Research Article

Inter-relationship and Path Coefficient Analysis in Tomato (*Solanum lycopersicum* L.)

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Abstract

Fifteen bacterial wilt resistant F_3 progenies of tomato along with one bacterial wilt resistant standard check (Palam Pride) were evaluated to determine the nature and extent of association between marketable yield and its component traits, and direct and indirect contribution of each of the component traits towards marketable yield. The trial was laid out in RBD with three replications in highly bacterial wilt sick plots at Vegetable Research Farm, Department of Vegetable Science and Floriculture, CSKHPKV, Palampur during summer-rainy season of 2015. To ascertain the severity of the disease, two susceptible checks, Roma and Marglobe were planted at every alternate 11th row in the experiment. Marketable yield per plant was positively and significantly correlated with total and marketable fruits per plant, plant height and gross yield per plant at phenotypic and genotypic levels and total soluble solids and duration of fruit harvest at genotypic level only. Path coefficient analysis revealed that marketable fruits per plant had the maximum positive direct contribution towards marketable yield per plant followed by average fruit weight. Thus, it suggested that direct selection based on these traits would be helpful for developing the high yielding varieties.

Keywords: Tomato, *Solanum lycopersicum*, correlation, path coefficient.

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Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular and widely grown vegetables in the world. It is a versatile vegetable for culinary purpose. Ripe tomatoes are consumed fresh as salad and utilized in the preparation of range of processed products such as powder, puree, ketchup, sauce, soup, canned fruit, etc. Unripe green fruits are used for preparation of pickles and *chutney*. Tomatoes are important source of lycopene (antioxidant), vitamin A, vitamin C and minerals [1]. Tomato is extensively grown as off-season vegetable in mid hills of Himachal Pradesh during summer-rainy season which fetches high prices in the markets located in the plains. Bacterial wilt is one of the most important constraints in humid tropical and sub-tropical areas due to which huge losses occur. Hence, identification and development of new improved disease resistant cultivars is very important to further boost up the production and productivity of the crop in wilt prone areas of Himachal Pradesh. Correlation coefficient is a measure of the degree of association between the two traits worked at the same time [2]. The correlation coefficient provides information regarding the association of different characters among themselves, whereas better insight into the cause of the association is provided by the path coefficient analysis. It allows the partition of the correlation coefficients into direct and indirect effects of the traits contributing towards the dependent variable. The present investigation was therefore undertaken to ascertain magnitude and extent of correlation and path coefficient analysis in tomato progenies.

Experimental

The investigation was carried out with 15 bacterial wilt resistant F_3 progenies of tomato *viz*., (12-1 × BWR-5)-1, (12-1 × BWR-5)-2, (CLN 2070 B-1 × 12-1)-2, (CLN 2070 B-1 × 12-1)-3, (Hawaii 7998 × 12-1)-1, (Hawaii 7998 × 12-1)-3, (Hawaii 7998 × Palam Pride)-1, (Hawaii 7998 × Palam Pride)-2, (Hawaii 7998 × BWR-5)-1, (Hawaii 7998 × BWR-5)-3, (CLN 2123 A-1 × BWR-5)-1, (CLN 2123 A-1 × BWR-5)-3, (Palam Pride × BWR-5)-1, (Palam Pride × BWR-5)-2 and Avtaar-1 (developed at CSK HPKV, Palampur) along with one bacterial wilt resistant check (Palam Pride). Susceptible checks (Roma and Marglobe) were grown at every alternate 11th row in the experiment to observe the disease incidence. These genotypes were evaluated in randomized block design with three replications during summer-rainy season, 2015 at Vegetable Research Farm of the Department of Vegetable Science and Floriculture,

COA, CSK HPKV, Palampur. Ten competitive plants from each genotype were used to record observations on the following traits *viz*., plant survival (%), days to 50% flowering, days to first harvest, gross yield per plant (kg), total fruits per plant, marketable yield per plant (kg), marketable fruits per plant, average fruit weight (g), fruit shape index (polar-equatorial diameter ratio), pericarp thickness (mm), locules per fruit, plant height (cm), duration of fruit harvest (days) and total soluble solids (%) were recorded. The recorded data were analyzed as suggested by [3] for correlation and Dewey and Lu [4] for path coefficient analysis. The statistical analysis was carried out using OP STAT software.

