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Correlation and path analysis for growth and economic characters in tomato (*Solanum lycopersicon* (Mill.) Wettsd)

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Abstract
The experiment comprising forty six diverse genotypes, grown in randomized block design with three replications. The study revealed that the In general, genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients suggested a strong inherent relationship in different pairs of the traits. Number of fruits per plant (0.532), plant height (0.473), primary branches per plant (0.314) and fruit length (cm) (0.132) has positive significant and desirable association with fruit yield and selection of these traits would be effective for yield improvement in tomato. Path coefficient analysis revealed appreciable amount of direct positive effect of fruits per plant (1.213) followed by average fruit weight (0.7921).

Keywords: Correlation, path analysis, fruit yield

Introduction

Total correlation does not give the true genetic picture of the relationship between two traits in which a breeder is interested, because it includes environmental influence on the covariance between two characters. This component is measured as environmental correlation.The genotypic correlation is essential for assessing the real genetic variation in traits of significance. The basic concepts of correlation was put forth by Galton (1889) [13] and elaborated by Fisher (1918) [15] and Wright (1921) [21]. Engledow and Wadham (1923) [16] advocated the physiological basis of yield and correlation between physiological components and yield.

The estimates of correlation coefficients indicate only the inter-relationship of the character but, do not furnish information on the cause and effect relationships. Wright (1921) [4] has devised the analysis of path coefficient to provide effective means of finding out direct and indirect causes of association which permits the critical examination of specific forces acting to produce a given correlation and measures the relative importance of each causal factor. Dewey and Lu (1959) [2] were the first to demonstrate the utility of path coefficient analysis in breeding programme using crested wheat grass progenies.

Tomato is one of the most vegetable crop grown throughout the world because of its wider adaptability, high yielding potential and suitability for uses in fresh as well as processed food industries. It is one of the most popular and widely cultivated vegetable throughout the world and ranking second in importance after potato in many countries including India (Anonymous, 2015) [1]. In India, total area is 0.77 million hectare and production is 18.28 million tonnes with 23.74 tonnes per hectare productivity, which is very low as compared to average productivity of world.

Adapting the potentiality of this crop, there is a need for improvement and to develop varieties suited to specific agro-ecological conditions and also for specific end use. A thorough knowledge regarding the amount of genetic variability existing for various characters is essential for initiating the crop improvement programme. With limited variability much cannot be achieved and the breeder will have to enrich the germplasm or resort to create greater variability through hybridization, mutation and polyploidy.

Materials and Methods

The experiment was laid out in Randomized Block Design with three replications to assess the performance of 46 genotypes of tomato. Seedling were transplanted in the experimental field on 07 November 2014 in two row of 4.5 m length with inter and intra row spacing of 60 cm x

45 cm respectively. Fertilizer @ 120kgN: 80kgP_2O_5: 50kg K_2O/ha were applied to the crop. A A light irrigation was given immediately after transplanting. All recommended cultural practices were followed to maintain good crop stand and growth of the plant. Observations were recorded on five randomly selected plants from each genotype in each replication, summed up and divided by five to get mean value. The observation were recorded on characters *viz*., days to 50% flowering, plant height (cm), number of primary branches per plant, number of fruits per plant, days to first fruit harvest, average fruit weight (g), fruit circumference (cm), pericarp thickness (cm), number of locules per fruit, total soluble solids (T.S.S.), length of fruits (cm), harvest duration and fruit yield per plant (kg).

Statistical analysis

For computing phenotypic, genotypic and environmental correlation coefficients, analysis of co-variance were carried out in all possible combination pairs of the characters following Al-jibouri 1958 [11]. The correlation significance was tested against r values as described by Fisher and Yates, 1963 [12] at $(n - 2)$ degrees of freedom, where n is the number of genotypes. The path analysis of important traits was done following Dewey and Lu, 1959 [2]. The residual effect was the variation in the dependent variable assumed to be due to variable(s) not included. Genotypic and phenotypic correlation coefficients were utilized to compute direct and indirect contribution toward marketable yield. Direct and indirect paths were obtained following Dewey and Lu, 1959 [2].

