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Correlation and Path Coefficient Analysis in Tomato (*Solanum lycopersicum* L.)

N. Vinod Kumar Rathod*, B.G. Suresh and S. Manohar Reddy

Department of Genetics and Plant Breeding, Naini Agriculture Institute, Sam Higginbottom University of Agricultural Technology & Sciences, Allahabad U.P., India

**Corresponding author*

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A B S T R A C T

Thirty tomato genotypes were studied for correlation and path co-efficient analysis in tomato (*Solanum lycopersicum* L.) at Field Experimentation Center of Department of Genetics and plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, U.P during *Rabi* 2017-18. Fruit yield had positive and significant correlation with fruit weight, number of fruits per plant, number of primary branches per plant, number of flowers per cluster and number of locules per fruit. In path coefficient fruit weight, number of fruits per plant, number of flowers per cluster, number of primary branches per plant, days to 50% flowering and days to last fruit harvest exhibited positive direct effects on fruit yield 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.

Introduction

Tomato (*Solanum lycopersicum* L.) is an important vegetable crop and particularly now a commercial crop widely grown all over tropical, sub-tropical and temperate regions of the world for both fresh and processing purpose. It is the world's largest vegetable crop after potato and sweet potato, but it tops the list of canned vegetables and the second most important vegetable crop next only to potato in India.

Tomato belongs to the family solanaceae and is native of Peru Equador region (Rick, 1969). Tomato is a typical day neutral plant and is mainly self-pollinated, but a certain percentage of cross-pollination also occurs. It is a warm season crop reasonably resistant to heat and drought and grows under wide range of soil and climatic conditions. Globally, tomato is treated as 'Protective Food' since it is rich in essential minerals like Ca, P and Fe, vitamins A, C, B, small amounts of vitamin E (Rai *et al.*, 2012); antioxidants such as carotenoids (mainly lycopene and *β*-carotene), organic acids (healthy acids) and phenolics in daily diets. It plays a vital role in maintaining health, vigor and very helpful in healing wounds because of the antibiotic properties found in the ripe fruit. Pulp and juice are very appetizing, easily digestible, promoters of gastric secretion, blood purifiers and have a pleasing and refreshing taste.

It plays a vital role in improving nutrition resources of poor population as compared to meat, milk, fruits and other high priced fruit items and considered as most versatile vegetable with wide usage in Indian culinary tradition. It is consumed fresh as salad, sandwiches, cooked and processed into several products like ketchup, juice, puree, sauce, pickles, paste, soup and whole canned fruit. An important point is that fresh tomatoes are not only nutrient rich but are also devoid of nutrients such as unsaturated fatty acids and cholesterol, considered unhealthy in terms of cardio vascular diseases. Fresh tomatoes are also very low in sodium, although some processed tomato products such as paste and sauce do contain higher level. Considering 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.

The phenotypic expression of the plant characters is mainly controlled by the genetic make-up of the plant and the environment, in which it is growing. Further, the genetic variance of any quantitative trait is composed of additive variance (heritable) and non-additive variance includes dominance and epitasis (non-allelic interaction). Therefore, it becomes necessary to partition the observed phenotypic variability into its heritable and non-heritable components with suitable parameters such as phenotypic and genotypic coefficient of variation, heritability and genetic advance. Further, genetic advance can be used to predict the efficiency of selection.

Yield is a complex character controlled by large number of contributing characters and their interactions. A study of correlation between different quantitative characters provides an idea of association that could be effectively exploited to formulate selection strategies for improving yield components. For any effective selection programme, it would be desirable to consider the relative magnitude of association of various characters with yield.

Materials and Methods

The field experiment was conducted at Field Experimentation Centre of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, U.P during *Rabi* 2017-18. Thirty tomato genotypes were evaluated for correlation and Path co efficient analysis of fruit yield and its attributing traits in tomato. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Appropriate agronomic practices were followed to raise a good crop. Ten randomly taken plants were used to record observations on yield and yield attributed traits as days to 50% flowering, plant height, number of primary branches, number of flowers per cluster, days to first fruit harvest, days to last fruit harvest, number of fruits per cluster, number of fruits per plant, fruit length, Fruit width, fruit weight, number of locules per fruit, TSS, fruit yield per plant which included correlation co-efficient calculated for all quantitative and qualitative character combinations at phenotypic and genotypic levels correlation analysis by the formula given by Al-Jibouri *et al.*, (1958) and path co-efficient analysis developed by Wright (1921) and elaborated by Dewey and Lu (1959).

