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Genetic Variability, Correlation and Path Coefficient Analysis of Tomato (*Lycopersicon esculentum* Mill.)

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Abstract

To assess the magnitude of genetic variability and character association, 20 genotypes of tomato were evaluated in randomized block design with three replications. A great extent of variability was observed for various character like fruit yield q/ha, average fruit weight, storability, number of locules per fruit, number of fruits per plant, number of seeds per fruit, plant height, fruit length, number of fruit clusters per plant. High genotypic and phenotypic coefficient of variation (GCV and PCV) were observed for fruit yield q/ha, average fruit weight, storability, number of locules per fruit, number of fruits per plant and number of seeds per fruit. The highest heritability in broad sense was found for all characters except number of branches per plant. The highest genetic advance coupled with high heritability, PCV and GCV estimated were recorded for average fruit weight, fruit yield per plant, storability, number of fruits per plant, number of locules per fruit, number of seeds per fruit, plant height, fruit length, number of fruit clusters per fruit yield showed positive and significant genotypic and phenotypic correlation with number of fruits per plant, average fruit weight, ascorbic acid and reducing sugar. Path coefficient analysis revealed that number of fruits per plant had maximum direct effect towards fruit yield followed by fruit width, number of seeds per fruit and TSS.
Key words : Variability, Heritability, Genetic gain, Correlation, Path coefficient, Tomato.

Tomato (*Lycopersicon esculentum* Mill) is an important vegetable crop belonging to the family Solanaceae. Tomato is an annual vegetable crop of wide spread culture and popularity. Some biometric techniques like variability, correlation and path analysis provides information about the relative contribution of various yield related traits. Genotypic and phenotypic coefficient of correlation seeks out the association between yield and yield contributing traits in tomato. If the association is positive and significant, simultaneous improvements can be made by if selecting any correlated character. As correlation measure the mutual relationship between different traits of a plant. It helps to determine the best yield contributing component. Path analysis splits the correlation coefficient into a measure of direct and indirect effects and determines the direct and indirect contribution of various characters towards the yield. Thus, these biometric techniques help in selection of superior genotypes for breeding programme. Therefore, the present study was undertaken to assess the extent of variability for different character to correlation and path coefficient analysis for yield and yield traits in tomato.

Methods

The present experiment was undertaken on twenty genotypes of tomato at Vegetable Research Farm of Department of Horticulture, Institute of Agricultural Sciences, BHU, Varanasi 221005 (UP) during *rabi* season 2007-2008 in randomized block design with three replications. Seedlings were transplanted at a spacing of 60 × 45 cm in 3 × 2.25 m plot. During the course of investigation all the cultural practice were followed in the experiment to raise a good crop. Five plants were selected at random in each plot and tagged. Observation were recorded on days to 50% flowering, plant height (cm), number of branches per plant, spread of plant (cm), days to fruit maturity, fruit length (cm), fruit width (cm), number of fruit clusters per plant, number of fruits per plant, average fruit weight (g), number of locules per fruit, fruit yield per plant (kg), fruit yield per hectare (q), number of seeds

Table 1. Estimate of range, mean, genotypic and phenotypic coefficient of variation (GCV and PCV) heritability, genetic advance and genetic gain for different characters of 20 genotypes of tomato.