Results and Discussion

Genetic correlations between characters could be due to linkage and pleotropic effect of genes. Therefore, selection made for one trait influenced by the other linked or pleotropically affected traits. The fruit yield or economic yield, in almost all the crops, is referred as super character, which resulted from multiple interactions of several other component characters that are termed as yield components. Thus, identification of important yield components and information about their inter relationship with each other will be very useful for developing efficient breeding strategy (Johanson *et al*. 1955) [4].

In this respect, the correlation coefficient, which provides symmetrical measurement of degree of association between two variables or characters help in understanding the nature and magnitude of association among yield and yield components.

The perusal of table 1 and 2 indicated that the phenotypic correlation coefficient between different characters was generally similar in sign and nature to the corresponding genotypic correlation coefficient in the experiment. However, in general genotypic correlations were higher in magnitude from the corresponding phenotypic values. In the present study, correlation between thirteen characters was worked out in all possible combinations at phenotypic and genotypic level.

The most important trait yield per plant had exhibited highly significant and positive phenotypic correlation with number of fruits per plant, plant height, primary branches per plant and fruit length. Similar finding was also reported by Kumar *et al*. 2003 [6] and Mohanty 2003 [7].

Days to 50 % flowering had significantly and negatively correlated with primary branches per plant and pericarp thickness (cm). Plant height showed positive and significant associated with primary branches per plant, no of fruits per plant and TSS. While, it was negative and significant associated with average fruit weight. Primary branches per plant exhibited significant and positive association with number of fruits per plant and pericarp thickness. Whereas it was negatively and significantly correlation with average fruit weight, harvest duration and days to first fruit harvest. Number of fruits per plant had negative and significant association with average fruit weight and fruit circumference. Days to first fruit harvest was positively associated with harvest duration. Average fruit weight showed positive and significant correlation with fruit circumference, number of locules per fruits and fruit length at phenotypic level. At phenotypic level, fruit circumference shows positive and significant association with number of locules per fruit and fruit length. Pericarp thickness was negatively and significantly correlation with number of locules per plant. Number of locules per fruit showed significant positive association with fruit length and TSS, while it was negatively and significantly correlated with harvest duration. These results are in conformity with the reports of earlier researches namely Singh *et al.* 2004 [10] and Golani *et al*. 2007.

Path coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effects of yield component on yield to provide more clear picture of character association for formulating effective selection strategy. Path analysis differs from simple correlation in that it points out the causes and their relative importance whereas, the latter measures simply the mutual association ignoring the causation.

In the present study, path coefficient analysis was carried out at phenotypic as well as genotypic levels (Table 3 and 4). The direct and indirect effect of different characters on fruit yield at phenotypic level had been presented in table 3. The highest positive direct effect on fruit yield per plant was exerted by number of fruit per plant followed by average fruit weight, pericarp thickness, plant height, number of locules per fruit, fruit circumference, and harvest duration. The substantial negative direct effect on yield was showed by TSS followed by number of primary branches per plant. Similar result was also reported by Prashanth *et al.* (2008) [8], Khapte *et al.* (2014) [5]. This indicates that direct selection for number of fruits per plant and fruit weight in desired direction would be very effective for yield improvement.

