (81.48%),chlorophyll a:b ratio (74.79%) and lowest in polar diameter of fruit (34.66%).

Estimates of genetic advance as percent of mean were recorded very low for polar diameter of fruit (3.42%), days to first harvest (4.25), test weight of seed (6.74), chlorophyll a:b ratio (7.68%), average fruit weight (7.74%), leaf area index (8.35%), number of flowers per cluster (10.77%), number of trusses per plant (12.06%), total soluble solids (12.35%), ascorbic acid (13.56%), equatorial diameter of fruit (15.63%), number of locules per fruit (15.64%), whereas, very high genetic advance as percent of mean was recorded for number of branches per plant (47.72%) followed by pericarp thickness (29.77%), acidity (28.53%), plant height at 60 DAT (25.27), number of fruits per plant (24.96%) plant height at 120 DAT (24.55), while the estimates of genetic advanceas percent of mean for marketable yield (18.72%), plant height at 90 DAT (18.52%), days to 50% flowering (17.43%) and number of fruits per truss (16.65%) were in average range. And presented in table-1.

Correlation among yield components : The correlation coefficients among the characters were analyzed at phenotypic and genotypic level, which gives the information on nature of association of characters with tomato fruit yield and aids the selection process more

Table-2 : Genotypic correlation coefficient among marketable yield and its component characters in tomato.

	PLH1	PLHT2	PLHT3	NBR	DFF	LAI	NFCL	NTPL	NFPT	NFPL
PLHT1	1.000									
PLHT2	0.918**	1.000								
PLHT3	0.826**	0.971**	1.000							
NBR	–0.804**	–0.935**	–0.903**	1.000						
EFF	0.750**	0.720**	0.694**	–0.651**	1.000					
LAI	–0.857**	–0.814	–0.665**	0.574**	–0.811**	1.000				
NFCL	–0.848**	–0.882**	–0.864**	0.915**	–0.656**	0.617**	1.000			
NTPL	–0.827**	–0.731**	–0.715**	0.758**	–0.586**	0.471**	0.964**	1.000		
NFPT	–0.852	–0.922**	–0.884**	0.831**	–0.684**	0.755**	0.908**	0.843**	1.000	
NFPL	–0.938**	0.920**	–0.865**	0.885**	–0.711**	0.760**	0.995**	0.933**	0.966**	1.000
AFW	0.524**	0.155^{NS}	0.002^{NS}	–0.352*	0.131^{NS}	–0.303^{NS}	–0.485**	–0.547**	–0.117^{NS}	–0.392**
PDF	0.714**	0.642**	0.595**	–0.534**	0.581**	–0.824**	–0.557**	–0.585**	–0.878**	–0.821**
EDF	0.923**	0.924**	0.846**	–0.913**	0.72**	–0.709**	–0.911**	–0.875**	–0.953**	–0.968**
NLFR	–0.948**	–0.898**	–0.896**	0.820**	–0.768**	0.759**	0.862**	0.952**	0.915**	0.956**
PTF	–0.782**	–0.910**	–0.938**	0.821**	–0.676**	0.627**	0.885**	0.959**	0.933**	0.958**
TSS	0.898**	0.921	0.886**	–0.810**	0.792**	–0.813**	–0.855**	–0.888**	–0.934**	–0.946**
ASDY	0.901**	0.902**	0.899**	–0.911**	0.859**	–0.710**	–0.858**	–0.923**	–0.918**	–0.953**
ASAD	–0.950**	–0.955**	–0.899**	0.866**	–0.784**	0.723**	0.917**	0.891**	0.964**	1.001**
CHL	–0.979**	–0.983**	–0.851**	0.847**	–0.725**	0.818**	0.816**	0.827**	0.975**	0.993**
TW	–0.595**	–0.546**	–0.484**	0.588**	–0.366*	0.370**	0.876**	1.026**	0.794**	0.886**
DFH	–0.04^{NS}	–0.097^{NS}	–0.158^{NS}	0.277^{NS}	0.252^{NS}	–0.469**	0.218^{NS}	0.416**	0.220^{NS}	0.204^{NS}
MYD	–0.869**	–0.911**	–0.903**	0.813**	–0.747**	0.698**	0.872**	0.861**	0.992**	0.952**

Table-2 : Contd...

