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Selection strategies for fruit yield in tomato (*Solanum lycopersicum* L.)

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Abstract: The study was initiated to generate genetic information on characters associations for tomato genotypes maintained under Chhattisgarh conditions. Nineteen tomato (*Solanum lycopersicum* Mill.) genotypes were evaluated to estimate the nature and magnitude of associations of different characters with fruit yield and among themselves at College of Agricultural Raipur (C.G.) during *Rabi* Oct 2008 to Feb 2009. The genetic parameters, character association path coefficient analysis between yield and yield contributing characters of different tomato genotypes were studied. The genotypes exhibited a wide range of variability for all the traits studied. The traits were also found to be highly heritable. From the parent study it could be concluded that improvement in fruit yield of tomato could be brought by indirect selection for the days to first flowering.

Keywords: Tomato, *Solanum lycopersicum*, Divergence, Path analysis, Multiple Regression analysis, Fruit yield.

Introduction

Tomato is one of the most important solanaceous vegetable crop grown worldwide due to its acclimatization to a wide variety of environments, as well as its high nutritive value. The systematic approach for developing F_1 hybrids in any crop depends mainly on selecting desirable parents. The scope of improvement in tomato is mainly based on the extent of genotypic and phenotypic variability present in the material more is the genetic potential and there will be greater chances of producing a desired type. Knowledge in respect of the nature and magnitude of associations of yield with various component characters is a pre-requisite to bring improvement in the desired direction. A crop breeding programme, aimed at increasing the plant productivity requires consideration not only of yield but also of its components that have a direct or indirect bearing on yield.

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Material and Method

The present investigation were conducted at Department of Plant Breeding and Genetics, Horticulture farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during Rabi 2008-09. The experimental material comprised of nineteen genotypes (ATL-01-19,HADT-294,VR-35,PAU-2371,VTG-89,VTG-90,DVRT-2,CO-3,VTG-85,VTG-86,VR-415,Pant-T-10,Pant-T-11,VTG-93,VTG-106,PAU-2374,NDT-9,Arka Vikas,H-24) along with two checks (DVRT-2,CO-3) of tomato and the experiment was laid out in Randomized block design with three replication were sown in last week of September 2008 in the nursery beds. The seedlings were transplanted in a randomized block design with three replications at the spacing of 60 cm. between rows and 40 cm between plant to plant. A plot size of 3.6m x 3m. was kept for each genotypes. All the recommended cultural practices and plant protection measures were followed. Data were recorded for eleven characters viz plant height (cm), number of primary branches per plant, Days to first flowering, Days to 50% flowering, Days from transplanting to fruit setting, Days from fruit setting to green mature stage, Days from fruit setting to red ripe stage, fruit weight (g), fruit weight (cm), number of locules per fruit, number of calyx per fruit, fruit yield per plant.

Result and Discussion

The information on the nature of extent of genetic variability present in the population for desirable characters in selection for improvement of a crop. The knowledge of genotypic and phenotypic coefficient of variation is being useful in designing selection criteria from variable population. In general, it was noted that the value of phenotypic coefficient of variation is higher than the genotypic coefficient of variation. The highest

value of phenotypic coefficient of variation was recorded by fruit weight (29.86), which was followed by number of fruit width (22.79), number of branches per plant (20.76), number of locules (17.84), days from fruit set to green mature stage (16.03), whereas, lowest phenotypic coefficient of variation was recorded for fruit yield quintal per ha. (5.30). In case of genotypic coefficient of variation highest value was recorded by fruit weight (28.29), which was followed by number of fruit width (18.45), days from fruit set to green mature stage (15.00) number of branches per plant (14.96), whereas, lowest phenotypic coefficient of variation was recorded for fruit yield quintal per ha. (3.97).

High estimates for heritability was exhibited by fruit weight(89.80) followed by days from fruit setting to green mature stage (87.60) days of 50% flowering (80.6), days from fruit setting to red ripe stage (79.50). These characters demonstrated that they were least influenced by environmental changes and selection based on phenotypic performance would be reliable.

