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Parveen Sharma
Department of Vegetable Science and Floriculture, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Navjot Singh Dhillon
Department of Vegetable Science and Floriculture, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Vineet Kumar
Department of Vegetable Science and Floriculture, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Pardeep Kumar
Department of Vegetable Science and Floriculture, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

Correspondence
Navjot Singh Dhillon
Department of Vegetable Science and Floriculture, Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh, India

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Correlation and path analysis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.) Under the protected environment

Parveen Sharma, Navjot Singh Dhillon, Vineet Kumar and Pardeep Kumar

Abstract
Twenty seven genotypes of tomato were evaluated under modified naturally ventilated polyhouse at the Experimental Farm, Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during spring summer season, 2015-16 to study the correlation and path analysis in diverse genotypes of tomato. Genotypic correlations were comparatively higher than the respective phenotypic correlations for most of the traits. Number of marketable fruits/plant, plant height, internodal length and average fruit weight were the main traits which showed significant positive association with marketable yield/plant indicating that selection for higher yield through these traits would be effective. Path coefficient analysis indicated that number of marketable fruits/plant had the maximum direct contribution towards marketable yield/plant followed by average fruit weight and fruit shape index. These traits may be given more emphasis for direct selection of high yielding tomato genotypes in future breeding programmes.

Keywords: Correlation, path coefficient, tomato, yield

Introduction
Tomato (*Solanum lycopersicum* L.) a member of Solanaceae family, is one of the most important vegetable crops grown widely all over the world. It is the most popular cultivated and versatile garden vegetable grown in the world (Kumar *et al*., 2013) [1]. It is well adapted to wide range of soils and climates and is grown from the tropics to the temperate areas. Its fruits are used in different food preparations and also preserved in different forms. Ripe fresh tomato fruit is consumed as salad and also utilized in the preparation of processed products such as puree, paste, powder, ketchup, sauce, soup and canned whole fruits. Unripe green fruits are used for preparation of pickles and chutney. Tomatoes are important source of lycopene (an antioxidant), ascorbic acid and ß-carotene and valued for their colour and flavour. Lycopene is treasured for its anticancer attribute. It is reported to have properties as antiseptic and blood purifier.

Systematic study and evaluation of germplasm is of great importance for current and future agronomic and genetic improvement of the crop. Furthermore, if an improvement program is to be carried out, evaluation of germplasm is imperative, in order to understand the genetic background and breeding value of the available germplasm (Singh *et al.*, 2002) [2]. Yield is a complex trait that shows a chain of linear and non-linear associations among yield components with varying degree of effects. Various studies on such aspect had already been conducted using genetic pool *viz*. cultivars, elite lines, accessions and land races of tomato. Regarding the genetic parameters such as degree of association between the various characters and direct and indirect effects of characters contributory to total fruit yield are of permanent significance in formulator appropriate breeding strategy.

Improvement in self-pollinated crops like tomato is normally achieved by selecting the genotypes with desirable character combinations existing in nature or by hybridization (Salunke *et al.*, 2012) [3]. However, to improve genetic diversity of tomato genotypes, it is important to know the extent of already existing genetic variability in the available material.

Materials and Methods

The experiment was carried out at the experimental farm of Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during spring summer of 2015-16. The experimental material comprised of 27 diverse genotypes of tomato including 4 hybrids. The experiment was conducted in Randomized Block Design (RBD) replicated thrice inside the modified naturally ventilated polyhouse. Eight plants of each genotype were planted at a spacing of 70 cm × 30 cm and trained on two stems.

