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Genetic divergence studies in tomato (*Solanum lycopersicum* L.)

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Abstract
The present investigation was conducted in randomized block design with 26 genotypes of tomato in three replications. The objectives were to assess the relative performance, estimation of genetic parameters and genetic divergence for fruit yield and yield contributing characters. The magnitude of GCV and PCV was found highest for fruit shape index (35.28&37.46).The heritability estimates were found to be high (more than 70%) for plant height (cm) at 120 DAT (92.00) and fruit shape index (89.00). The high genetic advance was obtained for plant height (cm) at 120 DAT (53.88). Maximum number of genotypes were grouped into cluster 3rd which included 10 genotypes. The intra-cluster distance varied from 22.40 to 69.21. The maximum intra cluster distance was shown by cluster 6 (69.21). In the contribution of each character to divergence showed plant height (cm) at 120 DAT contributes highest (41.23) to divergence.

Keywords: Genetic variability, GCV, PCV, heritability, genetic divergence and tomato

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important solanaceae vegetable crop having diploid chromosome number 2n=2x=24. It is herbaceous, annual to perennial, prostrate and sexually propagated crop plant with bisexual flowers. There are four to eight flowers in each compound inflorescence. The total sown area under Rabi Tomato is 260.4 thousand ha so far in the different States. The major area sown are 38.8 thousand ha in Chhattisgarh, followed by Madhya Pradesh (37.0 thousand ha), Haryana (14 thousand ha), Uttar Pradesh (12.8 thousand ha), Tamil Nadu (12.7 thousand ha), Rajasthan (12.5 Thousand ha), Karnataka (9.5 thousand ha), Himachal Pradesh (1.3 thousand ha.). (State Departments of Horticulture & Agriculture, 2017-2018) The genetic variance of any quantitative trait is composed of additive variance (heritable) and non-additive variance and include dominance and epitasis (non-allelic interaction) therefore, it essential to partition the estimated phenotypic variability into its heritable and non-heritable components with suitable parameters such as genetic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, genetic advance, and heritability. Taisa *et al.* (2011) [20].

Materials and Methods
The present investigation entitled "Genetic Divergence Studies in Tomato (*Solanum lycopersicum* L.)" was conducted in randomized block design with 20 genotypes of tomato in three replications. The objectives were to assess the relative performance, estimation of genetic parameters. The characters studied were yield and yield attributing characters. The experiment was laid out at Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute SHUATS Allahabad. India in randomized block design (RBD) with three replications. The mean data of each character was subjected to statistical analysis for variance and tests the significance of each character as per the procedure of Panse and Sukhatme (1967). Genotypic and phenotypic correlation coefficients were calculated by standard procedures (Johnson *et al.* 1955; Hanson *et al.* 1956) [8, 3]. Heritability (h^2 broad sense) and Genetic advance method by Robinson (1966) [17] Genetic advance as percentage over mean method by Johnson *et al.* (1955) [8].

Results and Discussion
The variance measures the variation within a particular trait. But it does not provide any real measure for comparison of variance between different traits. The term Coefficient of Variation truly provides a relative measure of variance among different traits. Similar observations in tomato were also reported (Singh *et al.* 2006; Hayadar *et al.* 2007) [19, 4].

Analysis of variances

The recorded on different traits from the experiment conducted 2017-2018 were subjected to analysis of variance of test the significance difference among the character 13 genotypes of tomato (*Solanum lycopersicum* L.). The results of analysis of variance are presented in table 1. The analysis of variance of experiment showed that the differences due to genotypes were significantly the character viz.; plant height (cm) at 120 DAT, days to first flowering, days to 50 % flowering, flowers per cluster, flowers cluster per plant, fruit set per cluster, fruit weight (g), fruits per plant, fruit yield per plant (kg), fruit shape index, TSS (°Brix), ascorbic acid (vit c) mg/100g and acidity. Similar observations in tomato were also reported by) Singh & Raj (2004) and Barman *et al.* (1995), Asati *et al.* (2008), Mohammed *et al.* (2012) [13] and Narolia *et al.* (2012) [15].

Table 1: Analysis of variances for 13 characters in tomato genotypes growth, yield and quality traits

S. No	Character	Mean of sum square		
		Replication (df=2)	Treatment (df=25)	Error (df=50)
1	Plant Height (cm) At 120 DAT	103.45	2301.05**	66.18
2	Days to First Flowering	2.54	9.34*	4.33
3	Days to 50 % Flowering	5.16	6.53**	1.58
4	Flowers Per Cluster	1.52	6.02*	3.17
5	Flowers Cluster Per Plant	0.42	4.24**	1.12
6	Fruit Set Per Cluster	0.76	2.06**	0.56
7	Fruit Weight (g)	60.75	384.09**	59.97
8	Fruits Per Plant	106.89	289.93**	87.17
9	Fruit Yield Per Plant (kg)	0.65	1.61**	0.29
10	Fruit Shape Index	0.002	0.287**	0.011
11	TSS (°Brix)	0.24	1.46**	0.60
12	Ascorbic Acid (Vit C) Mg/100g	0.46	1.46**	0.60
13	Acidity	0.03	0.12**	0.37

*and **significant at 5% and1% level of significance, respectively.

Genetic divergence

The concept of D^2 statistics was originally developed by Mahalonobis (1936). Then Rao (1952) suggested the application of this technique for the arrangement of genetic diversity in plant breeding. Now, this technique is being extensively used in vegetable breeding also to study the selection of different parents.

