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Correlation and Path Analysis Studies for Yield and Quality Traits in Tomato (*Solanum lycopersicum* L)

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A B S T R A C T

Correlation and path analysis were carried out in forty tomato genotypes for yield and quality characters. The association studies showed that fruit yield per plant was positively and significantly correlated with number of fruits per plant and fruit width. However, fruit yield per plant was negatively and significantly correlated with days to last fruit harvest and shelf life. Path analysis studies done to study the cause and effect relationship revealed that plant height, number of fruits per plant, fruit weight, fruit length, fruit width and TSS had high positive direct effects on fruit yield per plant. Hence, direct selection for these traits is done for improving fruit yield per plant.

Introduction

Tomato (*Solanum lycopersicum* L.) is a member of the family Solanaceae and significant vegetable crop of special economic importance in the horticultural industry worldwide (He *et al.*, 2003). It has a chromosome number of 2n=24. Tomato is a native of Peru Equador region (Rick, 1969). It is the most important warm-season fruit vegetable grown throughout the world. Tomato is the most important vegetable crop next only to potato because of its wider adaptability, high yielding potential and multipurpose uses. 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. Tomato is grown as a annual or short lived perennial herbaceous plants. It has tap root and growth habit of the plant is determinate, semi determinate and indeterminate. Yield is a complex character and selection for yield and yield components deserves considerable attention. A crop breeding programme, aimed at increasing the plant productivity requires consideration not only of yield but also of its components that have direct or indirect

bearing on yield. Correlation and path coefficient analysis give an insight into the genetic variability present in populations. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. Path analysis splits the correlation coefficients into direct and indirect effects of a set of dependent variables on the independent variable thereby aids in selection of elite genotype. An improvement in yield and quality in self pollinated crop like tomato is normally achieved by selecting the genotypes with desirable character combinations existing in nature or by hybridization. Information on the nature and extent of variability present in genetic stocks, heritability, genetic advance and interrelationship among various characters is a prerequisite for framing any selection program.

Materials and Methods

The field experiment was conducted at Farm of Horticulture Section, College of Agriculture, Nagpur, during *Rabi* season of 2009-10. Forty tomato genotypes (Table 1 slient feather of tomato genotypes) were evaluated for correlation and Path coefficient analysis of fruit yield and it's attributing traits in tomato. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Forty genotypes of tomato consisting of thirty five local collections and five released varieties were evaluated. Appropriate agronomic practices were followed to raise a good crop. Pusa ruby, Pusa rohini, Dhanashree, PKM-1, S-22 was used as check. Twenty plants of each genotypes in each replication was planted at a spacing of 60 x45cm spacing.

Ten randomly taken plants were used to record observations on yield and yield attributed traits as plant height, number of branches, days to first flowering, days to 50% flowering, days to fruit set, number of fruits per plant, average fruit weight, fruit yield per plant, fruit yield per hectare, fruit weight, juice per cent, diameter of fruit, fruit length, pericarp thickness, TSS, Acidity, TSS, seed to pulp ratio 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 Hayes, Immer and Smith (1955 a,b) and path co-efficient analysis developed by Wright (1921) and elaborated by Dewey and Lu (1959).

Results and Discussion

Genotypic correlation coefficient

The result from table 1 on genotypic correlation coefficient revealed that yield per plant was significantly and positively correlated with diameter of the fruit (0.685), length of fruit (0.684) and weight of fruit (0.774). Plant height was found both genotypic and phenotypic correlation to be positive and significantly correlated with primary branches (0.385) whereas negatively correlated with days to first harvest (-0.541). The character primary branches was significant and positively correlated with leaves per plant (0.408), days to first flower (0.393), days to first fruit set (0.380) and negatively correlated with days to first harvest (-0.448). Leaves per plant showed positive and significant correlation with leaf area (0.366), days to first flower (0.471), days to first fruit set (0.437) and significant negative correlation with ascorbic acid (-0.383). Leaf area recorded significant and positive correlation with days to first flower (0.384), days to 50% flowering (0.471) and days to first fruit set (0.488). Days to first flower was observed to show positive and significant genotypic correlation coefficient for days to 50% flowering (1.262)