The genotypic and phenotypic correlation for fruit yield and its component in tomato are presented in Table 1. Fruit width had positive and significant correlation with number of calyx per fruit at phenotypic and genotypic levels also positively correlated with days from fruit set to green mature stage at genotypic level. Number of calyx per fruit exhibited significant positive correlation with days to first flowering, fruit weight, days from fruit set to green mature stage at genotypic levels and positively correlated with fruit weight at phenotypic level. Days to first flowering showed positive and significant correlation with days from transplanting to fruit set, fruit yield genotypic level also positive and significant correlation with days from fruit set to green mature stage at both genotypic and phenotypic level. Fruit weight shows positive and significant correlation with days from fruit set to green mature stage at genotypic and phenotypic levels. The findings clearly indicated that genotypic correlations were of higher magnitude to the corresponding phenotypic ones, thereby establishing strong inherent relationship among the characters studied. The low phenotypic value might be due to appreciable interaction of the genotypes with the environments.

Similar association were also confirmed by Padma *et al*. (2002) who studied positive and highly significant correlation between fruit yield per plant and fruit weight; plant height and number of primary branches per plant; fruit length and fruit width; fruit weight and fruit width.

Table 1: Genotypic and phenotypic correlation coefficient between fruit yield and its components in tomato

Character		Plant height (cm)	Fruit width (cm)	No. of calyx/ fruit	No of primary branches per plant	Days to first flowering	Days to 50% flowering	Fruit weight (g)	Days from flowering to fruit set	Days from fruit setting to mature green stage	Days from fruit setting to red ripe stage	Fruit yield q./ha.
1	G	0.208	0.389	0.341	-0.214	0.294	-0.181	-0.067	0.096	-0.094	-0.251	0.202
	P	0.087	0.322	0.226	-0.222	-0.041	-0.139	0.019	0.043	-0.057	-0.103	0.203
2	G		-0.001	0.040	0.304	-0.326	0.091	0.206	-0.192	-0.236	-0.184	-0.255
	P		0.020	-0.017	0.168	-0.098	0.061	0.122	-0.130	-0.200	-0.163	-0.192
3	G			0.759**	0.036	0.446	0.313	0.287	0.367	0.515*	-0.238	0.119
	P			0.512*	-0.075	0.234	0.244	0.260	0.300	0.411	-0.198	0.097
4	G				-0.292	0.487*	0.333	0.754**	0.372	0.572*	0.075	0.399
	P				-0.122	0.262	0.238	0.496*	0.312	0.426	0.035	0.301
5	G					0.080	0.064	-0.038	0.124	-0.010	0.030	-0.335
	P					0.109	0.072	-0.071	0.136	0.011	-0.020	-0.211
6	G						0.294	0.176	1.198**	1.021**	0.150	0.457*
	P						0.242	0.071	0.730**	0.661**	0.047	0.274
7	G							0.046	0.377	0.232	0.449	0.360
	P							0.064	0.279	0.193	0.361	0.328
8	G								0.138	0.246	-0.166	0.266
	P								0.126	0.223	-0.113	0.171
9	G									0.931**	0.149	0.381
	P									0.744**	0.133	0.280
10	G										0.130	0.065
	P										0.077	0.061
11	G											0.094
	P											0.108

* 5% level and ** 1% levels of significance.

Whereas, negative correlation was observed between plant height and fruit weight.

Path coefficient analysis is an important tool for partitioning the correlation coefficients into the direct and indirect effects of independent variables on a dependent variable. With the inclusion of more variables in correlation study, their indirect association becomes more complex. Two characters may show correlation, just because they are correlated with a common third one. In such circumstances, path coefficient analysis provides an effective means of a critical examination of specific forces action to produce a given correlation and measure the relative importance of each factor. In this analysis, fruit yield was taken as dependent variable and the rest of the characters were considered as independable variables.

