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Original Research Paper

Assessment of growth and yield parameters in recombinant inbred line populations of tomato (*Solanum lycopersicum* L.) through correlation and path analysis

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ABSTRACT

Tomato (*Solanum lycopersicum* L.) is high value crop, also called as protective food due to its high nutritional and biochemical compounds. Correlation and path analysis was carried out for 147 tomato recombinant inbred line population. Correlation studies suggested that the association of fruit yield per plant was positive and significant with plant height (0.595), branches per plant (0.657), fruits per cluster (0.500), clusters per plant (0.717), average fruit weight (0.244) and fruits per plant (0.891). Path analysis revealed that among eleven characters studied only two characters *viz.*, average fruit weight (0.415) and fruits per plant (0.817) showed very high positive and direct effect on yield per plant. This study helps to understand the mutual relationship among various traits thereby assist in selecting the character contributing to the yield.

Keywords: Correlation, path analysis, tomato, yield

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the most important vegetable grown all over the world due to its economic significance and prospective health benefits as a good source of antioxidants, vitamins and mineral. It belongs to the family Solanaceae with the diploid chromosome number 2n=24 (Jenkins, 1948). All the species of tomato are native to Western South America (Rick, 1976), except the cultivated species *Solanum lycopersicum* (L.), which is native to the Peru-Ecuador region (Rick, 1969). It is grown as an annual or short-lived perennial herbaceous plant with a taproot system and determinate, semi-determinate and indeterminate growth habits.

Tomato cultivation is spread on a global surface of 5.05 million hectares with a production of 186.82 million tons and productivity of 37.10 metric tons. Globally, the main producers included China, which alone produces about 63 million tons, ≈ 33 %, of the total production, followed by India (19.00 million tons), Turkey (12.80 million tons), the USA (10.90 million tons) and Egypt (6.90 million tons) (Anon., 2020). In India, tomato occupies an area of 0.84 million hectares with a production of 20.33 million tons and productivity of 24.18 metric tons per hectare. Karnataka, occupies second place in the country with an area of 64.25 thousand hectares and production of 2081 thousand tons and productivity 32.40 metric tons per hectare (Anon., 2022).

The natural genetic variation for most of the yield contributing characters is considerable in this crop in the region and there is a need for the breeders to restructure the materials for increasing the production and productivity. Correlation study in yield and yield attributing characters will be of value in selection of traits during improvement. Path analysis provides an effective means of finding out direct and indirect causes of association and permits a critical examination of given correlation and measures the relative importance of each factor. It gives more accurate pattern of trait association through direct and indirect effects.

MATERIALS AND METHOD

The experiment was conducted at Kittur Rani Chennamma College of Horticulture, Arabhavi, University of Horticultural Sciences, Bagalkote, Karnataka, from November 2019 to December 2021. Two genetically diverse parents were used *viz.*, 'Anagha' (resistant to bacterial wilt disease and

average fruit weight 50-55 g) and 'FBT-41' (semi-determinate, small red, flat-surfaced fruits, carries the *Ty-1* and *Ty-3* genes) providing resistance to ToLCV disease. The parent 'FBT-41' was procured from the Center for Biotechnological Research, College of Horticulture, Bengaluru. These parents were employed to develop a total of 147 recombinant inbred lines through crossing and the development of F_1 hybrids, followed by selfing up to the F_6 generation using the single-seed descent method of generation advancement.

In each line, 20 plants were planted, and the recommended agronomic practices were followed throughout the growing season. Five plants were randomly tagged and selected for observations. All the lines were field evaluated using an augmented randomized block design. 'Sankranti' and 'PKM-1' varieties of tomato were used as checks.

Growth parameters, such as plant height (cm) and the branches per plant were recorded 90 days after transplanting. Flowering parameters, including days to first and 50% flowering and clusters per plant, were recorded as soon as the first flower appeared. Remaining yield and quality parameters, such as fruits per cluster, average fruit weight (g), locules per fruit, fruit length (cm), fruit diameter (cm), fruits per plant, total yield per plant (kg), total soluble solids (°Brix), and pH, were recorded at the final harvest for all 147 lines, including parents and checks. The recorded data were subjected to Fischer's method of analysis of variance, as described by Federer & Raghavrao (1975). Mean data were used for correlation and path coefficient analysis, as suggested by Miller et al. (1958) and Dewey & Lu (1959), respectively.

