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Genetic Divergence Studies for Quantative and Quality Traits in Tomato (*Solanum lycopersicum* L.)

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***Abstract*—** *The present experiment was carried out during spring-summer 2013 and 2014 to study genetic diversity for quantitative and quality traits in tomato at vegetable Experimental Farm, Division of Vegetable Science & Floriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha. The 25 genotypes were grouped into six clusters based on D^2 values, which exhibited no association between geographical and genetic diversity. The cluster VI was the largest containing 9 genotypes followed by cluster I, II and IV containing four genotypes each. However, the cluster III (Lehar & US-3383) and cluster V (DVRT-2 & Marglobe) had minimum number of genotypes i.e two in each cluster. The intra-cluster distance was recorded maximum for cluster III (3.69) consisting of 2 genotypes namely Lehar & US-3383. Whereas, cluster IV, V, VI had lowest intra cluster distance i.e 0.00. The maximum distance at inter-cluster level was between cluster II and cluster VI (11.48) followed by clusters III and VI (9.83) indicating that the genotypes in these groups can be used for heterosis and recombinant breeding programme which may serve as potential genotypes for hybridization programme. Cluster mean analysis (Table 4) showed that cluster I was earliest to flowering (29.07 days); days to first marketable fruit picking (70.15) and maximum number of fruits per plant (27.73); cluster II showed maximum performance for number of locules per fruit (3.77); betacarotene (5.13mg) and minimum incidence of fruit borer (18.64%); cluster III showed maximum plant height (123.20 cm) and minimum intensity of early blight (27.27%); cluster IV recorded maximum fruit diameter (5.17cm) and average fruit weight (81.33 g); cluster V recorded maximum marketable fruit yield (3.73 kg/plot) and total fruit yield (5.27 kg/plot), pericarp thickness (6.75 mm), pH (4.43) and minimum number of seeds per fruit (62.45); cluster VI gave maximum fruit length (6.91cm), total soluble solids (4.34^{0}B), lycopene (3.85mg) and ascorbic acid (26.07mg).*

***Keywords*— Multivariate analysis, Clusters, genetic diversity, Solanum lycopersicum L.**

I. INTRODUCTION

Tomato (*Solanum lycopersicum* L.), a member of family Solanaceae is one of the important warm season, self pollinated vegetable crop grown both for fresh and processing market (Das *et al.*, 2011; Nwosu *et al*., 2014). It is native of Peru Equador region (Rick, 1969) and second popular widely grown and consumed vegetable in the world, next to potato because of its wider adaptability, high yielding potential and multipurpose uses (Anonymous, 2005; Reddy *et al*., 2013). It stands unique among vegetables because of its high nutritive value and innumerable uses being a rich source of Vitamin A, C and Minerals (Kaushik *et al*., 2011; Akinfasoy *et al*., 2011). Its firmly ripened fruits are rich source of lycopene, ascorbic acid, and beta-carotene. Lycopene is treasured for its anticancer attribute and have antiseptic and blood purifier properties. It acts as an antioxidant which is often colligated with carcinogenesis (Giovannucci, 2002; Miller *et al*, 2002; Bai & Lindhot, 2007). Ascorbic acid may play a key role in delaying the pathogenesis of a variety of degenerative diseases, such as cardiovascular disease, certain cancers, cataracts and it also prevents DNA mutation induced by oxidative stress (Lutsenko *et al*., 2002).