	PLH1	PLHT2	PLHT3	NBR	DFF	LAI	NFCL	NTPL	NFPT	NFPL		
AFW	1.000											
PDF	0.141^{NS}	1.000										
EDF	0.250^{NS}	0.291^{NS}	1.000									
NLFR	–0.196^{NS}	–0.306^{NS}	–0.862**	1.000								
PTF	–0.076^{NS}	–0.184^{NS}	–0.758**	0.873**	1.000							
TSS	0.119^{NS}	0.281^{NS}	0.894**	–0.911**	–0.854**	1.000						
ASDY	0.142^{NS}	0.317*	0.882**	–0.890**	–0.779**	0.895**	1.000					
ASAD	–0.140^{NS}	–0.174^{NS}	–0.883**	0.867**	0.839**	–0.916**	–0.864**	1.000				
CHL	–0.163^{NS}	–0.037^{NS}	–0.696**	0.694**	0.801**	–0.723**	–0.642**	0.800**	1.000			
TW	–0.358*	–0.175^{NS}	–0.637**	0.616**	0.641**	–0.607**	–0.528**	0.671**	0.566**	1.000		
DFH	–0.017^{NS}	–0.051^{NS}	–0.265**	0.716^{NS}	0.273^{NS}	–0.225^{NS}	–0.320**	0.173^{NS}	0.112^{NS}	0.255^{NS}	1.000	
MYD	–0.065^{NS}	–0.285^{NS}	–0.868**	0.916**	0.891**	–0.957**	–0.858**	0.916**	0.730**	0.619**	0.255^{NS}	

**Significance at 5 % level *Significance at 1 % level

PLHT 1- Plant height at 60,90 and 120 days after transplanting, NBR - Number of branches per plant, PDF- Polar diameter of fruit, CHL- Chlorophyll a : b ratio, LAI - Leaf area index, NTPL - Number of trusses per plant, EQD - Equatorial diameter of fruit, TW- Test weight, TSS - Total soluble solids, NFPT - Number of fruits per truss, PTF- Pericarp thickness of fruit DFH- Days to first harvest, ASDY- Acidity, DFF-Days to 50% flowering, NFPL - Number of fruits per plant, MYD- Marketable yield, AFW- Average fruit weight, ASDD- Ascorbic acid, NFCL - Number of flowers per cluster, NLFR- Number of locules per fruit.

effective. Both the genotypic and phenotypic estimates of correlations were tested for their significance against tabulated value of correlation coefficient at five and one percent levels of significance. Correlation analysis studied the association of different traits with fruit yield at genotypic and phenotypic level and results have been presented in table-2.

Path analysis : Path analysis studies give an idea about actual effects of a character on yield. For a dependent character like yield, many independent characters affects directly and indirectly. Hence, for a improvement of a character, even it is showing significance with yield may not be considered for improvement as its correlation with yield may be due to the indirect effects of this trait through

Table-3 : Path coefficient analysis among marketable yield and its component characters in tomato.

	PLH1	PLHT2	PLHT3	NBR	DFF	LAI	NFCL	NTPL	NFPT	NFPL
PLHT1	–2.4875	–1.2634	–3.1460	4.4438	–1.3945	–0.2254	–1.4440	–1.3156	–1.0156	4.5511
PLHT2	–2.2837	–1.3762	–3.6989	5.1710	–1.3401	–0.2141	–1.5020	–1.1624	–1.0986	4.4597
PLHT3	–2.0536	–1.3358	–3.8108	4.9902	–.2906	–0.1749	–1.4702	–1.1376	–1.0536	4.1970
NBR	1.9996	1.2873	3.4400	–5.5281	1.2118	0.1508	1.5584	1.2053	0.9900	–4.2914
EFF	–1.8645	–0.9913	–2.6436	3.6005	–1.8605	–0.2133	–1.1166	–0.9318	–0.8154	3.4458
LAI	2.1323	1.1208	2.5353	–3.1709	1.5091	0.2629	1.0509	0.7468	0.9002	–3.6861
NFCL	2.1101	1.2143	3.2913	–5.0609	1.2204	0.1623	1.7023	1.5331	1.0821	–4.8260
NTPL	2.0575	1.0058	2.7256	–4.1892	1.0900	0.1234	1.6409	1.5905	1.0046	–4.5261
NFPT	2.1201	1.2688	3.3696	–4.5928	1.2731	0.1986	1.5459	1.3410	1.1916	–4.6850
NFPL	2.3343	1.2655	3.3979	–4.8917	1.3219	0.1998	1.6940	1.4844	1.1511	–4.8497
AFW	–1.3043	–0.2133	–0.0081	1.9476	–0.2440	–0.0795	–0.8257	–0.8693	–0.1399	1.8989
PDF	–1.7765	–0.8835	–2.2687	2.9541	–1.0804	–0.2168	–0.9477	–0.9308	–1.0458	3.9834
EDF	–2.2960	–1.2721	–3.2240	5.0479	–1.3529	–0.1864	–15516	–1.3913	–1.1352	4.6950
NLFR	2.3583	1.2360	3.4152	–4.5340	1.4282	0.1996	1.4676	1.5136	1.0906	–4.6372
PTF	1.9454	1.2524	3.5756	–4.5382	1.2581	0.1648	1.5066	1.5249	1.1119	–4.6481
TSS	–2.2336	–1.2678	–3.3769	4.4750	–1.4737	–0.2136	–1.4561	–1.4124	–1.1131	4.5900
ASDY	–2.2403	–1.2410	–3.4249	5.0380	–1.5978	–0.1866	–1.4600	–1.4674	–1.0933	4.6231
ASAD	2.3628	1.3139	3.4273	–4.7882	1.4589	0.1902	1.5618	1.4164	1.1481	–4.8549
CHL	2.4341	1.3530	3.2421	–4.6844	1.3487	0.2150	1.3896	1.3159	1.1614	–4.8174
TW	1.4796	0.7519	1.8433	–3.2527	0.6800	0.0974	1.4907	1.6322	0.9460	–4.2989
DFH	0.0092	0.1335	0.6024	–1.5304	–0.4681	–0.1233	0.3716	0.6615	0.2618	–0.9869