Characters	Range	Mean	GCV	PCV	Heritability (%)	Genetic advance	Genetic gain (%)
Days to 50% flowering	26.33-44.67	31.01	15.60	16.69	87.4	9.31	30.02
Palnt height (cm)	46.00-106.73	70.06	22.44	22.86	96.4	31.79	45.37
No. of branches/plant	5.10-9.40	7.11	15.10	18.97	63.3	1.76	24.75
Days to fruit maturity	68.00-90.33	76.66	6.38	6.73	89.7	9.54	12.44
Fruit length (cm)	2.63-5.13	3.68	21.26	22.32	90.7	1.54	41.84
Fruit width (cm)	2.11-5.15	3.78	18.33	19.36	89.6	1.35	35.71
No. of fruit clusters/plant	3.50-7.80	5.51	20.75	21.31	94.8	2.29	41.56
No. of fruits/plant	8.07-27.47	18.23	29.13	29.37	98.4	10.85	59.59
Average fruit weight (g)	104.00-706.67	337.01	38.09	38.29	98.9	263.03	78.04
No. of locules/fruit	2.20-5.20	3.28	29.34	30.01	95.6	1.94	59.14
Fruit yield (q/ha)	164.03-700.04	436.69	38.12	38.42	93.7	323.86	74.16
No. of seeds/fruit	81.00-222.07	121.85	25.74	26.03	97.8	63.89	52.43
Storability	5.00-15.33	10.76	30.35	31.72	91.5	6.44	59.85
TSS	3.27-5.75	4.44	14.05	14.29	96.7	1.27	28.60
Ascorbic acid	17.18-28.80	22.98	14.41	14.42	99.9	6.82	29.67
Reducing sugar	1.44-2.36	1.81	15.39	16.05	91.9	0.55	30.38

per fruit, storability, total soluble solids (^{0}B), ascorbic acid (mg) content and reducing sugar (%). Phenotypic and genotypic coefficients of variability were calculated following the method suggested by Burton and Devane (1). Heritability in broad sense and genetic advance was computed by the formula given by Johnson et al. (2) and by Lush (3) respectively. Genotypic and phenotypic correlation coefficient was estimated according to Panse and Shukhatme (4). Path coefficients were calculated by using the method suggested by Dewey and Lu (5).

Results and Discussion

The development of an effective plant breeding program is dependent upon the existence of genetic variability (Tables 1—3). The efficiency of selection largely depends upon the magnitude of genetic variability present in the plant population. Thus, the success of genetic improvement in any character depends on the nature of genetic variability present in gene pool for the character. Hence, an insight into the magnitude of variability present in the gene pool of a crop species is of utmost importance for a breeder for initiating a judicious plant-breeding program. The characters, which showed wide range of variations like plant height, number of branches per plant, flowering time, fruit length, number of fruits per plant and yield per plant, had maximum scope for selection. These findings are in accordance with Bhutani et al. (6) and Singh (7).

The variance measures the variation within a particular traits but it does not provide a real measure for comparison of variances between different traits. The term coefficient of variation truly provides a relative measure of variance among the different traits. The phenotypic coefficient of variation was higher than their respective genotypic coefficient of variation for nearly all the traits. Fruit yield q/ha, average fruit weight, storability, number of locules per fruit, number of fruits per plant and number of seeds per fruit, showed high phenotypic and genotypic coefficients of variation (PCV and GCV), whereas, it was moderate for plant height, fruit length, number of fruit cluster per plant fruit width, number of branch per plant, days to 50% flowering and reducing sugar. The variation was low for ascorbic acid. TSS and days to fruit maturity. Thus, the characters showing maximum phenotypic and genotypic coefficients of variation should be considered while making selection spite the influence of environment to certain extent. The result of high phenotypic and genotypic coefficients of variation for number of fruits per plant and fruit yield per plant is in agreement with by Singh and Narayan (8).

In the present investigation, heritability was found to be quite high for all the characters except number of branches per plant. Heritability was highest for ascorbic acid content (99.9%) followed

Table 2. Estimation of genotypic (G) and phenotypic (P) correlation coefficient for various characters of 20 genotypes of tomato. *, ** Significant at $P = 0.05$, $P = 0.01$, respectively.