Knowledge of genetic diversity, its nature and degree is useful for any heritable improvement programme and selecting desirable parents from a germplasm for the successful breeding programme. Among the various methods identified/developed to study the genetic divergence in the genotypes. Mahalanobis D^2 (Mahalanobis, 1936) is reliable and the most frequently used. D^2 analysis is a useful tool in quantifying the degree of divergence between biological population at genotypic level and to assess relative contribution of different components to the total divergence, both at the inter and intra-cluster levels. The grouping of genotypes into different clusters is done by Tocher's method as described by Rao (1952). An improvement in yield and quality in self-pollinated crops like tomato is normally

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achieved by selecting the genotypes with desirable character combinations existing in nature or by hybridization (Reddy *et al*., 2013; Nalla *et al*., 2014). It is very useful technique of measuring genetic divergence as reported by various workers (Kumar *et al*., 2010; Reddy *et al*., 2013; Meena and Bahadur, 2013; Pedapati *et al*., 2014; Dar *et al*., 2015; Meena and Bahadur, 2015). Considering the above facts, the present studies had been planned with the objective to assess the extent of genetic diversity in available gene pool based on nineteen quantitative and quality traits.

II. MATERIALS & METHODS

The experimental material comprised of 25 tomato genotypes (12 hybrids and 13 open pollinated) collected from different State Agriculture Universities and private seed companies. The experiment was carried out at Division of Vegetable Science and Floriculture, SKUAST-Jammu for two years during spring summer season of 2013 and 2014. The experimental area is situated in the sub tropical zone of Jammu at 32º 40'N latitude and 74º 58' E longitude and has an elevation of 332 m above mean sea level. The place experiences hot dry summer, hot and humid rainy season and cold winter. The maximum temperature goes up to 45º C during summers (May to June) and minimum temperature falls to 1º C during winters. The experiment was conducted in Randomized block design with three replications. The uniform, healthy seedlings were planted on ridges maintaining inter and intra row spacing of 60 and 45 cm respectively, keeping three replication in a randomized block design. All the recommended package of practices were followed from time to time to raise a healthy crop. Observations were recorded on five randomly selected plants in each genotype and replication for characters namely days to 50% flowering, days to first marketable fruit picking, fruit length (cm), fruit diameter (cm), total number of fruits per plant, average fruit weight (g), marketable yield per plot(kg), total yield per plot (kg), plant height (cm), number of seeds per fruit, number of locules fruit^{-1}, pericarp thickness (mm), Total Soluble Solids (^{0}B), lycopene (mg/100g), Beta carotene (mg/100g), Ascorbic acid (mg/100g), fruit bore incidence (%) and intensity of early blight (%).The data collected were subjected to multivariate analysis utilizing Mahalanobis D^2 statistic as suggested by Mahalanobis (1936) using statistic software WINDOWSTAT 9.2 developed by INDOSTAT services Ltd. Hyderabad,India. Accessions were grouped into various clusters following Tocher's method as suggested by Rao (1952).

III. RESULTS AND DISCUSSION

On the basis of D^2 values, the 25 genotypes were grouped into six divergent clusters (Table 1). Among the six clusters, cluster VI was the largest, comprising of nine genotypes followed by cluster I, cluster II and cluster IV with four genotypes in each cluster whereas cluster III and cluster V consisted of two genotypes each. The clustering pattern did not show any relationship between genetic diversity and geographic diversity. These results are in agreement with the early work of Shashikanth *et al*. (2010); Pedapati *et al*. (2014); Meena and Bahadur (2015); Dar *et al*. (2015). So selection of genotypes for hybridization to generate diverse new gene combinations should be based on genetic diversity rather than geographic diversity.

The intra-cluster distances indicates the divergence among the genotypes within the clusters and inter-cluster indicates diversity between clusters. The intra and inter cluster D^2 values among 25 genotypes (Table 2) revealed that maximum intra-cluster D^2 value was recorded in cluster III (3.69) whereas, cluster III, cluster IV and cluster V showed minimum intra-cluster D^2 value (0.00) followed by cluster I (1.49) and cluster II (2.04) indicated that genotypes included in this cluster are very diverse and was due to both natural and artificial selection forces among the genotypes.