The path coefficient analysis which splits total correlation coefficient of different characters into direct and indirect effects on fruit yield per plant in such a manner that the sum of direct and indirect effects is equal to total genotypic correlation as presented in Table 2. The data revealed that days to 50% flowering showed the highest positive direct effect (1.016) on fruit yield followed by number of locules per fruit (0.846), fruit weight (0.546), days from fruit setting to green mature stage (0.264). Plant height (-0.874), fruit width (-0.706), days from fruit setting to red ripe stage (-0.407) and days from transplanting to fruit set (-0.290) showed negative direct effects on fruit yield quintal per ha. Whereas, the sum of direct and indirect effects of days to 50% flowering (3.066) showed positive effect on fruit yield quintal per ha. Number of locules per plant showed positive indirect effect on fruit yield through number of branch per plant (0.027), number of calyx per plant (0.008). Plant height exhibited positive indirect effect on fruit yield *via*., number of locules (0.176), fruit weight (0.112), days of transplanting to fruit set (0.056), days to 50% flowering (0.093), and number of branches per plant (0.030). Fruit width exhibited positive indirect effect on fruit yield through number of locules per fruit (0.329), days to 50% flowering (0.318), and days from fruit setting to red ripe stage (0.136). Number of calyx per plant had positive indirect effect on fruit yield through fruit weight (0.412) and days to 50% flowering (0.338). Number of branches per plant showed positive indirect effect on fruit yield *via*, days to 50% flowering (0.065). Days to first flowering showed positive indirect effect on fruit yield *via*, day to 50% flowering (0.299), number of locules per fruit (0.248) and plant height (0.141). Days to 50% flowering showed positive indirect effect on fruit yield through days of first flowering (0.027) and fruit weight (0.025). Fruit weight showed positive indirect effect on fruit yield through days from fruit setting to green mature stage (0.070) and fruit setting to red ripe stage (0.0.068). Days from transplanting to fruit setting showed positive indirect effect on fruit yield *via*, day to 50% flowering (0.383) and plant height (0.135). Days from fruit setting to green mature stage showed positive indirect effect on fruit yield through days of 50% flowering (0.236) and fruit weight (0.144). Whereas, Days from fruit setting to red ripe stage showed positive indirect effect on fruit yield through days of 50% flowering (0.456) fruit width (0.208) and plant height (0.130). The effect of residual factor (0.3544) on fruit yield per ha. was negligible, thereby, suggested that no other major yield component is left over. Fruit weight showed high positive and direct effect had significant positive correlation with fruit yield per plant. Therefore, the fruits with higher weight should be considered in selection criteria for increasing fruit yield per plant.

Table 2: Direct and indirect effect of component character on fruit yield in tomato

Character	1	2	3	4	5	6	7	8	9	10	11
1	0.846	-0.147	-0.340	0.008	-0.021	0.027	-0.184	-0.036	-0.028	-0.025	0.102
2	0.176	-0.706	0.001	0.001	0.030	-0.030	0.093	0.112	0.056	-0.062	0.075
3	0.329	0.001	-0.874	0.017	0.003	0.041	0.318	0.157	-0.106	0.136	0.097
4	0.288	-0.028	-0.663	0.022	-0.028	0.045	0.338	0.412	-0.108	0.151	-0.031
5	-0.0181	-0.214	-0.031	-0.007	0.097	0.007	.0065	-0.021	-0.036	-0.003	-0.012
6	0.248	0.230	-0.389	0.011	0.008	0.092	0.299	0.096	-0.347	0.270	-0.061
7	-0.153	-0.064	-0.273	0.007	0.006	0.027	1.016	0.025	-0.109	0.061	-0.183
8	-0.056	-0.145	-0.251	0.017	-0.004	0.016	0.046	0.546	-0.040	0.070	0.068
9	0.081	0.135	-0.320	0.008	0.012	0.111	0.383	0.075	-0.290	0.246	-0.061
10	-0.080	0.167	-0.450	0.013	-0.001	0.094	0.236	0.144	-0.270	0.264	-0.053
11	-0.213	0.130	0.208	0.002	0.003	0.014	0.456	-0.091	-0.043	0.034	-0.407

1. Number of locules/fruit 2. Plant height (cm) 3. Fruit width (cm) 4. Number of calyx /fruit 5. Number of primary branches per plant 6. Days to first flowering 7. Days to 50% flowering 8. Fruit weight (g) 9. Days from transplanting to fruit set 10. Days from fruit setting to mature green stage 11. Days from fruit setting to red ripe stage

Table 3: Mean performance of different clusters for fruit yield and its component traits

