Research Article

Morphological Variation and Genetic Distance in Tuberose (*Polianthes tuberosa* L.) Genotypes for Growth, Yield and Essential Oil Traits

Ujjwal Sirohi[1], Mukesh Kumar*[2], Pankaj Chauhan[1], Ravindra Kumar[1], Pooran Chand[3] and Veena Chaudhary[4]

[1]College of Biotechnology, SVPUAT, Meerut, UP, India 250110
[2]Department of Horticulture, College of Agriculture, SVPUAT, Meerut, UP, India 250110
[3]Department of Genetics and Plant Breeding, College of Agriculture, SVPUAT, Meerut, UP, India 250110
[4]Department of Chemistry, CSSS (PG) College, Machhra, Meerut, UP, India 250106

Abstract

Morphological variation and genetic diversity of 21 tuberose genotypes was studied at Horticultural Research Centre (HRC) of SVPUAT, Meerut, UP during the year 2015-16. The data were highly significant for all the twenty growth, flowering and bulbs traits studied indicating the presence of morphological variation and diversity among the genotypes. The genotypes were grouped into six clusters by D^2 analysis. The inter-cluster distances were higher than intra-cluster distance indicating wider genetic diversity among the genotypes of different clusters. The intra-cluster distances were lower in all the cases reflecting homogeneity of the genotypes within the clusters. The cluster II contained the highest number of genotypes (6) and the cluster IV had the lowest number of (1) genotype. The highest intra-cluster distance was noticed for the cluster V and the lowest for cluster IV. The highest inter-cluster distance was observed between cluster IV and VI followed by, cluster I and IV, cluster II and IV and the lowest inter-cluster exhibited between cluster I and III. The genotypes of cluster IV showed high genetic distance as compared to other clusters. The length of spike, length of rachis, number of corms per plant, corm yield/ ha and essential oil is the qualitative traits in tuberose and it is considered that the genotypes showed highest mean value among the clusters should be selected for further improvement programme.

Keywords: Tuberose, genetic diversity, morphological variation, essential oil traits

***Correspondence**
Author: Mukesh Kumar
Email: k.mukesh123@yahoo.com

Introduction

Tuberose (*Polianthes tuberosa* Linn.) is one of the most important commercial bulbous ornamentals due to its potentiality for cut flower trade, long vase life and essential oil industry, attractive long spikes, high cut-flower yield and nearly year round yield in tropical and subtropical climates [1, 2]. Among the flowers, tuberose is an important commercial cut as well as loose flower crop due to pleasant fragrance, longer vase-life of spikes, higher returns and wide adaptability to varied climate and soil. They are valued much by the aesthetic world for their beauty and fragrance. The flowers are attractive and elegant in appearance with sweet fragrance. It has long been cherished for the aromatic oils extracted from its fragrant white flowers. There are about fifteen species under the genus *Polianthes*, of which twelve species have been reported from Mexico and Central America. Of these, nine species have white flowers, one is white tinged with red and two are red. Except *Polianthes tuberosa* L., all the others are found growing wild. There are four types of tuberoses named on the basis of the number of rows of petals they bear. They are, Single, Semi-double, Double and Variegated. Studies on genetic diversity are important as the individual plant selection is slowly dependent on variability. In plant breeding, genetic diversity plays an important role because hybrids between genetically diverse parents manifest greater heterosis than those between closely related parents [3-5]. More the diversity is responsible for better chances of improving the economic characters under consideration in the resulting offspring. Crop improvement in tuberose has so far been achieved by exploiting the available sources of the variability. Naturally, the genetic variation or diversity for most of the yield attributes is considerably high in tuberose. There is an urgent need to seek improvement in complex quantitative traits such as flower and essential oil yield. As a result of free exchange of tuberose germplasm and lot of introgression of characters has taken place in many local tuberose cultivars resulting in enhancement of variability and new genetic combinations. D^2-statistics as multivariate analysis is a powerful tool in the estimating genetic divergence in crop plants. Being a numerical estimate this method has an added advantage over other as it permits precise comparisons among all possible traits of

population in a group and its commutation offers the automatic removal of the effects of correlations among the genetic variables involved to its efficiencies and usages. The D^2 technique based on multivariate analysis developed by Mahalanobis [6] is the most effective method for quantifying the degree of genetic diversity among genotypes, which helps in selecting the diverse parents for hybridization and the magnitude of genetic diveristy among all the possible pairs of population at genotypic level before effecting actual crosses in modeling the genotypes in a desired genetic architecture has become possible.