Characters		Days of 50% flowering	Plant height (cm)	No. of branches/ plant	Days of fruit maturity	Fruit length (cm)	Fruit width (cm)	No of fruit clusters/plant	No of fruits/ plant
Days of 50%	G	–	-0.398	0.157	0.628**	0.554*	0.576**	0.007	0.128
flowering	P	–	-0.363	0.060	0.560*	0.479*	0.509*	0.030	-0.122
Plant height (cm)	G		–	0.324	0.038	-0.018	-0.044	-0.332	-0.099
	P		–	0.281	0.031	-0.012	-0.064	-0.311	-0.102
No of branches/	G			–	-0.128	-0.049	0.088	-0.048	-0.118
plant	P			–	-0.117	-0.025	0.107	-0.047	-0.094
Days of fruit	G				–	0.375	0.099	-0.189	-0.053
maturity	P				–	0.344	0.065	-0.171	-0.058
Fruit length (cm)	G					–	0.295	-0.434	-0.366
	P					–	0.275	-0.404	-0.334
Fruit width (cm)	G						–	-0.019	-0.143
	P						–	-0.009	-0.137
No of fruit clusters/	G							–	-0.375
plant	P							–	-0.344
No of fruits/plant	G								–
	P								–
Fruit yield (q/ha)	G								
	P								
Average fruit	G								
weight (g)	P								
No. of locules/fruit	G								
	P								
No of seeds/fruit	G								
	P								
Storability (days)	G								
	P								
TSS	G								
	P								
Ascorbic acid	G								
	P								

Table 2. Continued.

		Fruit yield (q/ha)	Average fruit weight (g)	No of locules/ fruit	No of seeds/ fruit	Storabi- lity (days)	TSS	Ascorbic acid	Reducing sugar
Days of 50%	G	0.044	0.297	-0.132	0.498*	0.054	-0.226	0.075	-0.022
flowering	P	0.099	0.273	-0.134	0.475*	0.022	-0.218	0.073	-0.029
Plant height (cm)	G	-0.037	0.008	-0.195	-0.318	0.093	0.221	0.018	-0.289
	P	-0.044	0.006	-0.191	-0.304	0.102	0.219	0.018	-0.284
No of branches/	G	-0.206	0.082	-0.348	-0.018	0.052	-0.037	-0.118	-0.051
plant	P	-0.135	0.060	-0.293	-0.033	0.044	-0.030	-0.097	-0.047
Days of fruit	G	0.205	0.322	-0.057	-0.007	0.050	0.355	0.361	-0.270
maturity	P	0.193	0.307	-0.039	0.007	0.061	0.338	0.349	-0.236
Fruit length (cm)	G	-0.346	0.065	-0.211	0.130	-0.258	-0.112	-0.135	-0.367
	P	-0.312	0.067	-0.194	0.124	-0.223	-0.087	-0.127	-0.329
Fruit width (cm)	G	0.256	0.371	-0.066	0.207	0.297	0.034	0.407	-0.086
	P	0.232	0.363	-0.047	0.201	0.282	0.038	0.390	0.079
No of fruit clusters/	G	0.136	0.489*	-0.001	0.313	0.194	-0.478	0.200	-0.039
plant	P	0.147	0.472*	0.014	0.294	0.172	-0.464	0.188	-0.030
No of fruits/plant	G	0.487*	-0.315	0.027	-0.080	0.048	0.246	-0.113	0.283
	P	0.472*	-0.301	0.024	-0.074	0.054	0.225	-0.108	0.273

Table 2. Continued.

Characters		Fruit yield (q/ha)	Average fruit weight (g)	No of locules/ fruit	No of seeds/ fruit	Storability (days)	TSS	Ascorbic acid	Reducing sugar
Fruit yield (q/ha)	G	–	0.553*	0.270	0.282	0.104	0.309	0.464*	0.518*
	P	–	0.537*	0.264	0.275	0.072	0.300	0.448*	0.484*
Average fruit	G		–	0.277	0.277	0.107	0.313	0.459*	0.507*
weight (g)	P		–	0.272	0.270	0.079	0.306	0.449*	0.472*
No of locules/fruit	G			–	0.647*	0.082	0.009	0.563*	0.236
	P			–	0.635*	0.080	0.008	0.560*	0.227
No of seeds/fruit	G				–	-0.104	0.014	0.091	0.277
	P				–	-0.087	0.013	0.088	0.279
Storability (days)	G					–	-0.077	0.229	0.358
	P					–	-0.076	0.225	0.337
TSS	G						–	0.136	0.069
	P						–	0.133	0.066
Ascorbic acid	G							–	0.107
	P							–	0.112