Table 1: List of tomato (*Solanum lycopersicum* L.) genotypes used in the study and their sources

S. No.	Genotypes	Source
1.	BWR5 (F/R)	CSKHPKV, Palampur
2.	CLN 1314G	CSKHPKV, Palampur
3.	Palam Pride	CSKHPKV, Palampur
4.	1-2	CSKHPKV, Palampur
5.	12-1	CSKHPKV, Palampur
6.	15-2(H/R)	CSKHPKV, Palampur
7.	16-B	CSKHPKV, Palampur
8.	BL333-1	CSKHPKV, Palampur
9.	Palam Pink	CSKHPKV, Palampur
10.	Hawaii 7998	AVRDC, Taiwan
11.	BBWR 11-1	CSKHPKV, Palampur
12.	BBWR 21-7-16	CSKHPKV, Palampur
13.	BT 20-3 Red Egg Shape	CSKHPKV, Palampur
14	BBWR 10-7-18	CSKHPKV, Palampur
15.	BBWR 10-6	CSKHPKV, Palampur
16.	BBWR 13-7-9	CSKHPKV, Palampur
17.	BBWR 18-7	CSKHPKV, Palampur
18.	BBWR 10-7-17	CSKHPKV, Palampur
19.	7-2	CSKHPKV, Palampur
20.	BT 20-3 Yellow Egg Shape	CSKHPKV, Palampur
21.	BT 20-3 Yellow Round	CSKHPKV, Palampur
22.	Hawaii 7996	AVRDC, Taiwan
23.	CLN 2123	CSKHPKV, Palampur
24.	PTH-1	CSKHPKV, Palampur
25.	Avtar	Nunhems Company
26.	Rakshita	Indo-American Hybrid Seeds (India) Pvt. Ltd.
27.	Naveen 2000+	Indo-American Hybrid Seeds (India) Pvt. Ltd.

Observations were recorded on five randomly selected plants on the traits *viz*., days to 50 per cent flowering, days to first harvest, marketable yield/plant, number of marketable fruits/plant, average fruit weight, pericarp thickness, number of locules/fruit, TSS content, number of nodes, internodal length, plant height, fruit shape index and plant survival. For the characters *viz*., fruit shape index, pericarp thickness and TSS content, a random sample of 10 fruits per entry per replication was drawn from fifth picking and for number of locules/fruit, samples were drawn from the sixth picking. Character association between yield and yield components were studied through correlation and path analysis given by Al-Jibouri *et al.* (1958) [4] and Dewey and Lu (1959) [5].

Result and Discussion

The estimates of genotypic correlations, in general, were comparatively higher than the respective phenotypic correlations for most of the traits, thereby establishing strong inherent relationship among the characters studied. Number of marketable fruits/plant, plant height, internodal length and average fruit weight were the main traits which showed significant positive association with marketable yield/plant indicating that selection for higher yield through these traits would be effective. These findings are in consonance with the findings of Kant and Mani (2004) [6], Golani *et al.* (2007) [7], Bilashini *et al.* (2011) [8], Sherpa *et al.* (2014) [9], Nalla *et al.* (2015) [10], Meena and Bahadur (2015) [11] and Meena *et al.* (2018) [12]. However, TSS had the significant negative association with marketable yield/plant. Hence, it would be rewarding to pay attention on these characters in selection programme for increasing the marketable yield. Henareh (2015) [13] also found significant positive relationship between fruit yield and fruit weight and significant negative correlation between fruit yield and TSS.

At phenotypic level, highest direct positive effects of various traits on marketable yield per plant could be arranged in the following descending order: number of marketable fruits/plant, average fruit weight, fruit shape index, number of locules, TSS, days to 50 per cent flowering, internodal length, days to first harvest and number of nodes. The results are in conformity to that of Bilashini (2010) [14] and Meena and Bahadur (2015) [11]. At genotypic level, the estimates of direct effects indicated that average fruit weight, number of marketable fruits/plant, days to 50 per cent flowering, number of locules, pericarp thickness, TSS, number of nodes and fruit shape index had positive direct effect on marketable yield/plant while days to first harvest, plant height and internodal length had negative direct effects on marketable yield per plant. Dar *et al.* (2012) [15] and Meena and Bahadur (2015) has also given similar results.