Table 1: Estimates of phenotypic (P) correlation coefficients between different characters in tomato

Character	Plant height (cm)	Primary branches/ plant	No of fruits per plant	Days to first fruit harvest	Average fruit weight (g)	Fruit circumference (cm)	Pericarp thickness (cm)	No of locules per fruits	TSS (%)	Fruit length (cm)	Harvesting duration	Fruit yield per plant (kg)
Days to 50% flowering	0.006	-0.224**	-0.152	-0.014	0.162	-0.151	-0.266**	-0.063	-0.030	-0.120	0.021	-0.071
Plant height (cm)		0.461**	0.482**	-0.092	-0.259**	-0.070	-0.071	-0.014	0.222**	-0.073	-0.181*	0.380**
Primary branches / plant			0.461**	-0.236**	-0.354**	0.105	0.177*	0.132	0.005	0.060	-0.291**	0.215**
No of fruits per plant				-0.107	-0.701**	-0.210*	0.112	-0.128	0.034	0.003	-0.148	0.631**
Days to first fruit harvest					0.139	0.003	-0.011	0.021	0.052	0.014	0.221**	-0.018
Average fruit weight (g)						0.315**	-0.083	0.262**	0.080	0.185*	0.060	-0.020
Fruit circumference (cm)							0.031	0.683**	0.131	0.670**	-0.160	0.032
Pericarp thickness(cm)								-0.203*	-0.050	0.149	-0.126	0.130
No of locules per fruits									0.180*	0.478**	-0.191*	0.073
TSS (%)										0.029	0.028	-0.060
Fruit length (cm)											-0.117	0.160*
Harvesting duration												-0.121

* - Significant at 5 per cent probability level
** - Significant at 1 per cent probability level

Table 2: Estimates of genotypic (G) correlation coefficients between different characters in tomato

Character	Plant height (cm)	Primary branches/ plant	No of fruits per plant	Days to first fruit harvest	Average fruit weight (g)	Fruit circumference (cm)	Pericarp thickness (cm)	No of locules per fruits	TSS (%)	Fruit length (cm)	Harvesting duration	Fruit yield per plant (kg)
Days to 50% flowering	0.021	-0.331	-0.311	-0.152	0.261	-0.171	-0.491	0.032	0.013	-0.181	0.113	-0.290
Plant height (cm)		0.513	0.511	-0.164	-0.305	-0.075	-0.094	-0.001	0.321	-0.069	-0.326	0.410
Primary branches / plant			0.532	-0.396	-0.431	0.145	0.237	0.154	-0.002	0.120	-0.518	0.323
No of fruits per plant				-0.131	-0.742	-0.219	0.138	-0.145	0.100	-0.012	-0.217	0.743
Days to first fruit harvest					0.162	0.031	-0.100	0.070	-0.051	0.140	0.234	0.002
Average fruit weight (g)						0.340	-0.140	0.294	0.040	0.256	0.267	-0.062
Fruit circumference (cm)							-0.028	0.857	0.183	0.744	-0.270	0.086
Pericarp thickness(cm)								-0.280	-0.064	0.240	-0.044	0.128
No of locules per fruits									0.196	0.652	-0.427	0.120
TSS (%)										0.002	-0.112	0.135
Fruit length (cm)											-0.252	0.331
Harvesting duration												-0.0101

Table 3: Direct and indirect effects of thirteen characters on fruit yield per plant at phenotypic level in tomato