Materials and Methods

The experiment was carried out during the year 2016-17 at Horticultural Research Centre (HRC) of Department of Horticulture, S. V. P. U. A. T., Meerut, U. P., India. The trial was conducted in a randomized complete block design with three replications. The bulbs of twenty one varieties (**Table 1**) were grown in the field of 25 x 25 cm spacing at Meerut (North West Plains Zone, India, 28.99^0N and 77.70^0E. The land of experimental field was prepared by ploughing before planting of bulbs. At last ploughing well-rotten FYM @400 q/ha was applied and thoroughly mixed in the soil. Besides of FYM, a recommended doses of N: P: K @ 120:150:150 kg /ha were also added into the experiment, out of which 60 kg N and entire dose of P_2O_5 and K_2O are applied as basal dose at the time of planting of bulbs. The remaining N was applied in two split doses (30 +30 kg) at 30 and 60 days after planting of bulbs.

Observations were recorded from five randomly selected plants in each genotype for days taken to sprout, plant height (cm), number of leaves per plant, length of longest leaf (cm), width of longest leaf (cm), days required for visibility of first spike, number of florets per spike, diameter of floret (cm), number of spikes per clump, length of spike (cm), length of rachis (cm), longevity of spike, vase life (days), number of bulbs per plant, yield of bulb per plant, diameter of bulb (cm), yield of bulb (q/ha), weight of bulb (gm), absolute (%) and concrete (%).The data obtained from morphological characters were analyzed statistically using standard method as suggested by [7]. Genetic diversity was studied by Mahalanobis's [6] generalized distance (D^2) extended by Rao [8]. Clustering of genotypes was done according to Tocher's method [8].

Table 1 List of Tuberose genotype with their characters

S.No.	Genotype	Characteristics
1	Shringar	Single flowers on a sturdy spike a cross between Single x Double, (developed by IIHR)
2	SVPUAT-3	Double flowers on medium spike
3	Vaibhav	Semi-double flowers on medium spike, cross Mexican Single x IIHR-2, (developed by IIHR)
4	Prajwal	Single flowers on tall, stiff spikes; cross of Shringar x Mexican Single (developed by IIHR)
5	SVPUAT-4	Single flowers on a sturdy spike
6	SVPUAT-1	Pure single white flower with one row of corolla segment
7	Suvasini	A multi-whorled variety developed from cross between Single x Double, (developed by IIHR)
8	Mexican White Double	Creamy flower wit three row of corolla segments
9	Kalyani Single	Long single flowers, petals with creamy colour
10	Arka Nirantara	Single-flower type ,Single rows of petals, Flower Spike curvature Present
11	Sikkim Selection	Flowers are single but leaves are of variegated type
12	Hyderabad Double	More than three rows of corolla segment.
13	Mexican Single	Florets bearing single segment of corolla
14	GKTC-4	Single rows of petals , Flower Spike curvature Absent
15	Swarn Rekha	Doubled flowered type with golden yellow streak along the margin of leaf blade.
16	Phule Rajani	Single rows of corolla segment
17	Pearl Double	Flowers are pure white with more than three segments of corolla
18	Hyderabad Single	Single flower
19	SVPUAT-2	Single-flower type ,Single rows of petals
20	Pragya Culum Local	Single-flower type, long spike with white flower
21	Arka Sugandhi	Small size spike with more number of single florets

Results and Discussion

The mean values of twenty-one tuberose genotypes observed for different characters along with their range and critical differences are presented (**Table 2**). Analysis of variance revealed significant differences among the genotypes in terms of quantitative and qualitative traits (**Table 3**). Hyderabad Single took maximum days to sprouting (13.86 days) followed by, SVPUAT-1 (13.84 days) and Pragya Culum Local took minimum days to sprouting (10.98 days). GKTC-4 had the maximum plant height (60.46 cm) and minimum plant height (40.94 cm) was exhibited by genotype of Shringar. The maximum number of leaves per plant (59.00) was found in genotype Arka Sugandhi and minimum number of leaves per plant (36.90) was produced by genotype GKTC-4. The cultivar GKTC-4 gave the longest leaf (58.64 cm) followed by, SVPUAT-4 (56.85 cm) and minimum leaf length (38.64 cm) was found in genotype Shringar.