The path coefficient analysis (Table 3) revealed appreciable amount of direct positive effect of number of marketable fruits/plant followed by average fruit weight, fruit shape index, number of locules, days to 50 per cent flowering and days to first harvest on marketable yield/plant at phenotypic level. Significant phenotypic correlation coefficients of number of marketable fruits/plant, average fruit weight and fruit shape index strengthened the reliability in the process of selection for higher fruit yield. The direct effect of remaining component traits on marketable yield/plant was either negative or negligible. The phenotypic correlation coefficients of these traits with marketable yield/plant were also non-significant except for TSS. Therefore, these traits should be considered of little importance in improvement of tomato.

Table 2: Estimates of correlation coefficients at phenotypic (P) and genotypic (G) level among different traits of tomato

		Days to first harvest	Marketable fruits/ plant	Average fruit weight	Number of locules	Pericarp thickness	TSS	Plant height	Inter-nodal length	Number of nodes	Fruit shape index	Marketable yield/ plant
Days to 50% flowering	P	0.3796 *	-0.1037	0.1509	-0.1768	0.2915*	-0.0218	0.3392*	0.2535*	0.3320*	0.0373	0.0399
	G	0.7420*	-0.1480	0.2200*	-0.1450	0.3640*	-0.0510	0.4000*	0.3510*	0.4030*	0.1360	0.0880
Days to first harvest	P		-0.1830	0.2954*	0.0380	0.4243*	-0.3110*	0.1396	0.1410	0.0378	-0.0216	0.1133
	G		-0.3210*	0.5490*	0.1060	0.8590*	-0.7270*	0.1500	0.3960*	0.0630	-0.2450*	0.2360*
Marketable fruits/ plant	P			-0.5353*	-0.3503*	-0.2401 *	-0.1372	0.2579*	0.0354	0.2475*	0.3166*	0.4695*
	G			-0.5490*	-0.4030*	-0.2700*	-0.1010	0.2920*	0.0830	0.3520*	0.4140*	0.4500*
Average fruit weight	P				0.3065*	0.2934*	-0.2127	0.0205	0.2048	-0.1526	-0.3125*	0.4706*
	G				0.3310*	0.3060*	-0.3010*	0.0200	0.2580*	-0.2050	-0.3470*	0.4890*
Number of locules	P					-0.1805	0.0418	-0.0191	0.0239	-0.0465	-0.6172*	-0.0154
	G					-0.2180	0.1680	-0.0330	0.0220	-0.0470	-0.7720*	-0.0320
Pericarp thickness	P						-0.3728*	-0.0721	0.1489	-0.1659	0.2746*	0.0603
	G						-0.4870*	-0.0830	0.1630	-0.2060	0.3580*	0.0510
TSS	P							-0.1426	-0.2084	0.0183	-0.0348	-0.3227*
	G							-0.1720	-0.3120*	0.0050	-0.1420	-0.3680*
Plant height	P								0.3751*	0.8549*	0.1235	0.2492*
	G								0.4990*	0.9440*	0.1480	0.2690*
Internodal length	P									0.2637*	-0.0571	0.2398*
	G									0.3430*	-0.0700	0.3080*
Number of nodes	P										0.1200	0.0694
	G										0.1470	0.1050
Fruit shape index	P											0.0453
	G											0.0810

* Significant at P =0.05

Table 3: Estimates of direct and indirect effects of different traits on marketable yield/plant in tomato