by average fruit weight (98.9%), number of fruits per plant (98.4%), number of seeds per fruit (97.8%), TSS (96.7%), plant height (96.4%), number of locules per fruit (95.6%), number of fruit clusters per plant (84.8%), spread of plant (east-west) (94.6%), fruit yield per plant (94.1%), fruit yield q/ha (93.7%), spread of plant (north-south) (93.0%), reducing sugar (91.9%), storability (91.5%), fruit length (90.7%), days to fruit maturity after (89.7%), fruit width (89.65%) and days to 50% flowering (87.4%) while number of branches per plant (63.3%) showed moderate heritability. These findings are in accordance with Nair and Thamburaj (9) ; and Singh (7). So as genetic advance is concerned the characters viz., average fruit weight, fruit yield per plant, storability, number of fruits per plant, number of locules per fruit, number of seeds per fruit, plant height, fruit length, number of fruit clusters per plant exhibited high genetic gain. Whereas the characters like reducing sugar, days to 50% flowering, ascorbic acid, TSS and number of branches per plant showed moderate genetic gain, while it was lowest for days to fruit maturity.

High heritability may not be an index for high genetic advance. If heritability is mainly due to non-additive genetic effects (dominance, over-dominance, epitasis and their interactions) the genetic gain would be low, while in cases where heritability is mainly due to additive gene effect a high genetic advance may be expected. The mean value of the population can be shifted with the selection. The extent of charge is further dependent on the intensity of selection and genetic advance for the population. The genetic advance was also expressed as percentage of the mean to compare expected genetic gain for different characters. Some of the characters viz. average fruit weight, fruit yield per plant, storability, number of fruits per plant, number of locules per fruit, number of seeds per fruit, plant height, fruit length, number of fruit clusters per plant showed high value of heritability, PCV and GCV with high value of genetic gain. It may be attributed to additive gene effect. Hence, selection for these traits may also be done for improvement in yield of tomato. These findings are in accordance with Singh (7) ; and Mahesha et al. (10).

In general, the magnitudes of genotypic correlation coefficient in the present study were invariably higher than their corresponding phenotypic correlation coefficient. The results indicate that the genotypic and phenotypic correlation coefficients showed positive and significant days to 50% flowering with days to fruit maturity, fruit length, fruit width and number of seeds per fruit ; number of fruit clusters per plant with average fruit weight ; number of locules per fruit with number of seeds per fruit and ascorbic acid. Fruit yield (q/ha) also recorded positive and significant genotypic and phenotypic correlations with number of fruits per plant. Average fruit weight, ascorbic acid and reducing sugar. This result is in agreement with Das et al. (11).

In the present study, path coefficient was calcu-

Table 3. Genotypic path coefficient effect of various characters of 20 genotypes of tomato. Recidual -0.0407.

	Character	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	Days of 50% flowering	0.702	1.272	-0.264	-2.539	-1.819	2.992	-0.048	-0.829
X_2	Plant height (cm)	-0.279	-3.199	-0.544	-0.153	0.059	-0.228	2.267	-0.640
X_3	No of branches/plant	0.111	-1.037	-1.678	0.519	0.160	0.455	0.326	-0.767
X_4	Days of fruit maturity	0.441	-0.121	0.215	-4.044	-0.604	1.530	2.962	-0.371
X_5	Fruit length (cm)	0.389	0.057	0.082	-0.743	-3.286	3.505	0.127	-0.925
X_6	Fruit width (cm)	0.404	0.141	-0.147	-1.191	-2.218	5.193	1.272	-0.432
X_7	No of fruit clusters/plant	0.005	1.064	0.080	1.757	0.061	-0.969	-6.818	5.597
X_8	No of fruits/plant	-0.090	0.316	0.198	1.479	0.469	-1.949	-5.889	6.481
X_9	Average fruit weight (g)	0.209	-0.027	-0.137	-0.262	-1.218	2.542	2.149	-1.970
X_{10}	No of locules/fruit	-0.092	0.623	0.583	0.852	0.218	-0.004	-0.184	0.874
X_{11}	No of seeds/fruit	0.336	1.017	0.031	-0.525	0.681	1.626	0.544	-1.074
X_{12}	Storability (days)	-0.038	-0.298	-0.087	1.041	-0.976	1.005	-0.325	0.459
X_{13}	TSS	-0.158	-0.706	0.061	0.454	-0.113	-2.483	-1.675	2.538
X_{14}	Ascorbic acid	0.053	-0.056	0.198	0.547	-1.339	1.037	0.769	-0.588
X_{15}	Reducing sugar	-0.015	0.926	0.086	1.485	0.283	-0.201	-1.928	2.409