Table 2 Mean performance for Tuberose genotypes

TR no	Days taken to sprout	Plant Height (cm)	Number of leaves / plant	Length of longest longest leaf (cm)	Width of the longest leaf (cm)	Days required for visibility of first spike	Number of florets / spike	Diameter of floret (cm)	Number of spikes / clump	Length of spike (cm)
Shringar	12.65	40.94	51.27	38.64	1.51	58.54	42.56	3.47	1.94	68.89
SVPUAT-3	12.76	48.63	56.80	45.94	1.74	60.24	43.85	3.52	2.12	72.84
Vaibhav	12.40	51.94	50.00	49.00	1.78	61.56	48.64	3.62	1.86	70.94
Prajwal	13.40	47.46	52.64	44.00	1.52	59.64	46.25	4.18	1.94	74.56
SVPUAT-4	12.82	60.20	48.64	56.85	1.70	64.00	45.24	4.00	2.21	85.84
SVPUAT-1	13.84	42.64	48.00	40.00	1.82	60.56	44.94	3.81	1.50	70.24
Suvasini	12.56	49.85	51.24	46.85	1.56	61.94	43.00	3.70	1.58	74.56
Mexican White Double	11.20	46.50	40.65	44.00	1.54	58.69	40.00	3.41	1.68	70.56
Kalyani Single	13.65	49.64	44.00	46.45	1.60	60.25	42.56	3.68	1.38	68.94
Arka Nirantra	11.98	47.86	48.24	44.98	1.70	62.64	40.00	3.60	2.00	71.98
Sikkim Selection	12.00	46.00	40.00	42.00	1.98	66.75	46.56	3.84	1.76	68.37
Hyderabad Double	12.98	48.94	57.85	45.98	1.54	62.20	42.00	3.70	1.94	71.50
Mexican Single	13.00	51.20	55.00	49.65	1.85	59.64	50.80	2.98	1.86	70.68
GKTC-4	11.94	60.46	36.90	58.64	1.68	80.00	50.64	3.80	1.64	74.25
Swarna Rekha	12.62	51.44	54.54	48.24	1.90	58.64	53.20	3.76	2.05	73.00
Phule Rajani	13.20	55.28	39.56	53.00	1.75	62.00	40.56	3.61	1.86	72.56
Pearl Double	11.00	50.64	48.94	47.86	1.86	64.20	41.84	3.60	1.94	71.00
Hyderabad Single	13.86	48.24	52.20	45.69	1.64	65.46	45.64	3.85	1.89	71.98
SVPUAT-2	13.00	52.00	57.86	49.86	1.70	63.25	44.86	3.68	1.96	72.94
Pragya Culum Local	10.98	51.65	56.94	50.00	1.74	60.98	50.00	3.75	2.00	74.86
Arka Sugandhi	12.46	50.25	59.00	48.64	1.72	62.00	48.64	3.78	1.89	72.00
Mean	**12.59**	**50.08**	**50.01**	**47.44**	**1.71**	**62.53**	**45.32**	**3.68**	**1.86**	**72.50**
Range	10.98	40.94	36.90	38.64	1.51	58.54	40.00	2.98	1.38	68.37
	13.86	60.46	59.00	58.64	1.98	80.00	53.20	4.18	2.21	85.84
SE (d)	0.70	2.31	2.48	2.52	0.08	3.31	2.21	0.19	0.10	3.15
C.D.	1.43	4.69	5.02	5.11	0.17	6.72	4.49	0.39	0.20	6.39
C.V.	6.85	5.66	6.06	6.50	5.90	6.49	5.98	6.39	6.41	5.32

