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GENETIC DIVERGENCE STUDIES IN TOMATO GENOTYPES

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ABSTRACT
Present investigation was carried out at Vegetable Research Station, SKLTSHU, Rajendranagar, Hyderabad during 2014-15. About forty genotypes were evaluated for 19 growth, yield and quality traits which were grouped into seven clusters. Cluster II topped in having maximum of 24 genotypes followed by cluster I and VII with two genotypes while cluster III, IV and V were monotypic. The maximum intra-cluster distance was observed in cluster VII (2097.24) followed by clusters VI (824.01) and II (265.05) which were identified genetically divergent. The maximum inter-cluster distance was noticed between cluster II and VI (1647.87) and lowest between cluster III and IV (125.29). The genotypes of cluster III and VII recorded maximum mean values for number of fruits per plant, average fruit weight and fruit yield per plant while minimum values were recorded in genotypes belonging to clusters IV and VI. Among the nineteen characters studied reducing sugars contributed maximum to divergence followed by days to 50% flowering and have a major role in improvement of fruit yield in tomato. Therefore, crossing between genotypes belonging to cluster III and IV as well as between cluster VII and VI are expected to give maximum heterosis.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the important vegetable grown throughout the world. The cultivated tomato originated in a wild form in the Peru-Ecuador-Bolvia area of the Andes (South American) (Vavilov, 1951).

Despite its wide cultivation and high yield potential the average yield is very low due to non-availability of improved varieties or hybrids. Development of promising hybrids depends largely on selection of desirable inbred lines. Diversity in parents is a pre-requisite in the development of variety or hybrid. Very less work has been done to estimate the amount of genetic diversity under Telangana region. Systematic study and evaluation of germplasm is of great importance for current and future genetic improvement of the crop. Furthermore, evaluation of germplasm is imperative, in order to understand the genetic background and breeding value of the available germplasm (Singh *et al.,* 2002). Success of crop improvement programme depends on the extent of variability, choice of parents for hybridization and selection procedure. In plant breeding genetic diversity plays a very important role as it helps in selecting the suitable parents for hybridization programme resulting in superior hybrids and desirable recombinants (Rathi *et al.,* 2011). Multivariate analysis is a potent tool for measuring divergence among a set of populations based on multiple characters. D^2 statistic proposed by Mahalanobis (1936) has been generally used as an efficient tool in the quantitative estimation of genetic diversity for a rational choice of potential parent in a breeding programme. For the first time use of this technique for assessing the genetic variability in plants was suggested by Rao (1952).

Keeping in view the above facts present investigation was undertaken with an objective to study of genetic diversity in forty genotypes of tomato based on ninteen important traits, to help in selecting promising and genetically diverse parents for desired improvement.

MATERIALS AND METHODS

The experimental material consists of forty genotypes raised during *kharif* 2013-14 at Vegetable Research Station, SKLTSHU, Rajendranagar, Hyderabad which is situated at an altitude of 542.6 m above mean sea level. Geographically it lies at latitude of 17.19º N and a longitude of 79.23º E. The seeds were sown on a raised nursery bed and are transplanted after three weeks in main field at a spacing of 60 x 45cm following Randomized Block Design with three replications. Necessary prophylactic measures were taken to raise a healthy crop. Data relating to nineteen qualitative and quantitative traits *viz.,* plant height (cm), number of primary branches per plant, days to 50 percent flowering, number of flowers per cluster, number of fruits per cluster, average fruit weight (g), fruit length (cm), fruit width (cm), days to first fruit harvest, days to last fruit harvest, fruit yield per plant (kg), pericarp thickness (mm), total soluble solids (ºBrix), fruit pH, titrable acidity (%), ascorbic acid content (mg/100g), total sugars (%), reducing sugars (%) and lycopene content (mg/100g). In order to assess the genetic diversity, D^2 statistic was carried out following the procedure given by Rao (1952) and genotypes were grouped into different clusters following Tocher's method.