Results and Discussion

Interrelationship study in growth and yield parameters

The results of phenotypic correlation and genotypic correlation (Table 1) revealed that

plant height exhibited positive significant correlation with number of branches per plant and fruit yield per hectare along with negative significant correlation was days to 50% flowering showed positive and significant correlation with number of flowers per cluster, days to first fruit harvest, days to last fruit harvest and fruit length, while negative and significant correlation with number of primary branches per plant, number of fruits per cluster. Plant height exhibited negative and significant correlation with number of primary branches and the number of fruits per plant. Number of primary branches per plant has exhibited positive and significant correlation with fruit weight, and number of locules per fruit, whereas plant height, days to 50% flowering, day to first fruit harvesting and fruit length. Number of flowers per cluster showed positive and significant correlation with days to 50% flowering, number of fruits per plant, fruit length and total soluble solids. Significant positive correlations were observed with days to 50% flowering, days to last fruit harvest, fruit length and fruit width while negative and significant correlations were observed with number of primary branches per plant and number of fruits per cluster. Significant positive correlations were observed with days to 50% flowering and days to first fruit harvest, whereas negative and significant correlations were observed with number of fruits per cluster. Number of fruits per cluster has been observed with significant and negitive correlations with days to 50% flowering, days to first fruit harvest, days to last fruit harvest, fruit width and total soluble solids. The character number of fruits per plant has positive significant correlations with number of flowers per cluster and total soluble solids, whereas negative correlation is seen in fruit width and average fruit weight. Fruit length has exhibited positive and significant correlation with days to 50 % flowering, number of flowers per cluster, days to first fruit harvest and fruit weight, whereas negative significant correlation is seen in number of primary branches per plant. Fruit width has exhibited positive and significant correlation with days to first fruit harvest, fruit length and fruit weight, but it has been observed with negative and significant correlation with number of fruits per cluster and number of fruits per plant. Fruit weight has showed positive and significant correlation with number of primary branches per plant, fruit width and number of locules per fruit, but it has been recorded with negative and significant correlation with number of fruits per plant and total soluble solids. Positive significant correlation was observed with number of primary branches and average fruit weight but it has been observed with negative and significant correlation with fruit length and phenotypic negative significant correlation is not seen. Total soluble solids has significant negative correlation with number of flowers per cluster and number of fruits per plant, while negative and significant correlation is observed in number of fruits per cluster and average fruit weight.

These results are in consonance with the finding of Nandapuri *et al.,* (1974), Verma *et al.,* (1974), Anitha *et al.,* (2007) and Golani *et al.,* (2007). The trend of association observed in this study is mostly based upon the genetic contribution. Therefore, the value of 'r' for genotypic correlation between yield, yield contributing characters and quality characters should be considered for selecting the suitable characters for improvement. Fruit yield per plant showed the positive significance genotypic and phenotypic association with fruit weight, number of fruits per plant, number of primary branches, number of flowers per cluster, number of locules per fruit and positive non-significant genotypic and phenotypic correlation is seen in fruit width, days to 50% flowering days to last fruit harvest and fruit length.

Table.1 Phenotypic (P) and genotypic (G) correlation coefficients among yield and yield attributes in 30 genotypes of tomato