		Days to 50 % flowering	Days to first harvest	Marketable fruits/ plant	Average fruit weight	Number of locules	Pericarp thickness	TSS	Plant height	Inter-nodal length	Number of nodes	Fruit shape index	Marketable yield/plant
Days to 50 % flowering	P	0.0233	0.0041	-0.1087	0.1566	-0.0182	-0.0033	-0.0008	-0.024	0.0054	0.0012	0.0043	0.0399
	G	0.0667	-0.0228	-0.1631	0.2473	-0.0208	0.0051	-0.0011	-0.0861	-0.0033	0.0491	0.0164	0.0875
Days to first harvest	P	0.0088	0.0107	-0.1917	0.3065	0.0039	-0.0048	-0.011	-0.0099	0.003	0.0001	-0.0025	0.1133
	G	0.0495	-0.0307	-0.3528	0.6168	0.0152	0.0121	-0.0164	-0.0321	-0.0037	0.0076	-0.0295	0.2361*
Marketable fruits/plant	P	-0.0024	-0.002	1.0477	-0.5553	-0.036	0.0027	-0.0048	-0.0183	0.0008	0.0009	0.0363	0.4695*
	G	-0.0099	0.0098	1.1007	-0.6158	-0.0577	-0.0038	-0.0023	-0.0627	-0.0008	0.0428	0.0497	0.4500*
Average fruit weight	P	0.0035	0.0032	-0.5608	1.0374	0.0315	-0.0033	-0.0075	-0.0014	0.0044	-0.0006	-0.0358	0.4706*
	G	0.0147	-0.0169	-0.6037	1.1228	0.0475	0.0043	-0.0068	-0.0043	-0.0024	-0.0250	-0.0417	0.4885*
Number of locules	P	-0.0041	0.0004	-0.367	0.318	0.1028	0.002	0.0015	0.0014	0.0005	-0.0002	-0.0707	-0.0154
	G	-0.0097	-0.0032	-0.4430	0.3716	0.1434	-0.0031	0.0038	0.0072	-0.0002	-0.0057	-0.0927	-0.0316
Pericarp thickness	P	0.0068	0.0045	-0.2515	0.3044	-0.0186	-0.0113	-0.0132	0.0051	0.0032	-0.0006	0.0314	0.0603
	G	0.0242	-0.0263	-0.2974	0.3439	-0.0312	0.0141	-0.0110	0.0179	-0.0015	-0.0251	0.0430	0.0506
TSS	P	-0.0005	-0.0033	-0.1437	-0.2206	0.0043	0.0042	0.0353	0.0101	-0.0045	0.0001	-0.0040	-0.3227*
	G	-0.0034	0.0223	-0.1115	-0.3383	0.0241	-0.0069	0.0225	0.0369	0.0029	0.0006	-0.0170	-0.3677*
Plant height	P	0.0079	0.0015	0.2702	0.0212	-0.002	0.0008	-0.005	-0.0708	0.0081	0.0032	0.0141	0.2492*
	G	0.0267	-0.0046	0.3214	0.0222	-0.0048	-0.0012	-0.0039	-0.2149	-0.0047	0.1150	0.0177	0.2690*
Internodal length	P	0.0059	0.0015	0.0371	0.2125	0.0025	-0.0017	-0.0074	-0.0266	0.0215	0.001	-0.0065	0.2398*
	G	0.0234	-0.0122	0.0912	0.2901	0.0032	0.0023	-0.0070	-0.1071	-0.0094	0.0417	-0.0083	0.3078*
Number of nodes	P	0.0077	0.0004	0.2593	-0.1583	-0.0048	0.0019	0.0006	-0.0605	0.0057	0.0037	0.0137	0.0694
	G	0.0269	-0.0019	0.3870	-0.2305	-0.0067	-0.0029	0.0001	-0.2030	-0.0032	0.1218	0.0176	0.1053
Fruit shape index	P	0.0009	-0.0002	0.3317	-0.3242	-0.0635	-0.0031	-0.0012	-0.0087	-0.0012	0.0004	0.1145	0.0453
	G	0.0091	0.0075	0.4552	-0.3894	-0.1106	0.0050	-0.0032	-0.0317	0.0007	0.0179	0.1201	0.0805
Residual effect at phenotypic level					(P) = 0.1960								
Residual effect at genotypic level					(G)= 0.0892								

* Significant at P =0.05, Bold values indicate Direct effects

Therefore, selection on the basis of traits *viz*., number of marketable fruits/plant, average fruit weight and fruit shape index would be effective in view of the direct and indirect contribution of component traits towards fruit yield.