TR no	Length of rachis (cm)	Longevity of spike (days)	Vase life (days)	Number of bulbs per plant	Yield of bulb per plant (gm)	Diameter of bulb (cm)	Yield of bulb (q/ha)	Weight of bulb (gm)	Concrete %	Absolute %
Shringar	25.28	17.56	7.10	13.24	245.75	2.51	302.46	18.56	0.132	0.028
SVPUAT-3	27.50	18.46	7.56	15.86	278.56	2.68	324.80	17.52	0.148	0.046
Vaibhav	25.00	16.98	6.42	17.20	362.00	2.81	432.56	21.00	0.032	0.008
Prajwal	27.56	18.94	7.00	16.90	490.00	2.96	583.20	29.05	0.038	0.009
SVPUAT-4	29.00	18.00	8.12	18.12	588.50	2.54	690.84	18.00	0.160	0.042
SVPUAT-1	23.25	17.25	7.64	19.12	620.00	3.25	750.00	32.46	0.075	0.014
Suvasini	27.50	16.50	6.94	17.56	396.00	2.68	475.86	22.56	0.036	0.009
Mexican White Double	28.00	18.00	10.24	14.24	284.00	2.46	340.64	19.86	0.140	0.030
Kalyani Single	26.24	16.86	7.56	16.54	410.00	2.78	499.50	24.26	0.048	0.010
Arka Nirantra	25.64	18.94	8.94	17.00	305.46	2.62	370.84	17.86	0.138	0.029
Sikkim Selection	23.98	17.25	7.86	11.25	367.00	3.10	438.56	32.54	0.124	0.025
Hyderabad Double	25.00	19.46	9.00	17.84	356.00	2.58	440.56	20.00	0.029	0.007
Mexican Single	28.00	16.76	7.56	18.94	460.00	2.79	572.84	24.25	0.128	0.026
GKTC-4	30.46	17.54	6.94	12.25	550.00	3.50	640.56	45.00	0.118	0.028
Swarna Rekha	29.85	20.86	9.12	16.86	345.60	2.65	415.86	20.45	0.115	0.022
Phule Rajani	27.00	18.84	8.86	10.94	310.00	2.84	372.56	28.20	0.122	0.031
Pearl Double	29.00	17.94	7.52	9.84	272.00	2.75	341.54	27.56	0.114	0.024
Hyderabad Single	26.00	18.94	7.56	14.94	377.00	2.74	446.54	25.25	0.128	0.028
SVPUAT-2	25.96	21.00	9.58	16.12	305.64	2.51	373.00	18.92	0.028	0.009
Pragya	24.00	19.86	8.12	15.84	492.50	2.98	482.50	31.00	0.140	0.032
Culum Local										
Arka Sugandhi	29.84	20.00	8.86	14.12	280.84	2.54	347.50	19.86	0.146	0.034
Mean	**26.86**	**18.38**	**8.02**	**15.46**	**385.56**	**2.77**	**459.18**	**24.48**	**0.102**	**0.023**
Range	23.25	16.50	6.42	9.84	245.75	2.46	302.46	17.52	0.03	0.01
	30.46	21.00	10.24	19.12	620.00	3.50	750.00	45.00	0.16	0.05
SE (d)	1.43	0.94	0.42	0.82	20.10	0.15	26.00	1.29	0.005	0.002
C.D.	2.89	1.90	0.85	1.67	40.77	0.30	52.74	2.62	0.010	0.003
C.V.	6.50	6.24	6.43	6.52	6.38	6.50	6.94	6.45	6.14	8.26

The maximum width of longest leaf (1.98 cm) was recorded in genotype Sikkim Selection followed by, (1.90 cm) in Swarna Rekha, whereas, lowest leaf width (1.51 cm) was recorded in genotype Shringar. The variation in number of leaves per plant amongst the varieties might be due to variation amount of stored food material in mother corms expressed by their sizes. It could also be due to variation in rate of vegetative growth among the genotypes that could be attributed to their genetic makeup and could have been further influenced by the agro-climatic conditions. The results obtained from the study supported from the reports of [9-12]. The maximum days taken for visibility of first spike (80.00) was recorded in the genotype GKTC-4 and the cultivar Shringar emerged earlier spike (58.54 days). The days required for spike emergence is an important varietal character in tuberose and it might be primarily governed by the genetic makeup of the varieties. Spike emergence might have been primarily dependent on food reserves in plant that could be related to growth rate of plants regulating accumulation of the requisite level of carbohydrates for slipping. Similar results on varietal differences for spike emergence have reported by [10, 12, 13]. The results observed were in line with Chourasia et al., [14]. The genotype of Swarna Rekha produced maximum number of florets per spike (53.20), followed by (50.80 florets/ spike) in the genotype of Mexican Single and the minimum number of florets (40.00) was produced by each Arka Nirantra and Mexican White Double cultivars. The maximum