S. No.	Character		Days to 50% flowering	Plant height (cm)	No. of primary branches per plant	No. of flowers per cluster	Days to first fruit harvest	Days to last fruit harvest	No. of fruits per cluster	No. of fruits per plant	Fruit length (cm)	Fruit width (cm)	Fruit weight (gm)	No. of locules per fruit	TSS (°Brix)	Fruit yield per plant (kg)
1.	**Days to 50% flowering**	**P**	**1.00**	0.11	-0.22*	0.32**	0.59**	0.26*	-0.22*	0.14	0.49**	0.18	0.08	-0.10	0.02	**0.15**
		G	**1.00**	0.12	-0.23**	0.38**	0.72**	0.31**	-0.20*	0.17	0.51**	0.19	0.07	-0.12	0.05	**0.16**
2.	**Plant height (cm)**	**P**		**1.00**	-0.32**	0.01	-0.08	0.10	-0.15	-0.19	0.06	0.17	0.16	0.13	0.01	**-0.06**
		G		**1.00**	-0.34**	0.03	-0.07	0.10	-0.17	-0.20*	0.06	0.19	0.17	-0.14	0.01	**-0.08**
3.	**No. of primary branches / plant**	P			**1.00**	-0.10	-0.23*	0.03	-0.12	0.07	-0.43**	0.10	0.21*	0.38**	-0.06	**0.35****
		G			**1.00**	-0.10	-0.30**	0.04	-0.13	0.09	-0.47	0.15	0.25**	0.43**	-0.03	**0.38****
4.	**No. of flowers per cluster**	P				**1.00**	0.06	0.07	0.01	0.34**	0.29**	0.11	-0.09	0.03	0.22*	**0.24***
		G				**1.00**	0.05	0.09	-0.01	0.40**	0.33**	-0.15	-0.10	0.01	0.24	**0.28****
5.	**Days to first fruit harvest**	P					**1.00**	0.34**	-0.22*	-0.17	0.43**	0.34**	0.01	-0.01	-0.10	**-0.16**
		G					**1.00**	0.49**	-0.26**	-0.19	0.50**	0.34**	-0.01	-0.03	-0.11	**-0.14**
6.	**Days to last fruit harvest**	P						**1.00**	-0.37**	-0.03	0.06	0.15	0.07	0.08	-0.04	**0.11**
		G						**1.00**	-0.45**	-0.04	0.09	0.21*	0.11	0.09	-0.06	**0.12**
7.	**No. of fruits /cluster**	P							**1.00**	0.18	-0.02	-0.36**	-0.15	-0.06	-0.26**	**0.24***
		G							**1.00**	0.18	-0.01	-0.39**	-0.16	-0.09	-0.30**	**-0.06**
8.	**No. of fruits per plant**	P								**1.00**	0.03	-0.32**	-0.37**	0.05	0.28**	**0.39****
		G								**1.00**	0.04	-0.35**	-0.39**	0.04	0.30**	**0.45****
9.	**Fruit length (cm)**	P									**1.00**	0.45**	0.11	-0.16	0.12	**0.08**
		G									**1.00**	0.49**	0.12	-0.22	0.16	**0.08**
10	**Fruit width(cm)**	P										**1.00**	0.46**	0.05	0.07	**0.14**
		G										**1.00**	0.51**	0.08	0.07	**0.17**
11	**Fruit weight (gm)**	P											**1.00**	0.27**	-0.37**	**0.57****
		G											**1.00**	0.35**	-0.42**	**0.64****
12	**No. of locules /fruit**	P												**1.00**	-0.15	**0.31****
		G												**1.00**	-0.15	**0.35****
13	**TSS (°Brix)**	P													**1.00**	**-0.19**
		G													**1.00**	**-0.19**

Table.2 Genotypic (G) and Phenotypic (P) path coefficient analysis indicating direct and indirect effects of components characters on fruit yield in 30 genotypes of tomato