Table-3 : Contd.....

	AFW	PDF	EDF	NLFR	PTF	TSS	ASDY	ASAD	CHL	TWS	DFH	MYD
PLHT 1	–0.3443	0.1261	–4.9759	3.4684	–2.0708	2.5568	–0.0219	4.1543	–0.4925	0.0317	–0.0031	–0.8685**
PLHT 2	–0.1018	0.1133	–4.9829	3.2856	–2.4097	2.6231	–0.0220	4.1757	–0.4943	0.0292	–0.0813	–0.9111**
PLHT 3	–0.0014	0.1051	–4.5607	3.2785	–2.4844	2.5232	–0.0219	3.9334	–0.4282	0.0258	–0.1325	0.9031**
NBR	0.2314	–0.0943	4.9226	–3.0005	2.1737	–2.3050	0.0222	–3.7881	0.4265	–0.0314	0.2321	0.8127**
DFF	–0.0861	0.1025	–3.9202	2.8083	–1.7905	2.2555	–0.0209	3.4295	–0.3649	0.0195	0.2109	–0.7469**
LAI	0.1987	–0.1455	3.8222	–2.7773	1.6597	–2.3136	0.0173	–3.1633	0.4115	–0.0198	–0.3931	0.6980**
NFCL	0.3185	–0.0983	4.9135	–3.1540	2.3435	–2.4357	0.0209	–4.0126	0.4109	–0.0467	0.1830	0.8719**
NTPL	0.3589	–0.1033	4.7156	–3.4815	2.5387	–2.5286	0.0225	–3.8949	0.4164	–0.0548	0.3487	0.8610**
NFPT	0.0771	–0.1549	5.1357	–3.3483	2.4707	–2.6599	0.0223	–4.2141	0.4905	–0.0424	0.1842	0.9920**
NFPL	0.2571	–0.1450	5.2189	–3.4980	2.5378	–2.6950	0.0232	–4.3782	0.5000	–0.0473	0.1706	0.9516**
AFW	–0.6567	0.1052	–1.6236	1.0044	–0.2670	0.4454	–0.0068	0.9690	–0.1693	0.0246	–0.0826	–0.0949**
PDF	–0.3913	0.1765	–3.0964	2.8518	–2.1829	2.2517	–0.0175	2.3514	–0.3260	0.0363	–0.2464	–0.8053**
EDF	–0.1978	0.1014	–5.3908	3.2645	–2.3097	2.7393	–0.0241	4.2598	–0.4820	0.0406	–0.2722	–0.9376**
NLFR	0.1803	–01376	4.8104	–3.6583	2.4674	–2.7503	0.0230	–4.0434	0.4246	–0.0350	0.1452	0.9652**
PTF	0.0662	–0.1455	4.7024	–3.4090	2.6478	–2.5990	0.0213	–3.9931	0.4132	–0.0432	0.1416	0.9561**
TSS	–0.1027	0.1396	–5.1861	3.5335	–2.4169	2.8474	–0.0243	4.2797	–0.4335	0.0365	–0.1708	–0.9798**
ASDY	–0.1821	0.1268	–5.3337	3.4542	–2.3118	2.8377	–0.0244	4.1485	–0.4129	0.0341	–0.2675	–0.9812**
ASAD	0.1455	–0.0949	5.2507	–3.3822	2.4179	–2.7863	0.0231	–4.3735	0.4936	–0.0406	0.0817	0.9710**
CHL	0.2209	–0.1143	5.1626	–3.0855	2.1738	–2.4523	0.0200	–4.2893	0.5033	–0.0428	–0.1762	0.8769**
TW	0.3033	–0.1200	4.0988	–2.4003	2.1454	–1.9504	0.0156	–3.3256	0.4039	–0.0534	0.2570	0.7438**
DFH	0.0647	–0.0519	1.7502	–0.6379	0.4472	–0.5801	0.0078	–0.4259	–0.1058	–0.0164	0.8384	0.2218**