floret diameter (4.18 cm) was recorded in the genotype Prajwal, while the minimum diameter of floret (2.98 cm) was recorded in the genotype Mexican Single. The genotype SVPUAT-4 produced maximum number of spikes per clump (2.21) followed by, (2.12 spikes/clump) in the genotype SVPUAT-3 and the minimum number of spikes per clump (1.38) were recorded in the genotype Kalyani Single. The genotype SVPUAT-4 exhibited maximum length of spike (85.84 cm) followed by, Pragya Culum Local (74.86 cm) and the minimum spike length (68.37 cm) gave by the Sikkim Selection cultivar. The longest rachis (30.46 cm) was produced by the genotype GKTC-4 whereas, the shortest length of rachis (23.25 cm) was found in the genotype SVPUAT-1. The genotype SVPUAT-2 was observed to have maximum longevity of spike (21.00 days), while the genotype Suvasini showed minimum longevity of spike (16.50 days). The variation in flowering traits might be due to hereditary traits of different varieties. The results also find support from findings of [10, 14, 15].

Table 3 Analysis of variance (ANOVA) for twenty characters of Tuberose

Source of Variation	DF	Days taken to sprout	Plant Height (cm)	Number of leaves / plant	Length of longest longest leaf (cm)	Width of the longest leaf (cm)	Days required for visibility of first spike	Number of florets / spike	Diameter of floret (cm)	Number of spikes / clump	Length of spike (cm)
Replication	2	0.24	11.41	10.53	4.26	0.01	9.54	8.45	0.026	0.04	3.05
Treatment	20	2.12**	65.62**	131.02**	70.16**	0.05**	62.74**	43.86**	0.17**	0.12**	38.56**
Error	40	0.74	8.03	9.19	9.50	0.01	16.48	7.34	0.06	0.01	14.89
Source of Variation	**DF**	**Length of rachis (cm)**	**Longevity of spike (days)**	**Vase life (days)**	**Number of bulbs per plant**	**Yield of bulb per plant (gm)**	**Diameter of bulb (cm)**	**Yield of bulb (q/ha)**	**Weight of bulb (gm)**	**Concrete %**	**Absolute %**
Replication	2	4.88	1.58	1.73	3.56	2905.16	0.13	4660.28	20.39	0.0005	0.0000
Treatment	20	12.93**	5.25**	2.98**	21.37**	35836.18**	0.21**	46668.47**	139.84**	0.0065**	0.0004**
Error	40	3.05	1.32	0.27	1.02	605.86	0.03	1013.95	2.49	0.0001	0.0000

** significant at 5%

The maximum vase life (10.24 days) was recorded in genotype Mexican White Double and minimum vase life was observed with genotype Vaibhav (6.42 days). The vase life could be dependent upon carbohydrate reserve of the plants as blooming is an energy requiring process. Similar results were also reported by [12]. Among the genotypes, SVPUAT-1 produced the maximum number of bulbs per plant (19.12) and lowest number of bulbs per plant was found in genotype Pearl Double (9.84). The maximum yield of bulb per plant (620.00 g) was found in genotype SVPUAT-1, followed by, SVPUAT-4 (588.50 gm) whereas the minimum yield of bulbs per plant was found in genotype Shringar (245.75 g). The genotypes GKTC-4 produced larger size of bulb (3.50 cm) while the genotype Mexican White Double showed minimum bulb diameter (2.46 cm). The maximum yield of bulb (750.00 q/ha) was found in genotype of SVPUAT-1 and the minimum yield of bulb (302.46 q/ha) were found in genotype Shringar. The genotype GKTC-4 produced maximum weight of bulb (45.00 g), while SVPUAT-3 produced the lowest weight of bulbs (17.52 g). It might be due to partitioning of the food material and its less availability for accumulation into individual corm. Similar, results on corm diameter have been reported by [10, 14]. The maximum concrete (0.160%) was obtained from genotype SVPUAT-4 and the genotype SVPUAT-2 had minimum concrete (0.028%). The maximum absolute (0.046%) obtained from the genotype of SVPUAT-3 and it was minimum (0.008%) recorded in Vaibhav. Genetic variation may be the one of the reason for the variation in essential oil contents in the examined species. This is in accordance with the results of [16-18].