days to first fruit set (1.009), fruit diameter (0.391), fruit length (0.375) and negative correlation with fruits per plant (-0.573). Days to 50% flowering recorded positive and significant correlation for days to first fruit set (1.195) and negative correlation with days to first harvest (-0.856) and fruits per plant (-0.817). Days to first fruit set was observed to be negatively and significantly correlated with fruits per plant (-0.433) as compared to all other characters. Positive and significant correlation was observed for days to first harvest with fruits per plant (0.626) and negative correlation was observed for TSS (-0.378) and weight of fruit (-0.427).

Fruit diameter was positively and significantly correlated with fruit length (0.999), weight of fruit (0.823) and yield per plant (0.865) and significantly negatively correlated with fruits per plant (-0.410). The length of the fruit was significantly and positively correlated with weight of fruit (0.818) and yield per plant (0.684) and negatively correlated with fruits per plant (-0.403). Fruits per plant were found to be negatively and significantly correlated with weight of fruit (-0.623). Weight of fruit was significantly and positively correlated with yield per plant (0.774). The results are in accordance with Kumar *et al.,* (2006), Dhankhar and Dhankar (2006) for number of fruits per plant, Singh *et al.,* (2007) and Singh (2009) for fruit width

Phenotypic correlation coefficient

The table 1 indicates that phenotypic correlation coefficient was lower than that of genotypic level of association except for plant height with primary branches. The characters like primary branches, leaves per plant, leaf area, days to 50% flowering, days to first fruit set, days to first harvest, acidity (%), ascorbic acid, TSS (%) and juice percentage showed non significant association with other related characters. The phenotypic correlation coefficient was found to be positive and significant between plant height and primary branches (0.528), between days to first flower and days to 50% flowering (0.369) and days to first fruit set (0.846), between fruit diameter and length (0.983), weight of fruit (0.769) and yield per plant (0.584), between length of fruit and weight of fruit (0.770) and yield per plant (0.587) and between weight of fruit and yield per plant (0.685).

The phenotypic correlation coefficient was found to be negative and significant between fruits per plant and weight of fruit (-0.490). Phenotypic correlation coefficient was comparatively lower than the intensity of genotypic correlation coefficient except for plant height with primary branches. This indicates less influence of environment in association studies. 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 are considered for selecting the suitable characters for improvement. Similar to this result Anitha *et al.,* (2007) and Golani *et al.,* (2007) also observed high magnitude of genotypic correlation than the corresponding. Phenotypic correlation for most of the characters combinations establishing predominant role of heritable factor. In contrary to this Verma *et al.,* (1974) observed that the genotypic correlation are almost at par with the phenotypic correlation which reveals the constancy of proportion of genotypic and environmental variation for different characters Similar to this result Arunkumar and Veerasagavathatham (2005) also observed positive and significant correlation between fruit weight and yield per plant. Golani *et al.,* (2007) observed significant and positive correlation between fruit weight and fruit length and diameter of fruit.

However, scientists like Singh *et al.*, (1997) and Mohanty (2003) observed significant and positive correlation between yield per plant and fruits per plant.

Path Coefficient analysis

From table the Phenotypic and genotypic path coefficient of all the characters with yield were further partitioned into direct and indirect effect utilizing path coefficient analysis. The result on path analysis of various causes influencing yield per plant have been presented in Table 2. The direct and indirect effect of different characters on yield estimated from the path coefficient analysis reveals that the characters like leaves per plant (0.351) and days to first fruit set (0.382) has high positive direct effect on yield whereas characters fruit length (1.764), fruits per plant (1.195) and weight of fruit (1.792) has very high positive direct effect on yield. The other characters had either negligible positive direct effect or negative direct effect on yield.

The indirect effect of leaves per plant on yield through primary branches per plant (0.143), leaf area (0.128), days to first flower (0.165), days to first fruit set (0.153) and days to first harvest (0.107) was found to be low and positive. Similarly days to first flower has positive and low indirect effect on yield per plant through fruits per plant (0.133).