RESULTS AND DISCUSSION

The results of genetic divergence among forty genotypes of

Table 1: Distribution of forty genotypes in different clusters (Tocher's method)

Cluster	No. of genotypes	Genotypes
I	8	EC - 608243, EC - 705506, EC - 608262, EC - 620456, EC - 605701, EC - 605703, EC-570029 and EC – 605711I24,
II		EC-608360, EC-608398, EC-608428, EC-241148, EC-608331, EC-608272, EC-608334, EC-620419, Arka Abha, EC-608407, EC -611888, EC-608455, EC-611885, EC-608304, EC-611883, Punjab Chhuhara, EC-620407, Marutham, EC-611884, EC-20360, Arka Saurabh, Arka Meghali, EC-608415 and EC-620425
III	1	EC-620517
IV	1	EC-610662
V	1	EC-608436
VI	2	EC-523851 and EC-520078.
VII	3	EC-620557, EC-619982 and Pusa Ruby

Table 2: Average intra (bold) and inter-cluster D^2 values for seven clusters in forty genotypes (Tocher's method)

	I	II	III	IV	V	VI	VII
I	**100.29**	299.23	155.61	200.15	188.77	1342.99	643.65
II		**265.05**	409.21	403.06	400.02	1647.87	475.37
III			**0.00**	125.29	194.94	1269.31	824.27
IV				**0.00**	277.84	1258.66	833.44
V					**0.00**	824.01	822.09
VI						**824.01**	822.09
VII							**2097.24**

* Bold diagonal values indicate intra cluster distance, rest of the values show the inter cluster distances

tomato for yield and quality characters following Mahalanobis D^2 statistic are presented below.

Grouping of genotypes in to various clusters

Procedure suggested by Tocher (Rao, 1952) was used to group 40 genotypes into seven clusters by treating estimated D^2 values as the square of the generalized distance. From the Table 1 it is evident that out of seven clusters formed, cluster II was the largest group comprising of 24 genotypes, followed by cluster I with 8 genotypes, cluster VI and VII with 2 and 8 genotypes each and clusters III, IV and V were monotypic or solitary. This clearly indicates that the genotypes usually did not cluster according to geographical distributions. This is an agreement with results of Basavaraj *et al*. (2010), Joshi and Kohli (2003), Mohanty and Prusti (2001) and Omprakash Meena and Vijay Bahadur (2013).

Average intra and inter cluster distances

From the mean intra and inter cluster D^2 values among the seven clusters (Table 2), the intra cluster distance varied from zero to 2097.24. Cluster VII recorded maximum D^2 value (2097.24) followed by cluster VI (824.01), cluster II (265.05) and cluster I (100.29). Intra cluster distances were not observed in clusters III, IV and V as they were represented by single genotype.

The inter cluster D^2 values revealed that highest inter cluster distance (1647.87) was between cluster II and cluster VI while the lowest (125.29) was between cluster III and cluster IV. The inter cluster distance was minimum between cluster III and IV indicating narrow genetic diversity whereas maximum recorded between clusters II and VI followed by III and VI indicating wider genetic diversity in these groups. Selection of parents from these diverse clusters for hybridization would help in achieving novel recombinants. Similar type diversity in tomato germplasm was reported earlier by Om Prakash and Vijay Bahadur (2013), Rajasekhar *et al*. (2013) and Meena and Bahadur (2015). Average inter and intra-cluster distances revealed that, in general, intercluster distances were much higher than those of intra-cluster distances, suggesting homogeneous and heterogeneous nature of the germplasm lines within and between the clusters, respectively. These results are in accordance with the findings of Mahesha *et al*. (2006) and Sekhar *et al*. (2008) in tomato.

Performance of characters in cluster

From the data presented in Table 3 it can be seen that the genotypes belonging to cluster VI recorded highest plant height (158.16 cm) followed by cluster VI (117.60 cm), while genotypes of cluster I exhibited lowest plant height (65.67 cm) followed by cluster III (67.40 cm). Numbers of primary branches per plant were highest in cluster VII (6.08) followed by cluster II (5.59), while less number of primary branches was observed in genotypes of cluster V (4.00).

The character, days to 50 per cent flowering recorded minimum value in the genotypes of cluster VI (29.00) followed by cluster IV (33.33), while the genotypes of cluster VII (54.00) exhibited maximum mean value followed by cluster II (43.07). The genotypes belonging to cluster VI recorded highest number of flowers per cluster (7.44) followed by cluster V (5.93), minimum were exhibited by cluster I (4.47) followed by cluster IV (4.66). Cluster VI genotypes recorded highest number of fruits per cluster (6.20) followed by cluster V (5.31) with least number in cluster I (3.00) followed by cluster IV (3.56).