The genotypes were significantly different from each other with their morphological and qualitative traits. D^2 values also varied significant differences among the genotypes on quantitative and qualitative traits. Based on the degree of divergence 21 genotypes were grouped into six clusters on the basis of cluster analysis (**Table 4**). Swaroop, [19] formed eight clusters in 28 gladiolus genotype based on twelve characters, The maximum six entries were grouped into the cluster II followed by, five in cluster V, four in cluster I, three in cluster III, two in clusters VI. The cluster IV contained the lowest one genotype. This view has been supported by the earlier findings [20-22].

Table 4 Distribution of twenty one genotypes of Tuberose

Clusters	No of genotypes	Genotype name
I	4	SVPUAT-1, Shringar, Sikkim Selection, Mexican Single
II	6	Pearl Double, Vaibhav, Suvasini, Mexican White Double, Hyderabad Double, Arka Sugandhi
III	3	GKTC-4, SVPUAT-2, Pragya Culum Local
IV	1	Arka Nirantra
V	5	Prajwal, Phule Rajani, Hyderabad Single, SVPUAT-4, Kalyani Single
VI	2	Swarna Rekha , SVPUAT-3

Intra and inter-cluster distance are presented in **Table 5**. Inter-cluster distances were larger than the intra-cluster distance indicating presence of wider diversity among genotypes of distance groups. The highest intra cluster value 3.779 was recorded in cluster V and the highest inter-cluster value 10.099 was recorded between Cluster- IV and VI, followed by (9.994) in the cluster I and IV and minimum inter cluster value (3.960) was observed between I and III, which clearly indicated variability existed in the germplasm of different clusters. The cluster IV and VI produced the highest inter-cluster distances suggesting wide diversity of the genotypes within this group and the genotypes in these clusters could be used as parents in hybridization program for getting transgressive segregants. The minimum inter-cluster diversity was observed between cluster I and III (3.960) and cluster I and V (4.350) indicating that the genotypes of these clusters were genetically closed and hence, may not be emphasized upon to be used in hybridization programme. Arunachalam, [23] also stated that genotypes belonging to the cluster with maximum inter cluster distance are genetically more divergent. Therefore, it is suggested that selection of genotypes based upon large cluster distances from all the clusters may lead to favourable broad spectrum genetic variability for bulb yield improvement.

Table 5 Average intra and inter cluster (D^2) value distance in Tuberose

Clusters	I	II	III	IV	V	VI
I	**2.603**					
II	4.716	**3.049**				
III	3.960	4.556	**2.677**			
IV	9.994	8.137	7.408	**1.254**		
V	4.350	4.448	4.527	8.027	**3.779**	
VI	4.551	4.233	5.570	10.099	4.616	**1.255**
Bold values = Intra cluster distances						

The maximum intra cluster distance was found (3.779) for Cluster V followed by, (3.049) for Cluster- II, (2.677) for Cluster- III, (2.603) for Cluster- I, (1.255) for Cluster- VI and minimum intra cluster (1.254) was observed for Cluster IV. Therefore, the genotypes of various clusters do not differ so significantly with regards to their relative genetic distance as indicated from the low variation of D^2 values. It is obvious that in all the cases, the intra-cluster distances were low for all the six clusters with the range of 1.254 in cluster IV to 3.779 in cluster V which indicated homogeneous nature of the genotypes within the clusters. The results were supported by the findings [19-21].

Estimates of the cluster means for different traits are measures of inter cluster divergence and degree of homogeneity. Hence, cluster means were worked out (**Table 6**), which indicated that different clusters were superior with respect to various traits. The divergence cluster mean value for twenty characters showed that different clusters have higher mean values for different traits indicating that few clusters contained genotypes with most of the desirable characters. The highest cluster means for absolute (%) and concrete (%) were obtained from cluster I (Table 6). The days taken to sprout, diameter of floret and number of bulbs per plant were found in cluster II and Width of the longest leaf (cm) were found in cluster III. The genotypes of the cluster IV contains higher mean values for maximum characters namely, plant height, length of the longest leaf (cm), days required for the visibility of the first spike, number of florets per spike, length of rachis (cm), yield of bulb per plant (gm), diameter of bulb (cm), yield of bulb (q/ha), weight of bulb (gm) and concrete (%). The number of spikes per clump and length of spike (cm) were found in cluster V and characters like number of leaves per plant, longevity of spike (days) and vase life (days) were found in cluster VI. The clusters VI, V, and III had more and less average values for most of the traits like yield and yield contributory traits. Keeping in view the above aspects, the genotypes "SVPUAT-4 and Maxican Single" from Cluster I, "Arka Sugandhi and Maxican White Double" from cluster II, "SVPUAT-2 and Pragya Culum Local" from cluster III, SVPUAT-4 from cluster V and 'SVPUAT-3' from cluster VI, respectively deserve to be considered as potent parents for further utilization in tuberose improvement programme. Therefore, based on D^2 analysis, it has

