Character Association and Path Analysis Study in Determinate Tomato (*Solanum lycopersicum* L.)

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Field experiment was conducted at All India Co-ordinated Research Project on Vegetable Crops, OUAT, Bhubaneswar, Odisha, India during *rabi*, 2017-18 to study the correlation and path coefficient analysis in determinate tomato for improvement of desirable genotype (s) for fruit yield and yield attributes. Eighteen genotypes were evaluated by adopting RBD replicated thrice. At both phenotypic and genotypic level, marketable fruit yield plant^{-1} was positive and significantly correlated with plant height (0.45 and 0.31) and primary branches plant^{-1} (0.51 and 0.38). Similarly, traits like average fruit weight (0.334), number of locules (0.204), fruit length (0.143), % of fruit set (0.126), flowers cluster^{-1} (0.106), days to fruit set (0.102), fruits plant^{-1} (0.096), primary branches plant^{-1} (0.070) and plant height at final harvest (0.009) in order of merits imposed positive direct effect on marketable fruit yield plant^{-1}. Hence on selecting these characters may give varieties with high yield and better quality fruits.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crop grown throughout the world because of its wider adaptability, high yielding capacity and suitability of variety to be used in fresh as well as processing industries (He *et al.,* 2003; Nwosu *et al.,* 2014). It belongs to the family Solanaceae. Tomato is cultivated in all the three major climates of temperate, sub-tropical and tropical regions of the world, under both open and protected conditions as well. Apart from contributing nutritive elements, colour and flavour to the diet, tomatoes are also act as a valuable source of antioxidants or chemo-protective compounds and may thus be termed a "functional food" (Ranieri *et al.,* 2004). Indian yield levels (24.2 tha^{-1}) are far below the world average of 37 tha^{-1} (NHB, 2016). Low yield increases the cost and the risk of growing tomatoes. Therefore, farmer's income is decreased. Yield is a quantitative character controlled by many genes. The consideration

of yield components in selection is based on the assumption that a strong positive correlation exists between yield and yield components and that these component characters have higher heritability than yield (Lungu, 1978) and is very useful for plant breeder in developing commercial variety or hybrid. However, it does not give an exact picture of relative importance of direct and indirect effects of various yield attributes.

Under such circumstances, the technique of path coefficient analysis was developed by Wright (1921) and demonstrated by Dewey and Lu (1959) as a means of separating direct and indirect contribution of various traits. Therefore, it is necessary to study the path coefficient analysis to find out the characters which directly or indirectly contributes to yield. Thus, keeping above situations in view, the present research work was conducted to study the correlation and path coefficient analysis of eighteen genotypes of determinate tomato for fourteen characters.

Materials and Methods

The experiment was carried out at All India Co-ordinated Research Project on Vegetable Crops, OUAT, Bhubaneswar, during *rabi*, 2017-18 with 18 tomato genotypes. The experiment was laid out in Randomized Block Design (RBD) with three replications. In each replication, each entry was grown in five rows having six plants in each row spaced 60 cm between rows and 45 cm between plants. From randomly selected 5 plants per each plot observations were recorded for fourteen characters *viz*., plant height (cm), primary branches plant[-1], intermodal length (cm), days to first flowering., number of flowers cluster[-1], % of fruit set, days to fruit set, average fruit weight (g), fruit length (cm), fruit girth (cm), pericarp thickness (cm), number of locules, fruits plant[-1,] marketable fruit yield plant[-1] (kg).

Results and Discussion

In general, correlation studies are highly beneficial in selecting superior genotypes for any population improvement programme (Robinson, 1966). It is highly essential to judge the interrelationship of the quantitative characters through correlation study both at genotypic and phenotypic level for an effective selection in developing a new genotype. All the genotypic and phenotypic correlation coefficient between fruit yield and yield components is given in Table 1 and 2.

Plant height

Plant height showed positive and significant correlation with marketable fruit yield plant[-1] (0.45 and 0.31), internodal length (0.67 and 0.62), % of fruit set (0.47 and 0.29), days to fruit set (0.60 and 0.39), average fruit weight (0.53 and 0.41) and fruit girth (0.51 and 0.41) at both phenotypic and genotypic level. This indicates that marketable fruit yield plant[-1] was increased with the increase of plant height. This result is in conformation with the findings of Prashanth *et al.,* (2008), Ara *et al.,* (2009), Monamodi *et al.,* (2013) and Kumar *et al.,* (2014). On the other hand, this character had significant and negative correlation with number of flowers cluster[-1] (-0.43 and -0.35) which indicated that this trait was increased with decrease of plant height.

