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Correlation and path coefficient analysis in tomato (*Solanum lycopersicum* L.)

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Abstract

Sixty genotypes of tomato were evaluated to estimate the nature and magnitude of association of different characters with fruit yield and yield attributing traits. The experiment was laid out during *kharif* 2018 in randomized complete block design (RCBD) with three replications. In order to find out the degree and direction of relationship of the yield contributing characters with yield and inter relationship between them, correlation analysis was carried out for all traits under investigation. Fruit yield per plant exhibited high significant positive correlations with plant height, number of clusters per plant, number of fruits per plant, average fruit weight, polar length of fruit, equatorial length of fruit, pericarp thickness, number of locules per fruit and titrable acidity. It also registered significant negative correlation with days to 50% flowering, days to 1st harvest, number of primary branches per plant, number of fruits per cluster, total soluble solids (TSS), pH of fruit juice and shelf life. Path analysis revealed that number of fruits per clusters and average fruit weight had positive direct effects on fruit yield while these traits recorded positive correlation with yield.

Keywords: Tomato, Correlation, path coefficient analysis, yield and yield related traits

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most economically important vegetable grown all over the world. It is universally treated as "protective food" due to its special value and widespread production. It is native of Peru Ecuador Bolivia Region of Andes, South America (Rick 1969) [11]. Its production in 2016 estimated to be around 189 lakh tons from 7.76 lakh hectare area, (Anonymous 2017) [3]. Tomato is mainly consumed as salad, cooked or processed into several products like ketchup, juice, puree, sauce and whole canned fruit Yadav *et al*. (2013) [13]. It is a good source of an antioxidant (lycopene), ascorbic acid and Vitamin B; recent epidemiological studies have shown that consumption of tomato and its products reduce risk of developing digestive tract and prostate cancers (Khapte and Jansirani 2014) [6]. The degree and direction of relationship between two or more variables could be find out through statistical measure of correlation coefficient. It helps to measures the mutual relationship between various plant characters and determines the component characters on which selection could be made for genetic improvement of yield and quality contributing traits while the path analysis partitioning the correlation coefficient into the direct and indirect effect of a set of independent variables on dependent variables (Nagariya et al. 2015) [7]. Hence, there is pre-requisite for preliminary investigation of characters in the genotypes for the development of superior hybrids in tomato.

Materials and Method

The experimental material consists of sixty genotypes of tomato. The material was sown during *kharif* 2018 in randomized complete block design (RCBD) with three replications at Botany Garden, Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad. Five plants were selected in each genotype to record the observations on days to 50% flowering, days to 1st harvest, plant height, number of primary branches per plant, number of clusters per plant, number of fruits per cluster, number of fruits per plant, average fruit weight (g), polar length of fruit (mm), equatorial length of fruit (mm), pericarp thickness (mm), number of locules per fruit, fruit yield per plant (kg), T.S.S. (°Brix), pH of fruit juice and shelf life (days). Correlation coefficient analysis was done as per Al-Jibouri *et al.* (1958) [1] and the path coefficient analysis was estimated according to the formulae suggested by Dewey and Lu (1959) [4].

Results and Discussion

The results of correlation coefficient (Table 1) revealed that fruit yield per plant had positive and significant phenotypic correlations with plant height (0.3615), number of clusters per plant (0.5987), number of fruits per plant (0.2916), average fruit weight (0.8140), polar length of fruit (0.5776), equatorial length of fruit (0.5921), pericarp thickness (0.6749), number of locules per fruit (0.6709) and titrable acidity (0.2038). It also showed significant negative phenotypic correlation with days to 50% flowering (-0.2247), days to 1st harvest (-0.2460), primary branches per plant (-0.4307), number of fruits per cluster (-0.5267) pH (-0.1544) and Shelf life (-0.4797). Yield being a complex character is governed by a large number of genes. The influence of each character on yield could be known through correlation studies with a view to determine the extent and nature of relationships prevailing among yield and yield attributing characters. Fruit yield per plant exhibited high significant positive association with average fruit weight, pericarp thickness, number of locules per fruit and number of clusters per plant indicating the importance of these traits in selection for yield. Direct selection based on these traits would result in simultaneous improvement of aforesaid traits and yield per se in tomato. Similar results were reported in tomato for different components *viz*., average fruit weight (Rathod *et al*. 2016 [8], Rawat *et al*. 2017 [9] and Singh *et al*. 2018 [12]); Anuradha *et al*. 2018 [2] for pericarp thickness and number of locules per fruit and number of clusters per plant (Rathod *et al*. 2016 [8]). Days to 50% flowering (-0.2247), primary branches per plant (-0.4307), number of fruits per cluster (-0.5267) and Shelf life (-0.4797) showed negative correlation these results were in accordance with Rathod *et al*. (2016) [8] and Reddy *et al*. (2013) [10].