Character	Days to 50% flowering	Plant height (cm)	Primary branches/ plant	No of fruits per plant	Days to first fruit harvest	Average fruit weight (g)	Fruit circumference (cm)	Pericarp thickness (cm)	No of locules per fruits	TSS (%)	Fruit length (cm)	Harvesting duration	Correlation with fruit yield per plant (kg)
Days to 50% flowering	-0.012	0.002	0.020	-0.197	0.001	0.139	-0.010	-0.030	-0.005	0.006	0.008	0.009	-0.073
Plant height (cm)	-0.001	0.101	-0.051	0.613	0.004	-0.217	-0.004	-0.008	-0.001	-0.045	0.005	-0.006	0.382
Primary branches / plant	0.002	0.047	-0.111	0.593	0.001	-0.298	0.006	0.020	0.012	-0.004	-0.004	-0.010	0.255
No of fruits per plant	0.001	0.049	-0.052	1.261	0.005	-0.599	-0.014	0.019	-0.011	-0.007	-0.003	-0.005	0.634
Days to first fruit harvest	0.001	-0.010	0.024	-0.132	-0.004	0.111	0.003	-0.001	0.009	-0.012	-0.002	0.008	-0.018
Average fruit weight (g)	-0.001	-0.026	0.039	-0.890	-0.006	0.8495	0.020	-0.009	0.022	-0.011	-0.012	0.002	-0.023
Fruit circumference (cm)	0.001	-0.007	-0.011	-0.265	0.000	0.267	0.066	0.003	0.059	-0.028	-0.040	-0.005	0.039
Pericarp thickness(cm)	0.002	-0.007	-0.019	0.141	0.000	-0.073	0.003	0.114	-0.017	0.010	-0.010	-0.004	0.137
No of locules per fruits	0.000	-0.001	-0.015	-0.162	-0.000	0.223	0.045	-0.023	0.087	-0.040	-0.033	-0.007	0.073
TSS (%)	0.000	0.023	-0.000	0.044	-0.000	0.068	0.008	-0.005	0.016	-0.214	-0.002	0.001	-0.060
Fruit length (cm)	0.001	-0007	-0.007	0.004	-0.000	0.154	0.044	0.017	0.041	-0.006	-0.070	-0.004	0.167
Harvesting duration	-0.000	-0.013	0.032	-0.1870	-0.000	0.052	-0.011	-0.012	-0.017	-0.006	0.008	0.034	-0.120

Residual effect =0.436

Table 4: Direct and indirect effects of thirteen characters on fruit yield per plant at genotypic level in tomato

Character	Days to 50% flowering	Plant height (cm)	Primary branches/ plant	No of fruits per plant	Days to first fruit harvest	Average fruit weight (g)	Fruit circumference (cm)	Pericarp thickness (cm)	No of locules per fruits	TSS (%)	Fruit length (cm)	Harvesting duration	Correlation with fruit yield per plant (kg)
Days to 50% flowering	-0.161	0.001	0.042	-0.417	0.017	0.244	0.064	-0.091	0.015	-0.003	-0.022	0.027	-0.291
Plant height (cm)	-0.004	0.184	-0.064	0.685	0.015	-0.277	0.027	-0.017	-0.001	-0.032	-0.008	-0.070	0.440
Primary branches / plant	0.056	0.097	-0.121	0.708	0.036	-0.397	-0.050	0.044	0.076	0.000	0.014	-0.117	0.343
No of fruits per plant	0.053	0.098	-0.067	1.324	0.012	-0.684	0.078	0.025	-0.068	-0.010	-0.001	-0.048	0.713
Days to first fruit harvest	0.026	-0.031	0.050	-0.184	-0.091	0.152	-0.013	-0.020	0.038	0.005	0.017	0.052	0.002
Average fruit weight (g)	-0.045	-0.057	0.054	-0.991	-0.015	0.911	-0.125	-0.026	0.142	-0.004	0.030	0.059	-0.062
Fruit circumference (cm)	0.029	-0.014	-0.017	-0.285	-0.003	0.317	-0.364	-0.005	0.418	-0.018	0.089	-0.062	0.086
Pericarp thickness(cm)	0.084	-0.018	-0.030	0.184	0.009	-0.130	0.010	0.186	-0.140	0.006	0.016	-0.009	0.168
No of locules per fruits	-0.005	-0.000	-0.019	-0.187	-0.007	0.267	-0.310	-0.053	0.488	-0.019	0.074	-0.106	0.120
TSS (%)	-0.005	0.062	0.000	0.132	0.005	0.037	-0.067	-0.012	0.095	-0.099	0.000	-0.033	0.115
Fruit length (cm)	0.032	-0.013	-0.015	-0.016	-0.013	0.234	-0.270	0.026	0.303	-0.000	0.119	-0.055	0.330
Harvesting duration	-0.021	-0.060	0.066	-0.288	-0.021	0.244	0.100	-0.008	-0.233	0.015	-0.029	0.223	-0.011

Residual effect =0.061

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