Primary branches plant[-1]

Primary branches plant[-1] was found to be significantly and positively associated with marketable fruit yield plant[-1] (0.51 and 0.38). This result is in agreement with the findings of Rawat *et al.,* (2017). This character also significantly and positively associated with pericarp thickness only at genotypic level (0.27). It indicated this trait was increased with the increase of pericarp thickness.

Internodal length

It was noticed that internodal length was positively and significantly correlated with days to fruit set (0.43 and 0.34), average fruit weight (0.53 and 0.48), fruit girth (0.52 and 0.48) and number of locules (0.42 and 0.41) at both phenotypic and genotypic level.

This character had significant and negative correlation with days to 1st flowering (-0.39 and -0.33) and fruits plant[-1] (-0.34 and -0.29).

Days to 1st flowering

Days to 1st flowering exhibited positive and significant correlation with days to fruit set (0.33 and 0.32) and % of fruit set (0.33) at genotypic level. This trait had significant negative association with number of flowers cluster[-1] (-0.32) and number of fruits plant[-1] (-0.30) at genotypic level.

Number of flowers cluster[-1]

It had negative and significant association with % of fruit set (-0.84 and -0.47), days to fruit set (-0.40 and -0.35), fruit length (-0.43 and -0.39), fruit girth (-0.65 and -0.57) and number of locules (-0.54 and -0.50) which indicates number of flowers cluster[-1] was decreased with the increase of these traits. Result for number of locules is in accordance with Shankar *et al.,* (2014).

% of fruit set

It was found that % of fruit set was positively and significantly correlated with days to fruit set (0.28 and 0.30).

It was also positively associated with characters like fruit length (0.28) at phenotypic level, but with fruit girth (0.43) and number of fruits plant[-1] (0.47) at genotypic level whereas, it had a negatively association

with average fruit weight (-0.36) only at genotypic level. Meena and Bahadur, 2015 had also reported similar result for the character number of fruits plant[-1].

Days to fruit set

Days to fruit set was positively and significantly correlated with average fruit weight (0.45 and 0.34) and fruit girth (0.44 and 0.28) both at genotypic and phenotypic level, but with fruit length (0.38) only at genotypic level.

Average fruit weight

It was observed that average fruit weight was positively and significantly correlated with fruit girth (0.34 and 0.30) which indicates that fruit weight was increased with increase of fruit girth. Similar result was observed by Rawat *et al.,* (2017). It had also positive association with pericarp thickness (0.29) only at genotypic level but it was negatively and significantly correlated with number of fruits plant[-1] (-0.64 and -0.60). This result was in line with findings of Kumar *et al.,* (2013).

Fruit length

Fruit length had positive and significant correlation with fruit girth (0.78 and 0.78) and number of locules (0.51 and 0.43) whereas, it had negative and significant correlation with fruits plant[-1] (-0.33 and -0.30). This negative association result is similar with the findings of Hidayatullah *et al.,* (2008).

Fruit girth

It was found from the correlation coefficient result that fruit girth was positively and significantly correlated with number of locules (0.83 and 0.73) but significantly negatively associated with fruits plant[-1] (0.39) at genotypic level.

Table.1 Genotypic correlation coefficient among 14 characters of 18 genotypes of determinate tomato

		2	3	4	5	6	7	8	9	10	11	12	13	14
1	G	0.25	0.67**	-0.06	-0.43**	0.47**	0.60**	0.53**	0.15	0.51**	-0.16	0.26	-0.03	0.45**
2	G		0.18	-0.03	0.02	-0.17	-0.24	0.08	-0.11	0.15	0.27*	0.23	0.11	0.51**
3	G			-0.39**	-0.26	-0.06	0.43**	0.53**	0.13	0.52**	0.05	0.42**	-0.34*	0.08
4	G				-0.32*	0.33*	0.33*	-0.09	0.24	0.03	0.18	-0.11	-0.30*	0.07
5	G					-0.84**	-0.40**	-0.17	-0.43**	-0.65**	0.008	-0.54**	0.21	-0.26
6	G						0.28*	-0.36**	0.50	0.43**	-0.16	0.24	0.47**	0.14
7	G							0.45**	0.38**	0.44**	0.08	0.19	-0.14	0.12
8	G								0.12	0.34*	0.29*	0.22	-0.64**	0.12
9	G									0.78**	-0.02	0.51**	-0.33*	0.11
10	G										0.07	0.83**	-0.39**	0.23
11	G											0.10	-0.30*	-0.07
12	G												-0.23	0.39**
13	G													0.20