Path coefficient analysis gives an idea about the contribution of each independent character on the dependent character. Since, the mutual relationship of component characters might vary both in magnitude and direction, it may tend to vitiate the association of fruit yield with other attributes. Therefore, it is necessary to partition the correlation into direct and indirect effects of each other (Table 2). Since, the traits *viz*., TSS and lycopene content showed non-significant correlation they are omitted for path coefficient analysis. Days to 50% flowering had direct and negative effects on fruit yield per plant (-0.1198). Further, it showed negligible indirect negative effect on fruit yield per plant at phenotypic level (-0.0987) through days to 1st harvest followed by number of fruits per plant (-0.1213). Days to 1st harvest showed positive direct effect on fruit yield per plant at phenotypic level (0.1141). Further, positive indirect effects on fruit yield was exhibited through number of clusters per plant (0.2422) followed by average fruit weight (0.0681) at phenotypic level. At phenotypic level, plant height exhibited negligible negative direct effect on fruit yield per plant (-0.0517). Further, high negative indirect effect on fruit yield was exhibited through number of fruits per plant (-0.3293) followed by number of fruits per cluster at phenotypic level (-0.0082). Number of primary branches per plant showed negligible negative direct effects on fruit yield per plant at phenotypic level (-0.0536). Further, high indirect effect was noticed on average fruit weight and pericarp thickness at phenotypic level (-0.1453) and (-0.1204) respectively. At phenotypic level, number of clusters per plant (-0.5733) exhibited high negative direct effect on fruit yield per plant. Further, negligible negative indirect effect on fruit yield was exhibited through number of fruits per cluster followed by plant height at phenotypic level (-0.0531 and -0.0272). Number of fruits per cluster recorded positive direct effect (0.1658) on fruit yield per plant at phenotypic level. Further, indirect negligible positive effect was noticed through polar length of fruit (0.0584) followed by lycopene content at phenotypic level (0.0127). The character number of fruits per plant showed high negative direct effect on fruit yield per plant at phenotypic level (-0.6565). Further, negligible indirect negative effect at phenotypic level (-0.0259 and –0.0221) on fruit yield was exhibited through plant height and days to 50% flowering. At phenotypic level, average fruit weight recorded positive direct effect on fruit yield per plant (0.3579). Further, indirect positive effect was recorded through number of clusters per plant and equatorial length of fruit at phenotypic level (0.2354 and 0.1496). Polar length of fruit recorded negligible positive direct effect at phenotypic level on fruit yield per plant (0.062). Further, indirect positive effect was recorded through number of cluster per plant (0.2911) and average fruit weight (0.1818). Equatorial length of fruit showed negative direct effect on fruit yield per plant at phenotypic level (-0.1271). Indirect negative effect on fruit yield per plant at phenotypic level showed by number of fruits per cluster (-0.0762) and number of locules per fruit (-0.0061).

Table 1: Phenotypic correlation coefficients for fruit yield and yield related characters in tomato genotypes

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18
X1	1.00	0.8649***	0.4752***	-0.1733*	0.2036**	0.0167	0.1848*	0.1949**	0.0577	-0.0513	-0.0576	-0.0497	0.0615	0.1132	0.2126**	-0.0304	0.3796***	-0.2247***
X2		1.00	0.4856***	-0.1671*	0.2445**	0.0180	0.2449***	0.1904*	0.0729	-0.0309	-0.0250	-0.0258	0.0975	0.0842	0.2154**	0.0271	0.3183***	-0.2460***
X3			1.00	-0.1472*	0.5263***	-0.0496	0.5015***	0.2370**	0.0919	0.0647	0.1664*	0.1731*	-0.0481	-0.0567	0.3539***	-0.1446	0.1387	0.3615***
X4				1.00	-0.3670***	0.1697*	-0.3480***	-4060***	-0.2235**	-0.1879*	-0.3257***	-0.3227***	0.1002	0.0406	-0.0523	-0.1668*	-0.2980***	-0.4307***
X5					1.00	-0.3200***	0.8733***	0.2375**	0.2938***	0.1190	0.4799***	0.4754***	-0.0679	-0.1117	0.4044***	-0.0367	0.1886*	0.5987***
X6						1.00	0.0946	-0.4658***	-0.2871***	-0.4598***	-0.4649***	-0.4654***	0.0892	0.1862*	-0.2329**	-0.1072	-0.0488	-0.5267***
X7							1.00	-0.0380	0.1182	-0.1535*	0.2909***	0.2868***	0.0023	-0.0517	0.2809***	-0.1102	0.1692*	0.2916***
X8								1.00	0.5079***	0.7142***	0.5906***	0.5870***	-0.0206	-0.1024	0.3223***	0.2721***	0.1066	0.8140***
X9									1.00	0.5679***	0.6920***	0.6885***	-0.0791	-0.3191***	0.2276**	-0.1123	0.0835	0.5776***