Maximum inter-cluster D^2 value was observed between the cluster II and VI (11.48) followed by cluster III and VI (9.83) indicating that the genotypes belonging to these groups were genetically most divergent. Minimum inter-cluster D^2 value was observed between the cluster I and IV (2.32) followed by cluster I and IV (2.37) indicating close relationship among the genotypes included in these clusters. Average inter and intra-cluster distances revealed that, in general, inter cluster distances were 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 Kumar *et al*., (2010); Meena and Bahadur (2013); Pedapati *et al*. (2014)

The percentage contribution of 15 characters for genetic divergence (Table 3) showed that fruit length contributed maximum (33.0%) towards genetic divergence followed by ascorbic acid (18.0%), plant height (13.33%), number of seeds/ fruit (11.0%), fruit diameter (10.33%) and fruit pH(6.33%). Reddy *et al*. (2013) also observed such maximum contribution for plant height to total divergence of tomato accessions. Whereas, intensity of early blight (3.00%), betacarotene(1.33%), average fruit weight (1.00%), number of locules (1.00%), total soluble solids (0.67%), lycopene (1.00%) and pericarp thickness (0.33%) contributed minimally towards total divergence. However, days to 50% flowering, days to marketable fruit picking, marketable fruit yield, total fruit yield and

percent incidence of fruit borer contributed less. Similar findings were obtained by early workers namely Dar *et al*. (2015) and Sekhar *et al*.(2008).

The means of the clusters for yield and quality traits (Table 4) depicted that days to 50% flowering was minimum in cluster I (29.07 days) followed by cluster IV (29.90 days) and cluster V (30.19days). Minimum days to first marketable fruit picking was observed in cluster I (70.15 days) followed by cluster IV and II i.e 71.10days. It reveals that if breeding program is aimed at earliness, then genotypes in these cluster can be selected (Meena and Bahadur, 2013). Fruit length was maximum in cluster VI (6.91cm) followed by cluster I (5.79cm). Fruit diameter was maximum in cluster IV (5.1cm) followed by cluster II (4.87cm). Number of fruits per plant were observed maximum in clusters I (27.73) followed by cluster V (26.24) and cluster II (24.93). Average fruit weight was observed maximum in cluster IV (81.33 g) followed by cluster number V (61.55 g) and cluster VI (58.29 g**).** It was observed that clusters V, I and IV had highest values of 3.73, 3.49 and 3.22kg, respectively, for marketable fruit yield per plot. The top ranking clusters for total yield per plot were clusters V (5.27), IV (5.26) and I (4.80 kg/plot) which indicates that the accessions included in this cluster could effectively be used for the crop improvement program for increasing yield (Meena and Bahadur, 2015**).** In case of plant height, cluster III had maximum plant height (123.20) followed by cluster VI (92.31) and cluster I (91.21).Minimum number of seed per fruit were recorded in Cluster V followed by cluster VI. However, clusters II, IV and III had the the maximum value for number of locules with the values of 3.77, 3.27 and 3.00 respectively. The pericarp thickness was found to be highest in clusters V (6.75), VI (6.56) and IV (6.20). For total soluble solids, the highest values were observed in clusters number VI (4.34), II (4.24) and III (4.22). For lycopene, top ranking clusters are VI (3.85mg), III (3.26 mg) and V (3.13 mg). Clusters II, I and VI are rich in β-carotene with the value of 5.13, 5.07 and 4.95 mg. However, clusters number VI (26.07 mg), II (23.85 mg) and III (19.85 mg) had highest values for ascorbic acid content while the clusters with greater pH are clusters number V (4.43), VI (4.37) and IV (4.35). Minimum percent incidence of fruit borer was observed in cluster II followed by cluster III. Whereas cluster III showed minimum intensity of early blight followed by cluster IV and cluster II.

Thus, from the present investigation it can be concluded that for earliness, genotypes in cluster I and IV can be selected for development of double cross hybrids. To improve maximum yield per plant, clusters V, I and IV are an ideal combination for three way cross or their derivatives for future selection.