S. No.	Character		Days to 50% flowering	Plant height (cm)	No. of primary branches per plant	No. of flowers per cluster	Days to first fruit harvest	Days to last fruit harvest	No. of fruits per cluster	No. of fruits per plant	Fruit length (cm)	Fruit width (cm)	Fruit weight (gm)	No. of locules per fruit	TSS (°Brix)	Fruit yield per plant (kg)
1.	**Days to 50% flowering**	**G**	**-0.504**	-0.06	0.119	-0.194	-0.363	-0.160	0.1047	-0.088	-0.260	-0.096	-0.036	0.061	-0.027	**0.164**
		P	**0.013**	0.001	-0.002	0.004	0.007	0.003	-0.0029	0.001	0.006	0.002	0.001	-0.001	0.0003	**0.157**
2.	**Plant height (cm)**	G	0.005	**0.047**	-0.016	0.001	-0.003	0.005	-0.0082	-0.009	0.003	0.009	0.008	-0.006	0.001	**-0.085**
		P	-0.008	**-0.072**	0.023	-0.001	0.006	-0.007	0.0113	0.014	-0.004	-0.012	-0.011	0.009	-0.001	**-0.066**
3.	**No. of primary branches / plant**	G	-0.022	-0.032	**0.093**	-0.009	-0.028	0.003	-0.0126	0.008	-0.044	0.014	0.023	0.040	-0.003	**0.388**
		P	-0.002	-0.036	**0.110**	-0.011	-0.025	0.003	-0.0132	0.008	-0.048	0.011	0.024	0.042	-0.007	**0.358**
4.	**No. of flowers per cluster**	G	0.080	0.006	-0.021	**0.209**	0.010	0.019	-0.0013	0.084	0.069	-0.031	-0.021	0.001	0.050	**0.286**
		P	0.040	0.002	-0.012	**0.123**	0.008	0.009	0.0002	0.043	0.036	-0.013	-0.011	0.004	0.027	**0.246**
5.	**Days to first fruit harvest**	G	0.440	-0.048	-0.184	0.031	**0.612**	0.303	-0.1625	-0.118	0.309	0.210	-0.001	-0.020	-0.072	**-0.145**
		P	-0.100	0.014	0.039	-0.011	**-0.169**	-0.058	0.0379	0.029	-0.073	-0.058	-0.002	0.001	0.018	**-0.160**
6.	**Days to last fruit harvest**	G	-0.036	-0.012	-0.004	-0.010	-0.057	**-0.115**	0.0528	0.005	-0.010	-0.024	-0.013	-0.011	0.008	**0.122**
		P	0.017	0.007	0.002	0.004	0.022	**0.065**	-0.0244	-0.002	0.004	0.010	0.005	0.005	-0.002	**0.110**
7.	**No.of fruits /cluster**	G	0.014	0.012	0.009	0.001	0.018	0.032	**-0.0708**	-0.013	0.001	0.028	0.011	0.006	0.021	**-0.067**
		P	0.030	0.021	0.016	-0.0002	0.030	0.051	**-0.1371**	-0.024	0.003	0.049	0.021	0.008	0.036	**-0.075**
8.	**No. of fruits per plant**	G	0.183	-0.215	0.099	0.426	-0.204	-0.051	0.1922	**1.053**	0.043	-0.373	-0.412	0.042	0.321	**0.458**
		P	0.095	-0.128	0.048	0.227	-0.114	-0.025	0.1169	**0.649**	0.022	-0.214	-0.245	0.037	0.182	**0.392**
9.	**Fruit length (cm)**	G	-0.101	-0.013	0.094	-0.065	-0.099	-0.017	0.0037	-0.008	**-0.196**	-0.096	-0.023	0.043	-0.033	**0.080**
		P	0.037	0.004	-0.033	0.022	0.033	0.005	-0.0020	0.002	**0.076**	0.034	0.008	-0.012	0.009	**0.086**
10	**Fruit width(cm)**	G	-0.017	-0.017	-0.014	0.014	-0.031	-0.019	0.0368	0.032	-0.045	**-0.092**	-0.047	-0.007	-0.007	**0.179**
		P	0.003	0.003	0.002	-0.002	0.007	0.003	-0.0075	-0.006	0.009	**0.020**	0.009	0.001	0.001	**0.141**
11	**Fruit weight (gm)**	G	0.089	0.215	0.316	-0.126	-0.002	0.147	-0.2115	-0.492	0.151	0.647	**1.256**	0.443	-0.530	**0.645**
		P	0.055	0.116	0.154	-0.063	0.011	0.054	-0.1085	-0.265	0.077	0.328	**0.702**	0.194	-0.259	**0.573**
12	**No. of locules /fruit**	G	0.027	0.032	-0.100	-0.001	0.007	-0.022	0.0221	-0.009	0.051	-0.018	-0.081	**-0.230**	0.034	**0.358**
		P	0.001	0.001	-0.003	-0.0003	0.0001	-0.001	0.0006	-0.0006	0.001	-0.0005	-0.002	**-0.010**	0.001	**0.311**
13	**TSS (°Brix)**	G	0.002	0.001	-0.001	0.010	-0.004	-0.002	-0.0126	0.012	0.006	0.003	-0.017	-0.006	**0.041**	**-0.194**
		P	-0.004	-0.002	0.014	-0.045	0.021	0.008	0.0536	-0.057	-0.026	-0.016	0.075	0.031	**-0.203**	**-0.197**

These results are in consonance with the finding of Singh *et al.,* (1990), Patil and Bojappa (1993), Singh *et al.,* (2004), Mohanty (2003). The present study further indicated that yield per plant can be improved by improving the characters like number of fruits per plant and weight of fruit.