X10										1.00	0.6023***	0.6002***	0.0967	-0.0984	0.3093***	0.0229	0.0179	0.5921***
X11											1.00	0.9895***	0.0296	-0.3565***	0.3333***	-0.0207	0.1352	0.6749***
X12												1.00	0.0272	-0.3424***	0.3261***	-0.0450	0.1394	0.6709***
X13													1.00	0.5616***	0.1071	0.0768	0.0540	-0.0577
X14														1.00	-0.0376	0.0886	0.0785	-0.1544*
X15															1.00	-0.1359	0.0241	-0.4797***
X16																1.00	0.1807*	0.1015
X17																	1.00	0.2038**
X18																		1.00

*= significance at 5% level of significance
**= significance at 1% level of significance
X_1= Days to 50% flowering X_6= Number of fruits per cluster X_{11}= Pericarp thickness (mm) X_{16} = Lycopene content (mg/kg fresh weight)
X_2= Days to 1st harvest X_7=Number of fruits per plant X_{12}= Number of locules per fruit X_{17}= Titrable acidity (%)
X_3= Plant height (cm) X_8= Average fruit weight (g) X_{13}= Total soluble solids (TSS) (^{0} brix) X_{18}= Fruit yield per plant (Kg)
X_4= Number of Primary branches X_9= Polar length of fruit (mm) X_{14}= pH
X_5= Number of clusters per plant X_{10}= Equatorial length of fruit (mm) X_{15}= Shelf Life (days)

Table 2: Direct (diagonal) and indirect effects of fifteen characters on fruit yield per plant at phenotypic level in tomato genotypes

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	Phenotypic Correlation with yield per plant
X1	-0.1198	-0.0987	-0.0246	0.0093	0.2018	0.0028	-0.1213	-0.0698	-0.0266	0.0065	-0.0312	0.0005	-0.0011	0.0198	0.0277	-0.2247***
X2	-0.1036	0.1141	-0.0251	0.009	0.2422	0.003	-0.2648	0.0681	0.0045	0.0039	-0.1061	0.0003	-0.1048	-0.1099	0.0232	-0.2460***
X3	0.0569	0.0409	-0.0517	0.0079	0.507	-0.0082	-0.3293	0.0848	0.0058	-0.0082	0.0137	-0.0018	0.0006	0.033	0.0101	0.3615***
X4	0.0208	-0.0191	0.0076	-0.0536	-0.3637	0.0281	0.2285	-0.1453	-0.0138	0.0239	-0.0268	0.0033	-0.0004	-0.0049	-0.0217	-0.4307***
X5	-0.0244	0.0279	-0.0272	0.0197	-0.5733	-0.0531	0.9909	0.085	0.0182	-0.0151	0.0394	-0.0048	0.0011	0.0377	0.0138	0.5987***
X6	-0.002	0.0021	0.0026	-0.0091	-0.3171	0.1658	-0.0621	-0.1667	-0.0178	0.0584	-0.0382	0.0047	-0.0018	-0.0217	-0.0036	-0.5267***
X7	-0.0221	0.0279	-0.0259	0.0186	0.8654	0.0157	-0.6565	-0.0136	0.0073	0.0195	0.0239	-0.0029	0.0005	0.0262	0.0123	0.2916***
X8	-0.0233	0.0217	-0.0123	0.0218	0.2354	-0.0772	0.0249	0.3579	0.0315	-0.0908	0.0485	-0.006	0.001	0.0262	0.0078	0.8140***
X9	-0.0069	0.0083	-0.0048	0.012	0.2911	-0.0476	-0.0776	0.1818	0.062	-0.0722	0.0568	-0.007	0.0032	0.0212	0.0061	0.5776***
X10	0.0061	-0.0035	-0.0033	0.0101	0.1179	-0.0762	0.1008	0.2556	0.0352	-0.1271	0.0495	-0.0061	0.001	0.0288	0.0013	0.5921***
X11	0.0069	-0.0029	-0.0086	0.0175	0.4755	-0.0771	-0.191	0.2114	0.0429	-0.0766	0.0821	-0.0101	0.0035	0.0311	0.0099	0.6749***
X12	0.006	-0.0029	-0.009	0.0173	0.471	-0.0772	-0.1883	0.2101	0.0427	-0.0763	0.0813	-0.0102	0.0034	0.0304	0.0102	0.6709***
X13	-0.0136	0.0096	0.0029	-0.0022	0.1107	0.0309	0.0339	0.0367	-0.0198	0.0125	-0.0293	0.0035	-0.0099	-0.0035	0.0084	0.1544*
X14	-0.0255	0.0246	-0.0183	0.0028	0.4007	-0.0386	-0.1844	-0.1154	0.0141	0.0393	0.0274	-0.0093	0.0004	0.0933	0.0018	0.4797***
X15	-0.0455	0.0363	-0.0072	0.016	0.1868	-0.0081	-0.1111	0.0381	0.0052	-0.0023	0.0111	-0.0014	0.0008	0.0023	0.0729	0.2038**