Results and Discussions

The understanding of the nature and magnitude of inter-relationships among yield and its components is necessary for the simultaneous improvement of the yield and characters. The studies on correlation are quite helpful in estimating the correlated response to selection and simultaneous improvement of several traits at a time. In present investigation, genotypic correlations were observed higher than the corresponding phenotypic ones indicating predominant role of heritable factors. The estimates of correlation and path coefficient analysis were worked out for all the characters included in the present study (Table 1) except plant survival (%), since all the progenies and standard checks were resistant to bacterial wilt disease ranging from 88.33 to 98.33%. Correlation coefficients in the present article have been discussed at phenotypic level only. However, in some of the cases where correlation coefficients at phenotypic level were non-significant, in those cases correlation coefficients at genotypic level were discussed. At phenotypic level, marketable yield per plant was positively and significantly correlated with marketable fruits per plant (0.838), gross yield per plant (0.833), total fruits per plant (0.805) and plant height (0.295). Similarly, gross yield per plant was positively and significantly correlated with marketable fruits per plant (0.722) and total fruits per plant (0.705). This suggested that effective improvement in tomato yield through these characters could be achieved by simple recurrent selection.

Days to 50 per cent flowering and days to harvest are the two important parameters which determine the earliness of a particular genotype. Early maturing genotypes are of immense value in catching early markets and early produce can fetch a higher price. Therefore, negative correlation of these characters with other component traits is desirable. At phenotypic level, none of the traits could exhibit significant negative correlation with days to 50 per cent flowering. At genotypic level days to 50 per cent flowering had significant negative correlation with gross yield per plant (-0.382), total fruits per plant (-0.435) and marketable fruits per plant (-0.464). Days to harvest was negative and significant correlated with total fruits per plant (-0.395) and marketable fruits per plant (-0.366) at phenotypic level. Fruit shape index is a measure of fruit shape as consumer preference is towards spherical fruit shape. At phenotypic level, fruit shape index showed a positive significant association with total soluble solids (0.368) and average fruit weight (0.345). Negative significant associations were observed for total number of fruits/plant (-0.416) and marketable fruits per plant (-0.422). The improved shelf-life resulting from thicker pericarp helps in reducing post-harvest losses and also helps in long distance transport with minimal transportation injuries. So, positive correlation is desirable with the component traits. At phenotypic level, none of the trait could exhibit significant positive correlation with pericarp thickness; however duration of fruit harvest exhibited significant positive correlation with pericarp thickness (0.403) at genotypic level. Generally, fruits with less locules are preferred because it suggests higher fruit firmness. Locules per fruit did not exhibit negative correlation with any of the traits at phenotypic level. At genotypic level exhibited significant negative correlation with gross yield per plant (-0.429) and total fruits per plant (-0.353).

Total soluble solids directly influence flavor of tomato and is an important quality parameter in the processing industry. Total soluble solids had a phenotypically positive and significant association with duration of fruit harvest (0.404). The longest harvest duration is preferred under Indian conditions because it will not only avoid the glut in the market but off-season nature of the crop is maintained. At phenotypic level none of the traits could exhibit significant negative correlation with duration of fruit harvest; however average fruit weight (0.785), plant height (0.602) and gross yield per plant (0.532) had positive signification correlation with duration of fruit harvest at genotypic level. Indeterminate types of varieties/hybrids are preferred over semi-determinate and determinate types in high rainfall area, where huge losses occur due to fruit rot disease. Plant height exhibited positive and significant correlation with average fruit weight (0.313) at genotypic level.

The results are in consonance with the findings of earlier researchers [5-15].

The path-coefficient analysis is a powerful method in analyzing the scheme of causal relationship between yield and its component traits. Here, the correlations are partitioned into direct and indirect effects to know the precise direct and indirect cause of associations [16]. The phenotypic path-coefficient analysis for different component traits is presented in **Table 2**.

Table 1 Estimates of correlation at phenotypic (P) and genotypic (G) levels among different traits of tomato