Table 3. Continued.

	Character	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	Correlation with yield
X_1	Days of 50% flowering	-0.592	0.387	1.277	0.013	-0.404	-0.041	0.023	0.044
X_2	Plant height (cm)	-0.017	0.573	-0.849	-0.023	0.394	-0.010	0.311	-0.037
X_3	No of branches/plant	-0.163	1.021	-0.049	-0.013	-0.065	0.065	0.055	-0.206
X_4	Days of fruit maturity	-0.129	0.620	0.347	0.062	-0.201	0.074	0.394	0.205
X_5	Fruit length (cm)	-0.737	0.195	0.554	-0.072	0.062	-0.223	0.092	-0.346
X_6	Fruit width (cm)	-0.974	0.002	0.836	-0.047	-0.855	-0.109	0.042	0.256
X_7	No of fruit clusters/plant	0.627	-0.079	-0.213	-0.012	0.439	0.062	-0.304	0.136
X_8	No of fruits/plant	0.605	-0.397	-0.442	-0.017	0.700	0.050	-0.399	0.487*
X_9	Average fruit weight (g)	-1.990	-0.648	1.729	-0.020	0.016	-0.308	-0.253	0.553*
X_{10}	No of locules/fruit	-0.439	-2.939	1.392	0.025	0.025	-0.050	-0.297	0.270
X_{11}	No of seeds/fruit	-1.288	-1.532	2.570	0.010	-0.138	-0.125	-0.384	0.282
X_{12}	Storability (days)	-0.163	0.305	-0.109	-0.243	-0.565	-0.074	-0.074	0.104
X_{13}	TSS	-0.018	-0.042	-0.206	0.077	1.788	-0.147	-1.115	0.309
X_{14}	Ascorbic acid	-0.120	-0.266	0.610	-0.033	0.481	-0.547	-0.334	0.464*
X_{15}	Reducing sugar	-0.470	-0.813	0.956	-0.017	0.191	-0.170	-1.074	0.518*

lated taking fruit yield per hectare as dependent variable and rest of 15 characters as independent variables. The direct and indirect effects of yield contributing traits on yield revealed that the maximum positive direct effect towards the fruit yield was exhibited by number of fruits per plant followed by fruit width, number of seeds per fruit, TSS and days to 50% flowering. High negative direct effect toward fruit yield was recorded by number of fruit clusters per plant followed by days to fruit maturity, fruit length and plant height. Similar finding were observed by Sharma et al. (12).

The various characters also contributed positive indirect effect towards fruit yield via various characters like plant height via days to 50% flowering, and number of fruits per plant ; number of branches per plant via number of fruits per plant and number of locules per fruit ; fruit length via number of fruits per plant and number of seeds per fruit ; fruit width via fruit length and average fruit weight ; number of fruit cluster per plant via plant height and average fruit weight ; number of fruits per plant via number of fruit clusters per plant and TSS ; average fruit weight via number of fruit clusters per plant and number of fruits per plant ; number of locules per fruit via number of branches per plant and days to fruit maturity ; num-

ber of seeds per fruit via average fruit weight and number of locules per fruit.

These characters emerge as icey components of yield per plant and should be kept in mind during selection of any genotype. Thus it is concluded that besides the direct selection for productivity fruit yield, indirect selection for earliness to flowering, fruit cluster per plant, average fruit weight, number of fruit per plant, and fruit yield per plant should be considered for the selection and improvement of fruit production in tomato.

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