Residual Effect = 0.32
X_1= Days to 50% flowering X_6= Number of fruits per cluster X_{11}= Pericarp thickness (mm)
X_2= Days to 1st harvest X_7= Number of fruits per plant X_{12}= Total soluble solids (TSS) (^{0} brix)
X_3= Plant height (cm) X_8= Average fruit weight (g) X_{13}= pH
X_4= Number of Primary branches X_9= Polar length of fruit (mm) X_{14}= Shelf Life (days)
X_5= Number of clusters per plant X_{10}= Equatorial length of fruit (mm) X_{15}= Titrable acidity (%)

Pericarp thickness recorded negligible positive direct effect on fruit yield per plant at phenotypic level (0.0821). Further, positive indirect effect was showed by the character number of clusters per plant (0.4755) and average fruit weight (0.2114) respectively. Number of locules per fruit (-0.0102) exhibited negligible negative direct effect on fruit yield per plant at phenotypic level, Further, negative indirect effect was showed by number of fruits per plant (-0.1883) followed by equatorial length of fruit (-0.0763) at phenotypic level pH of fruit juice (-0.0099) showed negligible negative direct effect on fruit yield per plant at phenotypic level. Further, negligible negative indirect effect was showed by pericarp thickness (-0.0293) and polar length of fruit (-0.0198) respectively. Shelf life of fruit (0.0933) recorded negligible positive direct effect of fruit yield per plant at phenotypic level. Positive high indirect effect on fruit yield per plant was noticed through number of clusters per plant (0.4007) followed by equatorial length of fruit (0.1727) at phenotypic level. At phenotypic level titrable acidity (0.0729) recorded negligible positive direct effect on fruit yield per plant. Further, negligible positive indirect effect was noticed on number of cluster per plant (0.1868) followed by average fruit weight (0.0381) at phenotypic level. The unexpected variation in phenotypic path was 0.32 which predicted the 68 percent variation in fruit yield had been determined. It further imparted the occurrence of some more factors not considered here, contributed to yield of tomato.

Based on the present result findings on path coefficient analysis, direct selection of the character's like number of fruits per cluster, average fruit weight and polar length of fruit can be used as the basis of selection for improvement in tomato with respect to yield. Similarly, to this result, Golani *et al.* (2007) [5], Rawat *et al.* (2017) [9] and Singh *et al.* (2018) [12] reported that yield can be improved directly by improving these traits. This suggested that direct selection based on these traits will be worthwhile for crop yield improvement. In this study, yield per plant of tomato can also been increased indirectly through number clusters per plant and number of fruits per plant.

Conclusion
The results obtained in this investigation revealed the occurrence of considerable positive as well as negative direct and indirect effects by various characters on the fruit yield of tomato through one or other characters. Thus, it can be concluded that the characters mentioned above should be duly considered at the time of formulation of selection strategy to develop high yielding varieties in tomato.

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