Conclusion

Genotypic correlations were higher than the respective phenotypic correlations for most of the traits revealing that there was strong association between these traits. On the basis of correlation studies the selection for number of marketable fruits/plant, average fruit weight, number of nodes, plant height and internodal length content will be effective for isolating plant with higher yield in tomato. Path coefficient analysis also indicated that number of marketable fruits/plant had the maximum direct contribution towards marketable yield/plant followed by average fruit weight and fruit shape index. These traits may be given more emphasis for direct selection of high yielding tomato genotypes in future tomato breeding programmes for the protected environment.

Reference

1. Kumar M, Tanuja B, Mohar ST, Thakur KS. Genetic divergence and cluster analysis in tomato (*Solanum lycopersicum* L.). Progressive Agriculture. 2013; 13:114-117.
2. Singh B, Eitan N, Sirohi PS. Performance of indeterminate tomato varieties under climate control greenhouse conditions of northern plain. Abstract published in International Conference on Vegetables held at Bangalore (Nov. 11-14,). Abstract No. 2002; IV-87:191.
3. Salunke DS, Jadhav AS, Pawar BD, Kale AA, Chimote VP. Diversity analysis of tomato genotypes using RAPD markers and high- performance liquid chromatography in relation to β-carotene content. Vegetos. 2012; 25:95-101.
4. Al-Jibouri HA, Millar PA, Robinson HP. Genotypic and environmental variance and co-variance in an upland cotton cross of inter-specific origin. Agronomy Journal. 1958; 50:633-636.
5. Dewey DR, Lu KH. A correlation and path coefficient analysis of components of crested wheat grass seed population. Agronomy Journal. 1959; 51:515-518.
6. Kant L, Mani VP. Association and contribution of different characters towards fruit yield in tomato (*Lycopersicon esculentum* Mill.) in north western hill zone. Indian Journal of Horticulture. 2004; 61:327-330.
7. Golani IJ, Mehta DR, Purohit VL, Pandya HM, Kazariya MV. Genetic variability, correlation and path coefficient studies in tomato. Indian Journal of Agricultural Research. 2007; 41:146-149.
8. Bilashini M, Sharma P, Pathania NK, Vidyasagar. Variability studies in tomato (*Solanum lycopersicum* L.) under polyhouse conditions. Himachal Journal of Agricultural Research. 2007-2011; 37:35-38.
9. Sherpa P, Pandiarana N, Shende VD, Seth T, Mukherjee S, Chattopadhyay A. Estimation of genetic parameters and identification of selection indices in exotic tomato genotypes. Electronic Journal of Plant Breeding. 2014; 5:552-562.
10. Nalla MK, Rana MK, Pandav AK, Aslam T, Rao PG, Badiger M. Correlation and path coefficient analysis for yield and yield contributing traits in tomato (*Solanum lycopersicum* L.) genotypes. Progressive Research. 2015; 10:2854-2857.
11. Meena OP, Bahadur V. Genetic Associations analysis for fruit yield and its contributing traits of indeterminate tomato (*Solanum lycopersicum* L.) germplasm under open field condition. Journal of Agricultural Science. 2015; 7:18-27.
12. Meena RK, Kumar S, Meena ML, Kumar A. Correlation and Characters association studies in tomato (*Solanum lycopersicum* L.). International Journal of Pure & Applied Bioscience. 2018; 6(1):1291-1295.
13. Henareh M. Genetic variation in superior tomato genotypes collected from north west of Iran. International Journal of Scientific Research in Environmental Sciences. 2015; 3:219-225.
14. Bilashini M. Evaluation of bacterial wilt resistant hybrids of tomato (*Lycopersicon esculentum* Mill.) in modified naturally ventilated polyhouse. M. Sc. Thesis, Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, India, 2010, 74.
15. Dar RA, Sharma JP, Nabi A, Chopra S. Germplasm evaluation for yield and fruit quality traits in tomato (*Solanum lycopersicum* L.). African Journal of Agricultural Research. 2012; 7:6143-6149.