Table.1 Silent feathers of tomato genotypes

Sr.No.	Genotypes	Growth habit	Fruiting habit	Sr. No.	Genotypes	Growth habit	Fruiting habit
1	TMN-1	Determinate	Single	**21**	TMN-21	Determinate	Cluster
2	TMN-2	Indeterminate	Single	**22**	TMN-22	Determinate	Single
3	TMN-3	Indeterminate	Cluster	**23**	TMN-23	Determinate	Single
4	TMN-4	Indeterminate	Single	**24**	TMN-24	Determinate	Cluster
5	TMN-5	Indeterminate	Single	**25**	TMN-25	Determinate	Cluster
6	TMN-6	Determinate	Cluster	**26**	TMN-26	Indeterminate	Single
7	TMN-7	Indeterminate	Cluster	**27**	TMN-27	Determinate	Cluster
8	TMN-8	Determinate	Cluster	**28**	TMN-28	Determinate	Cluster
9	TMN-9	Indeterminate	Cluster	**29**	TMN-29	Determinate	Cluster
10	TMN-10	Determinate	Cluster	**30**	TMN-30	Indeterminate	Cluster
11	TMN-11	Determinate	Single	**31**	TMN-31	Indeterminate	Cluster
12	TMN-12	Determinate	Single	**32**	TMN-32	Determinate	Cluster
13	TMN-13	Determinate	Single	**33**	TMN-33	Determinate	Cluster
14	TMN-14	Indeterminate	Cluster	**34**	TMN-34	Determinate	Cluster
15	TMN-15	Determinate	Cluster	**35**	TMN-35	Determinate	Cluster
16	TMN-16	Indeterminate	Single	**36**	Pusa ruby	Indeterminate	Single
17	TMN-17	Determinate	Cluster	**37**	Pusa rohini	Determinate	Cluster
18	TMN-18	Determinate	Cluster	**38**	Dhanashree	Semi-determinate	Cluster
19	TMN-19	Determinate	Cluster	**39**	PKM-1	Determinate	Single
20	TMN-20	Determinate	Cluster	**40**	S-22	Determinate	Single

Table.2 Phenotypic and genotypic correlation coefficient among yield and yield contributing attributes in 40 tomato genotypes

Sr. No.	Characters		PH (cm)	PB	LA (cm^2)	DFF	DFPF	DFS	DFH	DF (cm)	LF (cm)	AP (%)	AA (mg/ 100g)	TSS (%)	FPP	WF (g)	YPP (kg)
1.	PH (cm)	P	1	0.528**	0.085	0.034	0.253	-0.029	-0.093	0.008	0.013	-0.049	0.009	0.122	0.007	-0.026	-0.041
		G	1	0.385*	0.155	-0.013	0.240	-0.062	-0.541**	0.098	0.086	-0.171	0.061	0.182	0.141	-0.007	0.021
2.	PB	P		1	0.138	0.138	0.086	0.168	-0.108	-0.038	-0.016	0.081	0.008	-0.001	-0.061	-0.111	-0.163
		G		1	0.279	0.393*	0.347	0.380*	-0.448*	-0.024	-0.001	0.037	0.016	0.018	-0.100	-0.207	-0.322
3	LA (cm^2)	P			1	0.254	0.151	0.282	-0.048	0.070	0.090	0.005	-0.095	0.106	-0.029	-0.064	-0.144
		G			1	0.384*	0.471*	0.488*	-0.062	0.061	0.091	-0.004	-0.095	0.118	-0.020	-0.077	-0.172
4.	DFF	P				1	0.369*	0.846**	-0.151	0.116	0.114	0.047	-0.171	0.098	-0.292	0.163	-0.053
		G				1	1.262**	1.009**	-0.199	0.391*	0.375*	0.175	-0.319	0.112	0.573**	0.354	0.001
5.	DFPF	P					1	0.357	-0.133	0.082	0.072	0.065	0.070	0.216	-0.311	0.116	-0.116
		G					1	1.195**	-0.856**	0.126	0.093	0.130	0.164	0.273	0.817**	0.229	-0.305
6.	DFS	P						1	-0.063	0.152	0.149	0.027	-0.154	0.123	-0.254	0.137	-0.064
		G						1	-0.205	0.340	0.335	0.107	-0.314	0.102	-0.433*	0.239	-0.056
7	DFH	P							1	-0.140	-0.144	0.011	-0.140	-0.228	0.339	-0.247	-0.026
		G							1	-0.322	-0.328	0.036	-0.232	-.0.378*	0.626**	-.427*	-0.082
8.	DF (cm)	P								1	0.983**	-0.045	-0.118	0.171	-0.303	0.769**	0.584**
		G								1	0.999**	-0.053	-0.141	0.191	-0.410*	0.823**	0.584**
9.	LF (cm)	P									1	-0.047	-0.171	0.161	-0.303	0.770**	0.587**
		G									1	-0.052	-0.191	0.176	-0.403*	0.818**	0.684**
	AP (%)	P										1	0.101	0.071	-0.197	0.204	0.143
12.		G										1	0.116	0.073	-0.221	0.227	0.171
13	AA (mg/100g)	P											1	0.036	-0.007	-0.197	-0.236
													1	0.038	-0.006	-0.245	-0.298
14	TSS (%)	P												1	0.006	0.108	0.169
														1	0.015	0.192	0.199
15	FPP	P													1	-0.490*	0.207
16		G													1	-0.623**	0.002
	WF (g)	P														1	0.685**
17		G														1	0.774**
18	YPP (kg)	P															1
																	1
		G															