Path co-efficient analyses

From the results, it was observed that genotypic direct and indirect effects (Table 2) were higher than their corresponding phenotypic values.

Direct effects

Path analysis at phenotypic level and genotypic level of characters like fruit weight, number of fruits per plant, number of flowers per cluster, days to first fruit harvest, number of primary branches per plant, days to 50% flowering, fruit length, fruit width and days to last fruit harvest had shown positive direct effect on fruit yield per plant and total soluble solids, days to first fruit harvest, number of fruits per cluster and number of locules showed negative direct effect. These results were conformity with Singh *et al.,* (2004) and Haydar *et al.,* (2007).

Indirect effect on growth and yield parameters

Days to 50% flowering showed the positive indirect effect on plant height, number of flowers per cluster, days to first fruit harvest, days to last fruit harvest, Plant height had a positive indirect effect on number of primary branches, days to last fruit harvest, number of fruits per cluster, number of fruits per plant and number of locules per fruit, number of primary branches per plant exhibited positive indirect effect on days to first fruit harvest, number of fruits per plant, fruit width, fruit weight and number of locules. Number of flowers per cluster exhibited positive indirect effect on 50% flowering, plant height, days to first fruit harvest, days to last fruit harvest, number of fruits per cluster, number of fruits per plant and fruit length Days to first fruit harvest recorded indirect positive effect on plant height, number of primary branches per plant, number of fruits per cluster, number of fruits per plant, number of locules per fruit and total soluble solids. Days to last fruit harvest recorded the indirect positive effect on days to 50% flowering, plant height, number of primary branches per plant, number of flowers per cluster, days to first fruit harvest, fruit length, fruit width, fruit weight and number of locules per fruit. Number of fruits per cluster recorded positive indirect effect on days to 50% flowering, plant height, number of primary branches per plant, days to first fruit harvest, days to last fruit harvest, fruit length, fruit width, fruit weight number of locules and total soluble solids. Number of fruits per plant exhibited positive indirect effect on days to 50% flowering, number of primary branches per plant, number of flowers per cluster, number of fruits per cluster, fruit length, number of locules and total soluble solids. Fruit length showed positive indirect effects on days to 50% flowering plant height, number of flowers per cluster, days to first fruit harvest, days to last fruit harvest, number of fruits per plant, fruit width, fruit weight and total soluble solids. Fruit width exhibited positive indirect effect on days to 50% flowering (plant height, number of primary branches per plant, days to first fruit harvest, days to last fruit harvest, fruit length, fruit weight, number of locules per fruit and total soluble solids. Fruit weight exhibit positive in direct effect on days to 50% flowering, plant height, number of primary branches per plant, days to first fruit harvest, days to last fruit harvest, fruit length, fruit width and number of locules per fruit. Number of locules per fruit exhibits positive indirect effects were recorded

through days to 50% flowering, plant height, days to first fruit harvest, number of fruits per cluster fruit length and total soluble solids. Total soluble solids positive indirect effects were recorded through number of primary branches per plant, days to first fruit harvest, days to last fruit harvest, number of fruits per cluster, fruit weight number of locules per fruit. Similar result was observed by Golani *et al.*, (2007) who reported that yield can be improved directly by improving fruit weight and Mohanty (2002a and 2002b) reported that yield can be improved directly by improving fruits per plant and fruit weight.

Fruit yield had a positive significance correlation was association with traits like fruit weight, number of primary branches per plant, number of flowers per cluster and number of fruits per plant strong association of these traits revealed that the selection based on these traits would ultimately improve the fruit yield were positive and significant correlated with fruit yield plant per plant. Hence, due weightage should be given to these characters while selecting the germplasm in crop improvement. In path coefficient analysis fruit weight, number of fruits per plant, number of flowers per cluster, number of primary branches per plant, days to 50% flowering and days to last fruit harvest observed positive direct effect on fruit yield per plant at both genotypic and phenotypic level. These characters contribute maximum to high fruit yield compared to other characters, thus selection for these characters help in selection of superior tomato genotypes.

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