RSQUARE=0.9070, RESIDUALEFFECT=0.3050

**Significance at 5 % level *Significance at 1 % level

PLHT 1- Plant height at 60,90 and 120 days after transplanting, NBR – The number of branches per plant, PDF- Polar diameter of fruit, CHL- Chlorophyll a : b ratio, LAI - Leaf area index, NTPL – The number of trusses per plant, EQD - Equatorial diameter of fruit, TW- Test weight, TSS - Total soluble solids, NFPT – The number of fruits per truss, PTF- Pericarp thickness of fruit DFH- Days to first harvest, ASDY- Acidity, DFF-Days to 50% flowering, NFPL – The number of fruits per plant, MYD- Marketable yield, AFW- Average fruit weight, ASDD- Ascorbic acid, NFCL - Number of flowers per cluster, NLFR- Number of locules per fruit.

other characters. In such cases, it is always more appropriate to split the correlation value into direct and indirect effects through path coefficient analysis. By partitioning the genotypic correlations, the direct effect of a chosen trait on fruit yield per plant and its indirect effect through other characters were analysed and the data related to direct and indirect effects are presented in Table-3.

Out of twenty-two, nine characters showed positive direct effect on fruit yield per plant at genotypic level. The characters, which had positive direct effect on fruit yield were leaf area index (0.262), number of flowers per cluster (1.7023), number of trusses per plant (1.5905), number of fruits per truss (1.1916), polar diameter of fruit (0.1765), pericarp thickness of fruit (2.6478) , total soluble solids (2.8474), chlorophyll a:b ratio (0.5033) and days to first harvest (0.8384). Among the positive direct effects, leaf area index,(0.6980), number of flowers per cluster (0.8719), number of trusses per plant (0.8610), number of fruits per truss (0.9920) , number of fruits per plant (0.9516) , number of locules per fruit (0.9652), pericarp thickness of fruit (0.9561), ascorbic acid (0.9710), chlorophyll a:b ratio (0.8769), test weight of seed (0.7438)and days to first harvest (0.2218) were highly significant and positive direct effect, and plant height at 60 DAT (-0.8685), plant height at 90 DAT (-0.911) and plant height at120 DAT(-0.9031) , average fruit weight (0.0949), polar diameter of fruit 0.8053) , equatorial diameter of fruit (0.9376), total soluble solids (0.9798) and acidity (0.9710)was found significant but negative direct effect, The characters, which had negative direct effect on fruit yield per plant, were plant height at 60 DAT (-2.4875), plant height at 90 DAT(-1.3762), plant height at 120 DAT days (-3.8108), days to 50% flowering (-1.8605), number of fruits per plant (-0.4849), average fruit weight (-0.6567), equatorial diameter of fruit (-0.53908), number of locules per fruit (-3.6583), acidity (-0.0244) ,ascorbic acid content (-4.37354) and test weight of seed (-0.0534) respectively.

CONCLUSION

High heritability along with high genetic advance was observed for seven genotypes, which indicate that maximum characters were more reliable for selection to enhance the fruit yield in tomato. The magnitude genotypic correlation coefficient and phenotypic correlation coefficient recorded for the characters like plant height, number of branches per plant, number of flowers per cluster, number of trusses per plant, number of fruits per plant and total soluble solids could be considered as criteria for finding out high yielding genotypes of tomato. Path coefficient analysis at genotypic and phenotypic level nine had direct and positive significant effect on marketable fruit yield per plant. Thus, these traits can be further utilized for selection of high marketable fruit yield of tomato genotypes. The wider phenotypic variability observed among different tomato genotypes may be due to the adoption of these genotypes to favorable environmental conditions. Therefore, these can be further utilized in future breeding programme.

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