RESULT AND DISCUSSION

The analysis of variance indicated significant differences among the recombinant inbred lines for all the characters studied (Table 1). The extent of variability present in the germplasm offers opportunities for crop improvement programmes and is also dependent on the level of heritability for each trait.

The correlation analysis helps in examining the possibility of improving yield and its attributing traits through an indirect selection of their highly correlated component traits. In this investigation, correlation coefficients were worked out on 147 developed recombinant inbred lines of tomato (Table 2). The study of the association of component characters with a complex traits like yield is very helpful for ease of gainful selection in any breeding programme. It has been established that the structure of yield must be probed through its components rather than yield.

The association of fruit yield per plant was positive and significant with plant height (0.595), branches per plant (0.657), fruits per cluster (0.500), cluster per plant (0.717), average fruit weight (0.244), fruits per plant (0.891). Since these associated characters were in the desirable direction, it indicated that simultaneous selection for these characters would be rewarding in improving the fruit yield. The characters such as days to first flowering (-0.679) and 50% flowering (-0.246) showed negative significant correlation, indicating that these attributes are highly influence fruit yield in tomato and therefore, important for bringing improvement in fruit yield. The relationship between fruit yield and fruits per plant and average fruit weight was also reported (Yadav et al., 2020; Sharma et al., 2021). The remaining characters are positive but non-significant *viz.*, number of locules per fruit, fruit length, and fruit diameter doesn't have effect on fruit yield.

The coefficient of correlation does not give the true picture under complex situations. Under such situations, path coefficient analysis provides a mean to determine the direct influence of one variable (cause) upon another variable (effect). For the establishment of cause-and-effect relationship, path coefficient analysis offers an opportunity for partition of correlation coefficient into component of direct and indirect effects (Wright, 1921). Path coefficient analysis is the effective measure of direct and indirect causes of association and also depicts the relative importance of each factor involved in contributing to the final product that is yield (Dewey & Lu, 1959). Path coefficient analysis was carried out by taking fruit yield per plant as dependent variable. Positive and negative, direct and indirect effect of yield components on fruit yield per plant is presented in Table 3.

Path analysis revealed that out of eleven characters studied, six characters showed positive direct effect, among them average fruit weight (0.415) and fruits per plant (0.817) showed very high direct effect on yield per plant. Therefore, these characters can be considered for direct selection criteria for the improvement of yield in tomato, which indicates that

Table 1 : Analysis of variance for yield component and quality traits in Anagha × FBT-41 cross

Source of variation	DF	Mean sum of squares													
		PHT	PB	NOFPC	NOCPP	FLO	DFF	D50F	FL	FD	AFW	NOF	YPP	TSS	PH
Block	2	1	0.3	0.11	0.08	0.17	0.11	1.33	0.0033	0.03	7.48*	0.88	0.0017	0.02**	0.00053
Entries	153	196.09**	2.49**	1.54**	22.88**	0.63**	6.32**	10.33**	0.64**	0.72**	70.14**	769.35**	1.33**	0.06**	0.05**
Checks	6	817.6**	2.01**	1.37**	19.05**	0.89**	18.55**	15.08**	0.61**	2.94**	89.11**	691.83**	2.05**	0.49**	0.06**
Lines	146	171.59**	2.47**	1.4**	22.69**	0.61**	5.84**	8.09**	0.63**	0.56**	69.76**	771.36**	1.28**	0.04**	0.05**
Checks vs. Lines	1	45.1**	7.91**	22.87**	72.95**	2.41**	2.76	304.09**	3.49**	11.51**	11.58*	940.75**	4.33**	0.69**	0.27**
Error	12	0.89	0.28	0.08	0.49	0.05	0.87	1.56	0.02	0.03	1.46	1.9	0.00082	0.002	0.0048

*=significant at 5%, **= significant at 1% probability level

PHT-plant height (cm), PB-number of branches per plant, NOFPC-number of fruits per cluster, NOCPP-number of clusters per plant, FLO-number of locules per fruit, DFF-days to first flowering, D50F-days to 50 percent flowering, FL-fruit length (cm), FD-fruit diameter (cm), AFW-average fruit weight (g), NOF-number of fruits per plant, YPP-total yield per plant (kg), TSS- total soluble solids (ºBrix) and PH-pH