On the basis of D^2 analysis, twenty six genotypes were grouped into six clusters (Table 2). Maximum number of genotypes were grouped into cluster 3rd cluster (TOINDVAR-5, TOINDVAR-6, TOINDVAR-4, Kashi Sharad, H-88-781, TOINDVAR-2, Azad T-6, Azad T-5, Angoorlata and Arka Abha) included 10 genotypes whereas cluster 1st Cluster (Kashi Hemant, Pusa Ruby, S-22, Hissar Lalit and TOINDVAR-1) and cluster 2nd (EC-501574, Pant T-7, Kashi Aman, Arka Vikash and Kashi Vishesh) followed by cluster 4th (Punjab Chhuhara, Pant T-5, Pusa Cherry and TOINDVAR-3) and minimum number of genotypes were grouped into cluster 5th and 6th (H-88-78-5 and AGETA-32). This indicates the fact that there was no parallelism between genetic diversity and geographical divergence in the tomato crop. Similarly Iqbal *et al.*, (2014), Lekshmi and Celine (2016) [10].

Table 2: Composition of clusters in tomato genotypes

Cluster Number	Number of genotypes included	Name of genotypes
1st Cluster	5	Kashi Hemant, Pusa Ruby, S-22, Hissar Lalit and TOINDVAR-1
2nd Cluster	5	EC-501574, Pant T-7, Kashi Aman, Arka Vikash and Kashi Vishesh
3rd Cluster	10	TOINDVAR-5, TOINDVAR-6, TOINDVAR-4, Kashi Sharad, H-88-78-1, TOINDVAR-2, Azad T-6, Azad T-5, Angoor lata and Arka Abha
4th Cluster	4	Punjab Chhuhara,, Pant T-5, Pusa Cherry and TOINDVAR-3
5th Cluster	1	H-88-78-5
6th Cluster	1	AGETA-32

Average intra and inter cluster distances

It is vivid from the Table 3 that maximum inter cluster distance was observed between Cluster2 and 6 (196.40) followed by cluster 2 and cluster 5 (194.44), cluster 1 and cluster 6 (145.65), cluster 3 and cluster 6 (133.47), cluster 4 and cluster 6 (128.67), cluster 1 and cluster 5(127.17), cluster 2 and cluster 4 (115.82), cluster 3 and cluster 5 (110.65), cluster 1 and cluster 2 (70.38), cluster 1 and cluster 3 (51.14), cluster 1 and cluster 4 (88.75), cluster 2 and cluster 3 (64.70), cluster 4 and cluster 5 (81.93) and cluster 5 and cluster 6 (61.02) and minimum inter cluster distance was observed between cluster 3 and cluster (49.01).

The intra-cluster distance varied from 22.40 to 69.21. The maximum intra cluster distance was shown by cluster 6 (69.21) followed by cluster 2 (49.58), cluster 1 (32.52), cluster 4 (31.57) and cluster 3 (25.78). cluster 5 showed minimum distance (22.4).

Depending upon the breeding objective, the potential lines to be selected from different clusters as parents in a hybridization program may be based on genetic distance. In accordance to the findings, Hazra *et al.* (2010) [5] and Meena and Bahadur (2015) [12] reported that the clustering pattern could be utilized in choosing parents for cross combinations likely to generate the highest possible variability for various economic characters.

Table 3: Intra (bold) and Inter cluster distance values in cluster formed of tomato genotypes

Cluster	1	2	3	4	5	6
1	32.52	70.38	51.14	88.75	127.17	145.65
2		49.58	64.70	115.82	194.14	196.40
3			25.78	49.01	110.65	133.47
4				31.57	81.93	128.67
5					22.4	61.02
6						69.21

Contribution of characters towards divergence

In the contribution of each character to divergence is presented in Table 4 which showed plant height at 120 DAT contributes highest (41.23) to divergence followed by fruit shape index (28.00), ascorbic acid(Vit c) (6.46), fruit weight (8.00), days to 50 % flowering (3.08), flowers cluster per plant (2.46), fruits per plant (2.77), fruit yield per plant (3.08) and acidity (3.69). Whereas, fruit set per cluster (0.92), flowers per cluster (0.31), days to first flowering (0.01) and TSS (0.01) contribute lowest to divergence. Mohanty and Prusti (2001) [14] also observed such maximum contribution of plant height. These results were almost in accordance with the studies of Khanna and Misra (1977) [9], Bhattacharya (1979) [1], Singh and Singh (1980) [18] and De *et al.* (1988) [2] proposed that traits contributing maximum towards the D^2 values need to be given great emphasis for deciding on the cluster to be chosen for the purpose of further selection and choice of parents for hybridization.

Table 4: Contribution of each character to divergence

Source	Contribution %	Times Ranked 1st
Plant Height (Cm) At 120DAT	41.23	134.000
Days To First Flowering	0.01	0.000
Days To 50 % Flowering	3.08	10.000
Flowers Per Cluster	0.31	1.000
Flowers Cluster Per Plant	2.46	8.000
Fruit Set Per Cluster	0.92	3.000
Fruit Weight (g)	8.00	26.000
Fruits Per Plant	2.77	9.000
Fruit Yield Per Plant (Kg)	3.08	10.000
Fruit Shape Index	28.00	91.000
TSS (°Brix)	0.01	0.000
Ascorbic Acid(Vit C) Mg/100	6.46	21.000
Acidity	3.69	12.000

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