Clus-ters	No. of locules/ Fruit	Plant height (cm)	Fruit width (cm)	No. of calyx/ fruit	No of primary branches per plant	Days to first flower-ing	Days to 50% flower-ing	Fruit weight (g)	Days from to fruit set	Days from fruit setting to mature green stage	Days from fruit setting to red ripe stage	Fruit yield q. /ha.
I	5.13	69.40	5.19	5.27	4.93	49.00	51.67	55.47	54.00	17.00	30.00	360.00
II	4.70	75.31	4.12	5.35	5.36	54.35	57.13	52.93	59.96	21.47	34.58	351.74
III	3.97	71.02	4.01	5.01	4.79	49.93	56.87	43.88	55.27	19.33	34.55	333.10
IV	4.00	61.36	4.38	5.86	5.20	53.67	58.22	65.07	59.02	22.13	36.49	360.30
V	3.35	79.67	3.63	5.00	7.15	47.33	49.67	63.75	52.33	17.31	28.00	318.98
VI	4.80	74.87	7.30	6.33	5.80	56.67	62.00	69.27	61.67	26.67	29.33	340.00
VII	3.83	65.57	3.30	4.34	7.57	52.33	57.33	28.33	57.33	18.00	32.33	338.98
VIII	3.49	70.45	4.49	5.17	6.57	57.00	59.67	52.15	63.50	25.80	37.45	337.49

Mohanty (2002) also observed that fruit weight exerted high positive and direct effect on fruit yield per plant. Similar results were obtained by Padma *et al*. (2002).

On the basis of D^2 analysis, 19 genotypes were grouped into eight clusters (Table 4). Maximum number of genotypes were grouped into cluster II (*viz*., NDT-9, VTG-94, H-24, ATL-01-19 & VTG-86) and cluster III (CO-3, VTG-90, VTG-85, VR-415, PANT T-11), whereas, cluster IV (ARKA VIKASH, HADT-294, PANT T-10), and cluster VIII (PAU2371, PAU2374) included 4 & 2 genotypes, respectively which is followed by cluster whereas only one genotypes in cluster I (DVRT-2), cluster V (VTG-89),cluster VI (VR-35), cluster VII (VTG-106) where only one genotype is there Table 5.

It is vivid from the Table 5. that maximum inter cluster distance was observed between cluster VI and V (8.183) followed by cluster VII and VI (8.091), cluster VI and III (6.677), cluster VIII and V (6.613), cluster VIII and I (6.500), cluster V and IV (6.452), cluster VI and I (6.362), cluster V and II (5.599), cluster VIII and VII (5.458), cluster VII and IV (5.412).

Table 4: Composition of clusters

Cluster Number	Number of genotypes included	Name of genotypes
I	1	DVRT-2
II	5	NDT-9, VTG-93, ATL-01-19, H-24, VIG-86
III	5	CO-3, VTG-90, VTG-85, VR-415, PANT-111
IV	3	ARKA VIKASH, HADT-294, PANT-T-10
V	1	VTG-89
VI	1	VR-35
VII	1	VTG-106
VIII	2	PAU2374, PAU2371

Table 5: Intra (bold) and Inter cluster distance values in tomato

Cluster Number	I	II	III	IV	V	VI	VII	VIII
I	0.000							
II	3.706	2.157						
III	3.622	2.885	2.290					
IV	4.396	2.639	3.661	2.161				
V	4.986	5.599	4.397	6.452	0.000			
VI	6.326	5.192	6.677	5.269	8.183	0.000		
VII	5.384	4.452	3.766	5.412	4.697	8.091	0.000	
VIII	6.500	3.397	4.456	3.594	6.613	5.458	4.676	1.506