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Table.1: Grouping tomato genotypes based on D2 analysis

Cluster	Numberof genotypes	Cluster Members
I	4	Karan, Sonali, NS-2535, Leh Local
II	4	Anand , Heem Sohna, Solan Lalima , Naveen
III	2	Lehar, US-3383
IV	4	Rupali, Maharishi, Aditya, Kubeergeeta
V	2	DVRT-2, Marglobe
VI	9	Tokita, Arka Abha, Angoorlata , Arka Saurabh, Pusa Ruby, Arka Vikas, Swarna Lalima,Swarna Naveen, Arka Meghali

Table.2: Inter & Intra Cluster Distances : Tocher Method

Cluster	I	II	III	IV	V	VI
I	**1.49**	6.28	5.61	2.37	2.32	4.52
II		**2.04**	4.32	5.39	4.67	11.48
III			**3.69**	5.08	4.83	9.83
IV				**0.00**	3.23	5.51
V					**0.00**	6.47
VI						**0.00**

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Table.3: Per cent contribution of 19 traits towards diversity in tomato genotypes

S.No	Traits	Times Ranked 1st	Contribution %
1	Days to 50% Flowering	0	0.00
2	Days to first Marketable fruit picking	0	0.00
3	Fruit Length (cm)	99	33.00
4	Fruit diameter (cm)	31	10.33
5	Number of fruits/ Plant	0	0.00
6	Average fruit Weight (g)	3	1.00
7	Marketable Yield/ Plot (kg)	0	0.00
8	Total Yield / Plot (kg)	0	0.00
9	Plant Height (cm)	40	13.33
10	Number of seeds/ Fruit	33	11.00
11	Number of locules/ Fruit	3	1.00
12	Pericarp Thickness(mm)	1	0.33
13	Total Soluble Solids (ºB)	2	0.67
14	Lycopene (mg/100g)	2	0.67
15	Beta Carotene (mg/100g)	4	1.33
16	Ascorbic Acid (mg/100g)	54	18.00
17	pH	19	6.33
18	Incidence of Fruit Borer(%)	0	0.00
19	Intensity of Early Blight(%)	9	3.00

Table .4: Cluster mean for various quantitative and qualitative characters in tomato

Cluster	Days to 50% Flowering	Days to First Marketable fruit picking	Fruit Length (cm)	Fruit diameter (cm)	Number of fruits/ Plant	Average fruit Weight (g)	Marketable Yield/ Plot (kg)	Total Yield / Plot (kg)	Plant Height (cm)	Number of seeds/ fruit	Number of locules/ Fruit
I	29.07	70.15	57.97	44.86	27.73	54.09	3.49	4.80	91.21	116.93	2.77
II	30.25	71.10	42.21	48.72	24.93	55.24	3.21	4.48	77.02	127.52	3.77
III	30.63	71.64	47.28	47.75	22.74	57.76	2.90	4.06	123.20	116.96	3.00
IV	29.90	71.10	57.52	51.78	24.07	81.33	3.22	5.26	87.28	187.06	3.27
V	30.19	71.73	52.42	48.11	26.24	61.55	3.73	5.27	75.69	62.45	2.97
VI	32.12	72.53	69.10	42.85	20.49	58.29	2.64	4.34	92.31	103.71	2.42

Continue ..

Cluster	Pericarp Thickness (mm)	Total Soluble Solids (^{0}B)	Lycopene (mg/100g)	Beta Carotene (mg/100g)	Ascorbic Acid (mg/100g)	pH	Incidence of Fruit Borer (%)	Intensity of Early Blight (%)
I	6.13	3.83	2.87	5.07	15.84	4.33	21.31	38.43
II	4.85	4.24	2.47	5.13	23.85	4.29	18.64	37.09
III	5.56	4.22	3.26	4.62	19.85	4.20	19.62	27.27
IV	6.20	4.08	2.31	3.31	16.85	4.35	23.98	35.73
V	6.75	3.84	3.13	1.75	15.37	4.43	24.27	48.88
VI	6.56	4.34	3.85	4.95	26.07	4.37	26.00	42.45