		Days to first harvest	Fruit shape index	Pericarp thickness (mm)	Locules/ fruit	TSS	Duration of fruit harvest (days)	Plant height (cm)	Gross yield/ plant (kg)	Total fruits/ plant	Marketable fruits per plant	Average fruit weight (g)	Marketable yield/ plant (kg)
Days to 50 per cent flowering	P	0.393**	0.459**	0.067	0.332*	0.449**	0.211	0.294*	-0.134	-0.199	-0.260	0.364*	-0.060
	G	1.106**	1.077**	0.251	0.382**	0.531**	0.847**	0.642**	-0.382**	-0.435**	-0.464**	0.693**	-0.145
Days to first harvest	P		0.575**	0.334*	0.128	0.243	0.128	0.155	-0.130	-0.395**	-0.366*	0.413**	-0.149
	G		1.005**	0.316*	0.166	0.495**	0.650**	-0.013	-0.203	-0.451**	-0.430**	0.497**	-0.224
Fruit shape index	P			0.133	-0.020	0.368*	0.173	0.107	-0.237	-0.416**	-0.422**	0.345*	-0.283
	G			0.663**	0.075	0.579**	0.419**	0.192	-0.256	-0.494**	-0.512**	0.532**	-0.302*
Pericarp thickness (mm)	P				-0.216	0.024	0.175	-0.148	-0.043	-0.313*	-0.281	0.158	-0.256
	G				-0.542**	0.193	0.403**	-0.558**	-0.390**	-0.543**	-0.574**	0.208	-0.674**
Locules per fruit	P					0.090	-0.066	0.320*	-0.250	-0.237	-0.171	0.297*	-0.017
	G					-0.053	0.384**	0.476**	-0.429**	-0.353*	-0.177	0.335*	-0.035
TSS	P						0.404**	-0.023	0.118	0.117	0.032	0.106	0.155
	G						0.843**	-0.085	0.269	0.208	0.064	0.352*	0.356*
Duration of fruit harvest	P							-0.048	0.205	0.033	0.029	0.312*	0.277
	G							0.602**	0.532**	0.135	-0.006	0.785**	0.499**
Plant height (cm)	P								0.150	0.020	0.079	0.324*	0.295*
	G								0.245	0.088	0.181	0.313*	0.449**
Gross yield/ plant (kg)	P									0.705**	0.722**	-0.143	0.833**
	G									0.768**	0.777**	-0.237	0.877**
Total fruits/ plant	P										0.928**	-0.576**	0.805**
	G										0.971**	-0.700**	0.873**
Marketable fruits per plant	P											-0.649**	0.838**
	G											-0.718**	0.884**
Average fruit weight (g)	P												-0.144
	G												-0.316*

*Significant at 5% level of significance
** Significant at 1% level of significance

At phenotypic level, the direct positive effect of various traits on marketable yield per plant could be arranged in the following descending order *viz.*, marketable fruits per plant (1.259), average fruit weight (0.688), days to first harvest (0.053), total fruits per plant (0.050), TSS (0.015), duration of fruit harvest (0.014), days to 50 per cent flowering (0.010) and locules per fruit (0.002). Whereas direct negative effects were exhibited by plant height (-0.040), pericarp thickness (-0.021), gross yield per plant (-0.005) and fruit shape index (-0.005). Days to 50 per cent flowering showed negative indirect effect via marketable fruits per plant (-0.327) and positive indirect effect via average fruit weight (0.250) at phenotypic level. Days to first harvest exerted negative indirect effect via marketable fruits per plant (-0.461) and positive indirect effect via average fruit weight (0.284) at phenotypic level. Fruit shape index showed positive indirect effect via average fruit weight (0.237) and gross yield per plant (0.001) and negative indirect effect via marketable fruits per plant (-0.531) at phenotypic level. A positive indirect effect was shown by pericarp thickness on marketable yield per plant via average fruit weight (0.109) and negative indirect effect via marketable fruits per plant (-0.354) at phenotypic level. At phenotypic level, locules per fruit showed negative indirect effect via marketable fruits per plant (-0.215) and positive indirect effect via average fruit weight (0.204). Plant height imposed positive indirect effect via average fruit weight (0.220) at phenotypic. Gross yield per plant had positive indirect effect via marketable fruits per plant (0.909) at phenotypic level. The maximum direct effect of total fruits per plant was positive with marketable yield per plant (0.050) which can be attributed by the indirect effect via marketable fruits per plant (1.168) and negative indirect effect via average fruit weight (-0.400) at phenotypic level. Marketable fruits per plant exhibited negative indirect effect via average fruit weight (-0.447) at phenotypic level. Average fruit weight had negative indirect effect via marketable fruits per plant (-0.818) at phenotypic level. Similar

results were reported by earlier workers [5], [9], [10], [13], [17-19].

Table 2 Direct and indirect effects of component traits on marketable yield of tomato at phenotypic and genotypic level