The mean performance for different clusters of genotypes for fruit yield and its components are presented in Table 3. The data of cluster means for all the characters showed appreciable differences. Days to first flowering showed the highest mean performance for cluster VIII (57.00 days), which was followed by cluster VI (56.67 days), cluster II (54.35 days), cluster IV (53.67), cluster VII (52.33 days), cluster III (49.93 days), cluster I (49.00 days) and cluster V (47.33 days). Days of 50% flowering exhibited the highest mean performance for cluster VI (62.00) cluster VIII (59.67 days) followed by cluster IV (58.22 days), cluster II (57.13 days), cluster VII (57.33 days), cluster III (56.87 days), cluster I (51.67 days) and cluster V (49.67 days). As regards to plant height, the highest average performance (79.67 cm) was recorded in cluster V, which was followed by cluster II (75.31 cm), cluster VI (74.87 cm), cluster III (71.02 cm), cluster V (70.45), cluster I (79.40), cluster VII (65.57) and cluster IV (61.36cm). Number of branches per plant showed maximum cluster mean performance in cluster VII (7.57), which was followed by cluster V (7.15), cluster VIII (6.57), cluster VI (5.80), cluster II (5.36), cluster

IV (5.20), cluster I (4.93) and cluster III (4.79). The cluster mean performance for number of locules per fruit was highest in cluster I (5.13), which was followed by cluster VI (4.80), cluster II (4.70), cluster IV (4.00), cluster III (3.97), cluster VII (3.83), cluster V (3.53) and lowest for cluster VIII (3.45). The highest cluster mean value for fruit weight was recorded by cluster VI (69.27g) followed by cluster IV (65.07 g), cluster V (63.75 g), cluster I (55.47 g), cluster II (52.93 g.), cluster VIII (52.15 g.), cluster III (43.88 g.) and cluster VII (28.33g). The highest cluster mean was recorded for fruit width by cluster VI (7.30 cm), which was followed by cluster I (5.19 cm), cluster VIII (4.49 cm), cluster IV (4.38 cm), cluster II (4.12), cluster III (4.01), cluster V (3.63) and cluster VII (3.30 cm). The maximum number of calyx per fruit was recorded in cluster VI (6.33) followed by cluster IV (5.86), cluster II (5.35), cluster I (5.27), cluster VIII (5.17), cluster III (5.01), cluster V (5.00) and cluster VII (4.34). Days from transplanting to fruit set showed the highest mean performance for cluster VIII (63.50 days), which was followed by cluster VI (61.67 days), cluster II (59.96 days), cluster IV (59.02), cluster VII (57.33 days), cluster III (55.27 days), cluster I (54.00 days) and cluster V (52.33 days). Days from fruit setting to green mature stage exhibited the highest mean performance for cluster VI (26.67 days) cluster VIII (25.80 days) followed by cluster IV (22.13 days), cluster II (21.47 days), cluster III (19.33days), cluster VII (18.00 days), cluster V (17.31 days) and cluster I (17.00 days). Days from fruit setting to red ripe stage exhibited the highest mean performance for cluster VIII (37.45 days) followed by cluster IV (36.49 days) cluster II (34.58 days), cluster III (34.55 days), cluster VII (32.33 days), cluster I (30.00 days), cluster VI (29.33 days) and cluster V (28.00 days). The maximum mean for fruit yield q. / ha. was recorded in cluster VI (360.30 q. /ha.), followed by cluster I (360.00 q./ha.), cluster II (351.74q./ha.), cluster VI (340.00 q./ha.), cluster VII (338.98 q./ha.), cluster VIII (337.49 q./ha.) cluster III (333.10 q./ha.) and cluster V (318.98 q./ha.). In the Contribution of each cluster to divergence presented in table 4. Which shows fruit weight contribute highest 36.046% per cent to divergence followed be days from fruit setting to red ripe stage(31%), days from fruit setting to green mature stage (16.27%) and days to 50% flowering (13.37%). Whereas, number of calyx per fruit (1.162), number of primary branches (1.162), days from transplanting to fruit set (1.162) was lowest to divergence.

The clustering pattern revealed that geographical diversity could not be related to genetic diversity in the material investigated. Similar conclusions were drawn by Rai *et al*. (1998) for number of primary branches per plant, days to 50 per cent flowering, fruit length, plant height and average fruit weight; Sharma and Verma (2001) for fruit yield per plant, pericarp thickness and fruit diameter; Joshi and Kohli (2003) for fruit yield per plant and average fruit weight and Mahesha *et al.* (2006 b) for days to 50 per cent flowering, plant height, number of branches per plant, fruit weight, fruit length, fruit width, number of locules per fruit, number of seeds per fruit and fruit yield per plant.

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