Table 2 : Correlation co-efficient for yield and component traits in Anagha × FBT-41 cross

Traits	PB	NOCPP	NOFPC	FLO	DFF	D50F	FL	FD	AFW	NOF	YPP
PHT	0.923**	0.888**	-0.075	-0.051	-0.443**	-0.070	-0.091	0.015	-0.008	0.598**	0.595**
PB	1	0.936**	-0.023	-0.058	-0.474**	-0.074	-0.089	0.016	-0.035	0.671**	0.657**
NOCPP		1	-0.004	-0.065	-0.507**	-0.101	-0.086	0.029	-0.035	0.734**	0.717**
NOFPC			1	0.072	-0.303**	-0.178*	-0.231**	-0.145	-0.267**	0.644**	0.500**
FLO				1	0.173*	-0.006	-0.079	-0.127	-0.051	-0.018	-0.049
DFF					1	0.451**	-0.093	-0.047	-0.254**	-0.573**	-0.679**
D50F						1	-0.108	0.008	-0.145	-0.186*	-0.246**
FL							1	0.385**	0.534**	-0.218**	0.019
FD								1	0.298**	-0.074	0.075
AFW									1	-0.188*	0.244**
NOF										1	0.891**

Critical rp value at 5% = 0.159, * Significant at p =0.05, Critical value at 1% = 0.208, ** Significant at p=0.01

PHT-plant height (cm), PB-number of branches per plant, NOCPP-number of clusters per plant, NOFPC-number of fruits per cluster, FLO-number of locules per fruit, DFF-days to first flowering, D50F-days to 50 percent flowering, FL-fruit length (cm), FD-fruit diameter (cm), AFW-average fruit weight (g), NOF-number of fruits per plant and YPP-total yield per plant (kg)

Table 3 : Phenotypic path coefficient analysis for yield and component traits in Anagha × FBT-41 cross

Traits	PHT	PB	NOCPP	NOFPC	FLO	DFF	D50F	FL	FD	AFW	NOF	YPP (rg)
PHT	**-0.0154**	0.0337	0.0886	-0.0061	0.0003	0.0079	0.0000	0.0005	0.0003	-0.0032	0.4888	0.5954
PB	-0.0142	**0.0365**	0.0934	-0.0019	0.0004	0.0084	0.0000	0.0005	0.0004	-0.0146	0.5485	0.6573
NOCPP	-0.0137	0.0342	**0.0998**	-0.0004	0.0004	0.0090	0.0001	0.0005	0.0006	-0.0144	0.6006	0.7167
NOFPC	0.0012	-0.0009	-0.0004	**0.0822**	-0.0005	0.0054	0.0001	0.0014	-0.0031	-0.1110	0.5262	0.5005
FLO	0.0008	-0.0021	-0.0065	0.0059	**-0.0064**	-0.0031	0.0001	0.0005	-0.0027	-0.0210	-0.0146	-0.0492
DFF	0.0068	-0.0173	-0.0506	-0.0249	-0.0011	**-0.0177**	-0.0002	0.0006	-0.0010	-0.1055	-0.4681	-0.6791
D50F	0.0011	-0.0027	-0.0100	-0.0146	0.0000	-0.0080	**-0.0005**	0.0006	0.0002	-0.0603	-0.1523	-0.2465
FL	0.0014	-0.0033	-0.0086	-0.0190	0.0005	0.0017	0.0001	**-0.0059**	0.0081	0.2221	-0.1785	0.0187
FD	-0.0002	0.0006	0.0029	-0.0119	0.0008	0.0008	0.0001	-0.0023	**0.0211**	0.1239	-0.0603	0.0755
AFW	0.0001	-0.0013	-0.0035	-0.0219	0.0003	0.0045	0.0001	-0.0031	0.0063	**0.4158**	-0.1534	0.2440
NOF	-0.0092	0.0245	0.0733	0.0529	0.0001	0.0102	0.0001	0.0013	-0.0016	-0.0780	**0.8177**	0.8912

rg: correlation coefficient with total yield per plant, diagonal values indicate direct effects, residual effect=0.028

PHT-plant height (cm), PB-number of branches per plant, NOCPP-number of clusters per plant, NOFPC-number of fruits per cluster, FLO-number of locules per fruit, DFF-days to first flowering, D50F-days to 50 percent flowering, FL-fruit length (cm), FD-fruit diameter (cm), AFW-average fruit weight (g), NOF-number of fruits per plant and YPP-total yield per plant (kg)