been understood that characters need to be given more weightage, while selecting parents for improvement. [19, 24] also reported that the desired characters need to be given more weightage, while selecting parent for improvement. The analysis of genetic diversity in tuberose genotypes will help us in avoiding duplicates and minimize the efforts for maintenance of germplasm. This study also suggested that there is good scope for section of varieties for desirable traits and cultivation in different part of the country for higher productivity.

Table 6 Cluster mean values for twenty characters in Tuberose

Chr		Days taken to sprout	Plant Height (cm)	Number of leaves / plant	Length of longest longest leaf (cm)	Width of the longest leaf (cm)	Days required for visibility of first spike	Number of florets / spike	Diameter of floret (cm)	Number of spikes / clump	Length of spike (cm)
I	Mean	12.15	45.98	49.24	43.39	1.62	60.03	41.60	3.50	1.93	71.07
	SE±	0.72	3.48	6.73	3.26	0.11	1.90	1.92	0.08	0.19	1.73
II	Mean	13.28	48.30	49.68	45.33	1.65	61.57	45.17	3.81	1.69	71.87
	SE±	0.65	3.17	3.25	3.08	0.12	2.09	2.24	0.20	0.23	2.31
III	Mean	12.07	50.64	42.83	47.62	1.86	64.32	42.99	3.68	1.85	70.64
	SE±	1.10	4.64	5.29	5.50	0.12	2.38	3.16	0.14	0.09	2.12
IV	Mean	11.94	60.46	36.90	58.64	1.68	80.00	50.64	3.80	1.64	74.25
	SE±	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V	Mean	12.38	52.95	54.82	50.68	1.78	61.05	49.58	3.65	2.00	75.28
	SE±	0.81	4.09	3.88	3.53	0.09	2.09	2.94	0.39	0.14	6.10
VI	Mean	12.99	50.47	57.85	47.92	1.62	62.72	43.43	3.69	1.95	72.22
	SE±	0.01	2.16	0.02	2.74	0.11	0.74	2.02	0.01	0.01	1.02
Chr		**Length of rachis (cm)**	**Longevity of spike (days)**	**Vase life (days)**	**Number of bulbs per plant**	**Yield of bulb per plant (gm)**	**Diameter of bulb (cm)**	**Yield of bulb (q/ha)**	**Weight of bulb (gm)**	**Concrete%**	**Absolute%**
I	Mean	26.60	18.24	8.46	15.09	278.44	2.57	334.68	18.45	0.14	0.03
	SE±	1.35	0.59	1.42	1.67	24.70	0.10	28.75	1.03	0.01	0.01
II	Mean	25.93	17.58	7.19	17.04	442.50	2.87	531.28	25.76	0.06	0.01
	SE±	1.63	1.08	0.48	1.36	97.73	0.21	119.62	4.27	0.04	0.01
III	Mean	26.66	18.01	8.08	10.68	316.33	2.90	384.22	29.43	0.12	0.03
	SE±	2.53	0.80	0.70	0.74	47.82	0.18	49.55	2.71	0.01	0.00
IV	Mean	30.46	17.54	6.94	12.25	550.00	3.50	640.56	45.00	0.12	0.03
	SE±	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
V	Mean	28.14	19.10	8.36	16.78	433.49	2.70	501.91	22.71	0.14	0.03
	SE±	2.43	1.67	0.63	1.90	121.70	0.19	134.49	5.16	0.02	0.01
VI	Mean	25.48	20.23	9.29	16.98	330.82	2.55	406.78	19.46	0.03	0.01
	SE±	0.68	1.09	0.41	1.22	35.61	0.05	47.77	0.76	0.00	0.00

Conclusion

The genotypes having varied performances were grouped in to six clusters following Tocher's method on the basis of D^2 values for clustering the population into clusters and sub-clusters. Thus this grouping of genotypes has great relevance to the future breeding programme and the genotypes included in diverse clusters are likely to produce potential hybrids. Once the desirable hybrids are obtained they could be maintained and multiplied through asexual reproduction for commercial use.

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