*Significant at 5 % level ** Significant at 1 % level P- Phenotypic correlation coefficient G- Genotypic correlation coefficient

PH - Plant height, PB - Primary branches, LA - Leaf area, DFF - Days to first flower, DFPF - Days to 50% flowering, DFS - Days to first fruit set DFH - Days to first harvest, DF - Diameter of fruit, LF - Length of fruit, , AP - Acidity per cent, TSS - Total soluble solids, , FPP - Fruits per plant, WP - Weight of fruit, YPP - Yield per plant.

Table.3 Phenotypic (P) and genotypic (G) path coefficient analysis indicating direct and indirect effects of components characters on fruit yield in 40 genotypes of tomato.

Sr. No.	Characters	Plant height (cm)	Primary branches	Leaf area (m^2)	Days to 1st flower	Days to 50 % flowering	Days to 1st fruit set	Days to 1st harvest	Diameter of fruit (cm)	Length of fruit (cm)	Acidity (%)	Ascorbic acid (mg/100g)	TSS (%)	Fruit / plant	Weight of fruit (g)	Yield per plant
1	**Plant height (cm)**	**-0.295**	-0.114	-0.045	0.003	-0.071	0.018	0.160	-0.029	-0.025	0.050	-0.018	-0.054	-0.041	0.005	(0.021)
2	**Primary branches**	-0.044	**-0.114**	-0.032	-0.045	-0.039	-0.043	0.051	0.002	0.001	-0.004	-0.001	-0.002	0.011	0.023	(-0.322)
3	**Leaf area (m^2)**	-0.027	-0.049	**-0.176**	-0.067	-0.083	-0.086	0.011	-0.010	-0.016	0.008	0.016	-0.020	0.003	0.013	(-0.172)
4	**Days to 1st Flower**	0.003	0.091	-0.089	**-0.233**	-0.294	-0.235	0.046	-0.091	-0.087	-0.041	0.074	-0.026	0.133	-0.082	(0.001)
5	**Days to 50 % flowering**	0.009	0.013	0.018	0.049	**0.039**	0.046	-0.033	0.004	0.003	0.005	0.006	0.010	-0.031	0.009	(-0.305)
6	**Days to 1st fruit set**	-0.023	0.145	0.186	0.385	0.456	**0.382**	-0.078	0.130	0.128	0.041	-0.120	0.039	-0.165	0.091	(-0.056)
7	**Days to 1st harvest**	0.184	0.152	0.021	0.068	0.291	0.070	**-0.340**	0.109	0.111	-0.012	0.079	0.128	-0.213	0.145	(-0.082)
8	**Diameter of fruit (cm)**	-0.217	0.054	-0.136	-0.867	-0.279	-0.754	0.715	**-2.217**	-2.214	0.119	0.314	-0.425	0.910	-1.825	(0.685)
9	**Length of fruit (cm)**	0.152	-0.001	0.161	0.662	0.165	0.591	-0.579	1.762	**1.764**	-0.092	-0.338	0.312	-0.711	1.144	(0.684)
11	**Acidity (%)**	-0.010	0.002	-0.003	0.010	0.007	0.006	0.002	-0.003	-0.003	**0.060**	0.007	0.004	-0.013	0.013	(0.171)
12	**Ascorbic acid (mg/100g)**	0.015	0.004	-0.023	-0.078	0.040	-0.077	-0.056	-0.034	-0.047	0.028	**0.244**	0.009	-0.002	-0.060	(-0.298)
13	**TSS (%)**	0.005	0.001	0.003	0.003	0.008	0.003	-0.011	0.005	0.005	0.002	0.001	**0.029**	0.001	0.002	(0.199)
14	**Fruit / plant**	0.169	-0.120	-0.024	-0.685	-0.978	-0.518	0.749	-0.490	-0.482	-0.264	-0.008	0.018	**1.195**	-0.745	(0.002)
15	**Weight of fruit (g)**	-0.031	-0.371	-0.139	0.636	0.411	0.429	-0.767	1.476	1.468	0.407	-0.440	0.166	-1.117	**1.792**	(0.774)