Table.2 Phenotypic correlation coefficient among 14 characters of 18 genotypes of determinate tomato

		2	3	4	5	6	7	8	9	10	11	12	13	14
1	P	0.22	0.62**	-0.08	-0.35**	0.29*	0.39**	0.41**	0.15	0.41**	-0.09	0.24	0.01	0.31*
2	P		0.17	-0.05	-0.002	0.002	-0.11	0.08	-0.09	0.14	0.22	0.22	0.04	0.38**
3	P			-0.33*	-0.24	-0.01	0.34*	0.48**	0.13	0.48**	0.04	0.41**	-0.29*	0.05
4	P				-0.20	0.16	0.32*	-0.13	0.14	0.0007	0.10	-0.07	-0.15	-0.05
5	P					-0.47**	-0.35**	-0.14	-0.39**	-0.57**	-0.04	-0.5**	0.19	-0.20
6	P						0.30*	-0.15	0.28*	0.22	-0.14	0.12	0.16	0.17
7	P							0.34*	0.24	0.28*	0.11	0.16	-0.06	0.12
8	P								0.12	0.30**	0.16	0.18	-0.60**	0.20
9	P									0.78**	-0.04	0.43**	-0.30*	0.09
10	P										0.005	0.73**	-0.34	0.14
11	P											0.06	-0.19	-0.03
12	P												-0.18	0.25
13	P													0.17

1-Plant height (cm), 2-Primary branches plant[-1], 3- Internodal length (cm), 4-Days to first flowering, 5-Number of flowers cluster[-1], 6- % of fruit set, 7-Days to fruit set, 8- Average fruit weight (g), 9- Fruit length (cm), 10-Fruit girth (cm), 11-Pericarp thickness (cm), 12-Number of locules, 13-Number of fruits plant[-1,] 14-Marketable fruit yield plant[-1] (kg), G:Genotypic level; P: Phenotypic level

Table.3 Direct and indirect effects of component traits on yield on 18 genotypes of determinate tomato at Phenotypic level for 13 characters

Character	1	2	3	4	5	6	7	8	9	10	11	12	13
1	**0.009**	0.002	0.006	-0.001	-0.003	0.003	0.004	0.004	0.001	0.004	-0.001	0.002	0.0001
2	0.016	**0.070**	0.012	-0.003	-0.0001	0.0001	-0.008	0.006	-0.006	0.010	0.015	0.015	0.003
3	-0.044	-0.012	**-0.070**	0.023	0.017	0.001	-0.024	-0.034	-0.009	-0.034	-0.003	-0.029	0.020
4	0.007	0.004	0.028	**-0.085**	0.017	-0.013	-0.028	0.011	-0.012	0.0001	-0.009	0.006	0.013
5	-0.037	-0.0002	-0.025	-0.022	**0.106**	-0.050	-0.037	-0.015	-0.041	-0.061	-0.004	-0.053	0.021
6	0.037	0.0002	-0.001	0.020	-0.059	**0.126**	0.038	-0.019	0.036	0.028	-0.018	0.015	0.020
7	0.040	-0.011	0.035	0.033	-0.035	0.031	**0.102**	0.035	0.024	0.029	0.011	0.016	-0.006
8	0.137	0.027	0.161	-0.042	-0.048	-0.051	0.114	**0.334**	0.040	0.099	0.053	0.060	-0.199
9	0.021	-0.013	0.019	0.020	-0.055	0.041	0.034	0.017	**0.143**	0.111	-0.006	0.062	-0.043
10	-0.041	-0.014	-0.047	0.0001	0.057	-0.022	-0.028	-0.030	-0.077	**-0.099**	-0.0005	-0.072	0.034
11	0.007	-0.018	-0.004	-0.009	0.003	0.012	-0.009	-0.013	0.004	-0.0004	**-0.084**	-0.005	0.016
12	0.049	0.044	0.083	-0.015	-0.102	0.024	0.032	0.037	0.088	0.149	0.012	**0.204**	-0.038
13	0.001	0.004	-0.028	-0.014	0.019	0.015	-0.006	-0.057	-0.029	-0.033	-0.018	-0.018	**0.096**
14	0.3060	0.3800	0.052	-0.051	-0.199	0.172	0.117	0.198	0.092	0.142	-0.034	0.252	0.172
Partial R²	0.003	0.027	-0.004	0.004	-0.021	0.022	0.012	0.066	0.013	-0.014	0.003	0.051	0.016