The maximum fruit length was exhibited in genotype of cluster V (5.45 cm) followed by cluster I (5.27 cm), whereas minimum were in genotypes of cluster VI (1.95 cm) followed by VII (4.80 cm).The genotypes of cluster III recorded highest fruit width (6.50 cm) followed by cluster IV (5.76 cm), with the genotypes

Table 3: Mean values of clusters for ninteen characters of tomato germplasm (Tocher's method)

Cluster no.	Plant height (cm)	No. of primary branches per plant	Days to 50 per cent flowering	Number of flowers per cluster	Number of fruits per cluster	Fruit Length (cm)	Fruit width (cm)	Average fruit weight (g)	Days to first fruit harvest	Days to last fruit harvest	Fruit yield per plant (kg)	Pericarp thickness (mm)	Fruit pH	Total soluble solids (°Brix)	Titrable acidity (%)	Ascorbic acid content (mg/100 g)	Total sugars (%)	Reducing sugars (%)	Lyco pene content (mg/100 g)
1	65.67	5.11	42.26	4.47	3.00	5.27	4.51	56.30	80.33	130.50	1.39	4.28	4.97	4.81	0.34	16.36	3.04	2.46	5.16
2	101.11	5.59	43.07	5.37	3.80	4.84	4.41	55.68	79.25	124.85	1.52	4.60	4.83	4.33	0.40	20.47	3.48	2.99	6.00
3	67.40	5.20	37.33	4.84	3.62	5.17	6.50	46.67	75.67	108.67	1.71	3.11	4.66	4.99	0.29	16.97	2.77	2.39	5.54
4	115.91	4.94	33.33	4.66	3.56	5.24	5.76	91.10	74.00	108.33	1.28	3.07	4.55	5.04	0.35	16.83	3.02	2.65	5.06
5	116.98	4.00	40.00	5.93	5.31	5.45	4.18	31.10	74.33	124.00	1.33	3.24	5.16	4.13	0.36	17.20	2.57	2.23	5.93
6	158.16	5.38	29.00	7.44	6.20	1.95	0.85	2.31	45.33	124.83	1.18	0.98	5.26	5.63	0.38	26.95	2.02	1.63	8.11
7	117.60	6.08	54.00	5.83	4.26	4.80	4.07	59.68	77.89	131.78	1.70	4.02	5.02	5.02	0.39	22.97	3.74	3.37	7.82

of cluster VI (0.85 cm) recorded minimum fruit width followed by cluster VII (4.07 cm).

Maximum mean value for average fruit weight recorded in genotype belonging to cluster IV (91.10 g) followed by cluster VII (59.68 g). The least mean value was recorded in genotypes of cluster VI (2.31 g) followed by cluster V (31.10 g). The genotypes of cluster VI (45.33) took least number of days to first fruit harvest followed by cluster V (74.00), while the genotypes of cluster I took more number of days to first fruit harvest (80.33) followed by cluster II (79.25). Highest number of days taken to last fruit harvest was observed in genotypes of cluster VII (131.78) followed by cluster I (130.50) and lowest mean value was observed in cluster IV (108.33) followed by cluster III (108.67).

The genotypes of cluster III recorded highest mean value for fruits yield per plant (1.71 kg) followed by cluster VII (1.70 kg), the genotypes of cluster VI (1.18 kg) recorded lowest mean value followed by cluster IV (1.28 kg). The character pericarp thickness recorded its maximum mean value in genotypes of cluster II (4.60 mm) followed by cluster I (4.28 mm). The minimum mean value was recorded in genotypes of cluster VI (0.98 mm) followed by cluster IV (3.07 mm).

The character fruit pH recorded least mean value in genotypes of cluster IV (4.55) followed by cluster III (4.66) while, highest mean value was recorded in genotypes of cluster VI (5.26) followed by cluster V (5.16). The highest mean value for total soluble solids was recorded in genotypes of cluster VI (5.63 °Brix) followed by cluster IV (5.04° Brix). Least mean value was exhibited in cluster V (4.13 °Brix) followed by cluster II (4.33 °Brix).