Traits		Days to 50 per cent flowering	Days to first harvest	Fruit shape index	Pericarp thickness (mm)	Locules Per fruit	Total soluble solids	Duration of fruit harvest (days)	Plant height (cm)	Gross yield/ plant (kg)	Total fruits/ plant	Marketable fruits per plant	Average fruit weight (g)	Correlation with Marketable yield per plant
Days to 50 per cent flowering	P	**0.010**	0.021	-0.002	-0.001	0.001	0.007	0.003	-0.012	0.001	-0.010	-0.327	0.250	-0.060
	G	**0.003**	0.004	0.022	-0.002	-0.003	0.001	0.002	0.004	-0.013	0.001	-0.029	-0.818	-0.145
Days to first harvest	P	0.004	**0.053**	-0.003	-0.007	0.000	0.004	0.002	-0.006	0.001	-0.020	-0.461	0.284	-0.149
	G	0.043	**-0.003**	0.008	-0.030	-0.003	0.053	-0.032	-0.001	-0.012	-0.060	-0.441	0.254	-0.224
Fruit shape index	P	0.004	0.030	**-0.005**	-0.002	-0.000	0.005	0.002	-0.004	0.001	-0.020	-0.531	0.237	-0.283
	G	0.042	-0.003	**0.008**	-0.064	-0.001	0.062	-0.021	0.008	-0.015	-0.065	-0.525	0.272	-0.302*
Pericarp thickness (mm)	P	0.001	0.018	-0.001	**-0.021**	-0.000	0.000	0.002	0.006	0.000	-0.016	-0.354	0.109	-0.256
	G	0.010	-0.001	0.005	**-0.096**	0.009	0.021	-0.020	-0.025	-0.022	-0.072	-0.589	0.106	-0.674**
Locules per fruit	P	0.003	0.007	0.000	0.004	**0.002**	0.001	-0.001	-0.013	0.001	-0.012	-0.215	0.204	-0.017
	G	0.015	-0.001	0.001	0.052	**-0.017**	-0.006	-0.019	0.021	-0.024	-0.047	-0.181	0.171	-0.035
Total soluble solids	P	0.005	0.013	-0.002	-0.001	0.000	**0.015**	0.006	0.001	-0.001	0.006	0.040	0.073	0.155
	G	0.021	-0.002	0.004	-0.019	0.001	**0.106**	-0.041	-0.004	0.015	0.028	0.066	0.180	0.356*
Duration of fruit harvest (days)	P	0.002	0.007	-0.001	-0.003	-0.000	0.006	**0.014**	0.001	-0.001	0.002	0.036	0.215	0.277
	G	0.033	-0.002	0.003	-0.039	-0.007	0.090	**-0.049**	0.027	0.030	0.018	-0.006	0.401	0.499**
Plant height (cm)	P	0.003	0.008	-0.001	0.003	0.001	-0.000	-0.001	**-0.040**	-0.001	0.001	0.099	0.22	0.295*
	G	0.025	0.000	0.001	0.054	-0.008	-0.009	-0.029	**0.044**	0.014	0.012	0.186	0.160	0.449**
Gross yield/ plant (kg)	P	-0.001	-0.007	0.001	0.001	-0.000	0.002	0.003	-0.006	**-0.005**	0.036	0.909	-0.100	0.833**
	G	-0.015	0.001	-0.002	0.037	0.007	0.029	-0.026	0.012	**0.057**	0.100	0.798	-0.121	0.877**
Total fruits/ plant	P	-0.002	-0.021	0.002	0.006	-0.000	0.002	0.000	-0.001	-0.004	**0.050**	1.168	-0.40	0.805**
	G	-0.017	0.001	-0.003	0.052	0.006	0.022	-0.007	0.004	0.044	**0.132**	0.997	-0.357	0.873**
Marketable fruits per plant	P	-0.003	-0.020	0.002	0.006	-0.000	0.000	0.000	-0.003	-0.004	0.047	**1.259**	-0.447	0.838**
	G	-0.018	0.001	-0.004	0.055	0.003	0.005	0.000	0.008	0.044	0.128	**1.026**	-0.367	0.884**
Average fruit weight (g)	P	0.004	0.022	-0.002	-0.003	0.001	0.00	0.004	-0.013	0.001	-0.029	-0.818	**0.688**	-0.144
	G	0.027	-0.002	0.004	-0.020	-0.006	0.037	-0.039	0.014	-0.014	-0.092	-0.737	**0.511**	-0.316*

*Significant at 5% level of significance Residual effect (R) 0.015
**Significant at 1% level of significance Underlined values indicate direct effects

Conclusion

Since yield is a complex trait, for which inter-relationship studies among various characters are necessary, therefore the magnitude and sufficient knowledge about the direction of association of marketable yield with its attributing characters is of great value. From the above results, it appeared that there was a great role of heritable factors as indicated by higher genotypic correlations than the corresponding phenotypic ones. On the basis of correlation studies, it was concluded that selection for the traits like marketable fruits per plant, plant height and gross yield per plant shall be quite effective in improving the yield. Marketable fruits per plant had the maximum positive direct contribution towards marketable yield per plant followed by average fruit weight. Thus in selection programmes, more emphasis should be given on the above cited characters.

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