Residual effect: 0.448

1-Plant height (cm), 2-Primary branches plant[-1], 3- Intermodal length (cm), 4-Days to first flowering., 5-Number of flowers cluster[-1], 6- % of fruit set, 7-Days to fruit set, 8- Average fruit weight (g), 9- Fruit length (cm),10-Fruit girth (cm), 11-Pericarp thickness (cm), 12-Number of locules 13- Fruits plant[-1,] 14-Marketable fruit yield plant[-1] (kg).

Pericarp thickness

Pericarp thickness had significant and negative correlation with fruits plant[-1] (-0.30) at genotypic level. Similar result was reported by Hidayatullah *et al.,* (2008).

Number of locules

It was observed that number of locules was significantly and positively correlated with marketable fruit yield plant[-1] (0.39) at genotypic level which indicated that marketable fruit yield plant[-1] was increased with the increase of number of locules. Similar results have also been reported by Agong *et al.,* (2008), Haydar *et al.,* (2007), Mohanty (2003), Harer *et al.,* (2003), Mohanty (2002a), Mohanty (2002b) in tomato.

Number of fruits plant[-1]

Correlation coefficient revealed that number of fruits plant[-1] was significantly and negatively correlated with internodal length (-0.34 and -0.29), average fruit weight (-0.64 and -0.60) and fruit length (-0.33 and -0.30) both at genotypic and phenotypic level. Whereas, this character is significantly and negatively correlated with days to 1st flowering (-0.30), fruit girth (-0.39) and pericarp thickness (-0.30) only at genotypic level. This indicates those characters were decreased with the increase of number of fruits plant[-1]. Similar negative correlation of number of fruits plant[-1] with average fruit weight was found by Rawat *et al.,* (2017). But at this level this character had shown positive and significant association with % fruit set (0.47).

From the result of correlation coefficient analysis it was concluded that characters like plant height, primary branches plant[-1] and number of locules were important correlated characters contributing towards yield in determinate tomato. Therefore, simultaneous improvement in these characters will be highly beneficial for development of desirable genotypes in tomato.

In order to obtain a desirable genotype with higher yield potential in determinate tomato, it is highly essential to study direct and indirect effects. In general, studies on path analysis of characters showed direct and indirect effects contributing towards yield of the crop. The results presented in Table 3.

The path coefficient result showed both direct and indirect effects of component traits on marketable fruit yield plant[-1] through average fruit weight (0.334) closely followed by number of locules (0.204), fruit length (0.143), % of fruit set (0.126), flowers cluster[-1] (0.106), days to fruit set (0.102), fruits plant[-1] (0.096), primary branches plant[-1] (0.070) and plant height at final harvest (0.009). However, the study also showed negative direct path for marketable fruit yield plant[-1] with fruit girth (-0.099), days to 1st flowering (-0.085), pericarp thickness (-0.084) and internodal length (-0.070).Similar results of positive association have been reported by Kumar *et al.,* (2016) for average fruit weight, number of locules and plant height at final harvest by Reddy *et al.,* (2013) also reported similar observations for other traits like plant height, fruits plant[-1], fruit length, and fruit width. The findings confirmed the findings of Ara *et al.,* (2009) and Monamodi *et al.,* (2013) with respect to the direct and highest direct effect of average fruit weight on fruit yield.

The residual effect (0.448) was very low indicated that most of the important characters contributing towards yield through both direct and indirect path had been included. Similar reports of lower residual effect in determinate tomato have been

reported by Kumar *et al.,* (2016). They reported a residual effect of 0.6239 which showed that the characters under study contributed 99.5% variation to fruit yield. Ara *et al.,* (2009) too reported a residual value of 0.2268 in tomato.

The characters like number of flowers cluster[-1], % of fruit set, days to fruit set, average fruit weight, fruit length, number of locules can be put to direct selection pressure in order to increase the yield potential because these characters have direct effect on yield of determinate tomato.

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