Table 4 : Yield and yield related traits of the better performing RILs from the cross Anagha × FBT-41

Parents/Lines/checks	PHT	PB	NOCPP	NOFPC	FLO	DFF	D50F	FL	FD	AFW	NOF	YPP
Anagha	68	7	15	5	3.4	26	30	3.6	3.5	52.35	75	3.93
FBT 41	71	5.8	13.8	6.1	2.6	29	34	4.1	4.5	39.5	84.18	3.33
TRIP2-17	91	8.2	22.3	5.9	4	24	29	4.1	5.2	38.62	131.57	5.08
TRIP2-21	98	8	19.6	5.6	3	24	28	4.1	4.2	36.25	109.76	3.98
TRIP2-22	100	8.4	24.6	6.2	2	23	28	4.1	5.4	38.56	152.52	5.88
TRIP2-24	94	8.1	21.5	5.9	4	25	30	4.2	6.2	35.65	126.85	4.52
TRIP2-29	95	8.1	20.6	4.5	4	24	30	4.1	6.2	52.35	92.7	4.85
TRIP2-35	94	8.6	26.3	6.2	2	24	28	3.9	4.9	36.1	163.06	5.89
TRIP2-37	86	7.3	15.6	7.5	2	23	29	3.5	6.8	39.54	117	4.63
TRIP2-40	93	8.6	22.3	6.1	2	24	30	4.2	5.2	35.65	136.03	4.85
TRIP2-42	102	8.4	24.9	4.5	2	23	27	4.5	5.6	40.25	112.05	4.51
TRIP2-51	82	6.6	15.4	5.1	2	23	28	5.4	4.1	55.6	78.54	4.37
TRIP2-52	96.85	8.5	21.6	6.2	4	24	30	3.9	6.2	40.25	133.92	5.39
TRIP2-57	75.9	6	15.3	5.9	2	23	28	5.3	6.5	52.35	90.27	4.73
TRIP2-74	102.8	8.1	21.9	5.1	4	23	27	4.1	5.6	35.25	111.69	3.94
TRIP2-8	86	7.6	19.1	5.9	3	25	29	4.1	5.3	53.65	112.69	6.05
TRIP2-95	100	8	21.2	4.2	3	23	27	4.1	5.2	46.32	89.04	4.12
TRIP2-96	98.1	7.8	19.2	5.1	2	24	31	4.1	5.6	44.54	97.92	4.36
TRIP2-102	103	7.6	21.5	4.8	3	23	27	4.1	5.6	41.25	103.2	4.26
TRIP2-138	78	6.1	14.2	5.4	2	24	29	5.5	6.9	55.65	76.68	4.27
Sankranti (check)	101	8	12	6	2	26	31	4.2	5.5	38.65	74	2.86
PKM-1 (check)	62	7.2	16.2	5	3	23	29	4.5	6.2	45.2	81	3.66

PHT-plant height (cm), PB-number of branches per plant, NOCPP-number of clusters per plant, NOFPC-number of fruits per cluster, FLO-number of locules per fruit, DFF-days to fir st flowering, D50F-days to 50 percent flowering, FL-fruit length (cm), FD-fruit diameter (cm), AFW-average fruit weight (g), NOF-number of fruits per plant and YPP-total yield per plant (kg)

emphasis should be laid on fruits per plant while applying selection strategies in this population as the findings are supported by Behera et al. (2020), Basavaraj et al. (2021) & Kumar et al. (2021). The residual effect (0.028) obtained was less than 0.5, suggesting that some of the characters have not been included, which may be responsible to enhance the fruit yield of tomato (Table 3).

Out of 147 RILs developed and evaluated for growth and yield traits only 20 RILs were performed better than the standard checks used *i.e.* Sankranti and PKM-1 (Table 4). Therefore, these stabilized F_6 generation RILs can be used to develop F_1 hybrids or can be released as variety.

CONCLUSION

The association of fruit yield per plant was positively significant with most of the morphological characters under study. Path analysis revealed that number of fruits per plant and average fruit weight (g) showed highest positive direct effect on fruit yield per plant. Therefore, these characters may be considered in selection criteria for the improvement of yield in tomato. The lines which were showing high yield than standard checks can be used in future breeding programme.

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