Days to first fruit set has low and positive indirect effect on yield through primary branches (0.145), leaves per plant (0.167), leaf area (0.186), diameter of fruit (0.130), length of fruit (0.128). Whereas, days to first fruit set has positive and high indirect effect on yield through days to first flower (0.385) and days to 50% flowering (0.456). Days to first harvest showed positive and moderate indirect effect on yield through days to 50% flowering (0.291) and positive and low indirect effect through plant height (0.184), primary branches (0.152), diameter of fruit (0.109), length of fruit (0.111), TSS (0.128) and weight of fruit (0.145). The indirect effect of fruit diameter on yield was positive and high through days to first harvest (0.715), ascorbic acid (0.314), Juice per cent (0.656) and fruit per plant (0.990) and was positive and low through acidity per cent (0.119).

Fruit length has high positive indirect effect on yield via days to first flower (0.662), days to first fruit set (0.591), TSS (0.312) and has positive very high indirect effect through diameter of fruit (1.762) and weight of fruit (1.444). This character also has positive low indirect effect on yield through plant height (0.152), leaf area (0.161), days to 50% flowering (0.165), and has moderate indirect effect on yield through leaves per plant (0.218). Weight of fruit recorded very high positive indirect effect on yield through diameter of fruit (1.476), length of fruit (1.408). This traits also exhibited high positive indirect effect on yield via days to first flower (0.636), days to 50% flowering (0.411), days to first fruit set (0.429), acidity (0.407) and Low positive indirect effect through TSS (%) (0.166).

The path coefficient analysis done in this study reveals the improvement of yield by improving the characters leaves per plant, days to first flower, length of fruit, fruits per plant and weight of fruit. Similarly to this result Golani *et al.*, (2007) reported that yield can be improved directly by improving fruit weight and Mohanty (2002[a] and 2002[b]) reported that yield can be improved directly by improving fruits per plant and fruit weight.

In this study yield per plant of tomato can also been increased indirectly through days to first fruit set via days to first flower and days to 50% flowering, through weight of fruit via days to first flower, days to 50% flowering, days to first fruit set, diameter of fruit, length of fruit, pericarp thickness and acidity of fruit. The association and cause effect studies showed that fruit yield per plant was positively and significantly correlated with number of fruits per plant and fruit width. High direct effects are also observed for these traits. So, by improving these traits yield can be significantly increased.

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