Titrable acidity was highest in cluster II (0.40%) followed by cluster VII (0.39%), whereas least value was recorded in cluster III (0.29%) followed by cluster I (0.34%). The genotypes belonging to cluster VI recorded highest ascorbic acid content (26.95 mg/100g) followed by cluster VII (26.95 mg/100g), whereas the least ascorbic acid content was recorded in cluster I (16.36 mg/100g) followed by cluster IV (17.20 mg/100g).

Highest total sugars content exhibited by the genotypes of cluster VII (3.74%) followed by cluster II (3.48%) with least value by cluster VI (2.02%) followed by cluster V (2.57%). The genotypes belonging to cluster VII recorded highest content of reducing sugars (3.37%) followed by cluster II (2.99%) and least content by genotypes of cluster VI (1.63%) followed by cluster V (2.23%). Lycopene content of tomato genotypes recorded highest value in cluster VI (8.11 mg/100g) followed by cluster VII (7.82 mg/100g), whereas cluster IV recorded least value of 5.06 mg/100g followed by cluster I (5.16 mg/100g)

Relative contribution of characters towards diversity

Number of times each of nineteen traits appeared in first rank and its respective per cent contribution towards genetic divergence are presented in Table 4. The results showed that the character, reducing sugars contributed maximum (40.64%) towards diversity by taking 317 times first ranking, followed by days to 50% flowering (11.03%) by 86 times, titrable acidity (10.26%) by 80 times, lycopene content (8.33%) by 65 times, ascorbic acid content (7.82 %) by 61 times, average fruit weight (6.15%) by 48 times, plant height (5.38%) by 42 times, total

Table 4: Percent contribution of different characters towards genetic divergence

S.No.	Source	Times Ranked 1st	Contribution %
1.	Plant height (cm)	42	5.38
2.	Number of primary branches per plant	1	0.13
3.	Days to 50% flowering	86	11.03
4.	Number of flowers per cluster	0.00	0.00
5.	Number of fruits per cluster	1	0.13
6.	Fruit length (cm)	0.00	0.00
7.	Fruit width (cm)	20	2.56
8.	Average fruit weight (g)	48	6.15
9.	Days to first fruit harvest	14	1.79
10.	Days to last fruit harvest	9	1.15
11.	Fruit yield per plant (kg)	0.00	0.00
12.	Pericarp thickness (mm)	8	1.03
13.	Fruit pH	2	0.26
14.	Total soluble solids (^{0}Brix)	21	2.69
15.	Titrable acidity (%)	80	10.26
16.	Ascorbic acid content (mg/100g)	61	7.82
17.	Reducing sugars (%)	317	40.64
18.	Total sugars (%)	5	0.64
19.	Lycopene content (mg/100g)	65	8.33

soluble solids (2.69%) by 21 times, fruit width (2.56%) by 20 times, days to 1st fruit harvest (1.79%) by 14 times, days to last fruit harvest (1.15%) by 9 times, pericarp thickness (1.03%) by 8 times, total sugar (0.64%) by 5 times and fruit pH (0.26%) by 2 times. Similarly, the character number of primary branches per plant and number of fruits per cluster contributed 0.13% each by 1 time respectively. In contrast, the traits, number of flowers per cluster, fruit length and fruit yield per plant did not contribute towards total diversity. Mahesha *et al*. (2006), Jag Paul Sharma *et al*. (2011), Rajeev and Reddy (2012) and Jitendra Kumar *et al*. (2013) also reported similar kind of results. Apart from high divergence, performance of the genotypes and characters with maximum contribution towards divergence should also be given due consideration which appears as desirable for inclusion in tomato improvement.

Hence, apart from selecting genotypes from the clusters which have high inter- cluster distance for hybridization, one can also think of selecting parents based on extent of genetic divergence in respect to a particular character of interest like genotypes belonging to cluster II for pericarp thickness, cluster III for fruit width, cluster IV for average fruit weight and fruit pH, cluster V for fruit length, cluster VI for plant height, early flowering and harvest, flowers and fruit per cluster, total soluble solids, ascorbic acid content and lycopene content and cluster VII for number of primary branches per plant, long duration, yield, titrable acidity, total and reducing sugars.

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