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Genetic variability and diversity study in tuberose (*Polianthes tuberosa* L.)

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Abstract

Twenty seven genotypes of tuberose (*Polianthes tuberosa* L.) were evaluated for growth, flower and bulb yield parameters at ICAR-Indian Institute of Horticultural Research, Bangalore during the year 2017-18 to assess their genetic variability and diversity. Significant differences among genotypes for all the traits except number of bulblets per clump in single and tepal thickness in double genotypes were observed through analysis of variance. Wide ranges in mean performance of different biometric parameters were recorded for both single and double cultivars of tuberose. High phenotypic coefficient of variation and genotypic coefficients of variation were recorded for number of leaves per clump, spike length, rachis length, weight of single floret, matured bud weight and number of spikes per clump in single tuberose genotypes. High PCV and GCV were observed for number of leaves per clump, duration of flowering, number of spikes per clump and weight of florets per spike were recorded in double tuberose genotypes. High heritability and genetic advance as percent of mean were registered for plant height, number of leaves per clump, duration of flowering, spike length, rachis length, number of florets per spike, weight of single floret, mature bud weight and number of spikes per clump in single and double tuberose genotypes. The genotypes studied were grouped into nine clusters, indicating the presence of wide range of genetic diversity. The maximum numbers of eight genotypes were grouped into cluster IV. The inter cluster distance was noticed maximum (75.98) between the cluster VIII and IX, indicating that the genotypes belonging to these groups were genetically most divergent and the genotypes included in these clusters can be used as parents in hybridization. Cluster IV had the highest mean values for plant height (42.68), duration of flowering (178.70) and spike yield per plant/spikes per clump (3.65) and spike yield per plant contributed the highest (36.75%) towards genetic divergence. The genotypes with superior traits, highest cluster mean can be selected as donor parents in the hybridization programme for development of superior variety.

Keywords: PCV, GCV, single, double cultivars, heritability

Introduction

Tuberose (*Polianthes tuberosa* L. belongs to the family Asparagaceae is a bulbous fragrant ornamental plant, native to Mexico (Trueblood, 1973) [27]. Tuberose occupies a prime position in Indian floriculture industry in the form of loose flowers and cut flowers. The highly fragrant single type tuberose cultivars contain 0.08 to 0.14% concrete which is used in high grade perfumes. It is commercially cultivated in India in an area of about 16.19 ('000 ha), with a loose flower production of 107.91 ('000 MT) and cut flower production of 89.29 (Lakh Nos.) of cut stems (Anon, 2016) [1]. The tuberose flowers are valued much for their sweet and lingering pleasant fragrance and longest shelf life. Due to the above it has gained considerable commercial importance and cultivated for its varied uses. The increase in demand necessitates the development of high flower and concrete yielding varieties in tuberose.

Exploration of genetic variability in the available tuberose germplasm is a pre-requisite in a breeding programme which provides ample scope for selecting superior and desired genotypes by the plant breeders for further improvement. High heritability along with high genetic advance can be used for efficient selection (Johnson *et al.* 1955) [8]. Genetic diversity plays a pivotal role in selecting the suitable parents for hybridization programme resulting in superior hybrids and desirable recombinants (Rathi *et al.*, 2011) [20]. Tyagi (1978) [28] and Shanmugam (1983) [22] also emphasized that the genotypes with greater divergence should be involved in Hybridization programme. The main aim of the breeder is to develop high yielding varieties and the knowledge on the degree of relationship between yield and its contributing characters is also essential.

Keeping the above in view, the present investigation was carried out with an objective to determine the genetic variability and diversity in tuberose which would be helpful in designing future breeding programme.

Material and Methods

The field experiment was conducted at the Division of Floriculture and Medicinal Crops, ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru. ICAR-IIHR is situated at an altitude of 930 meter above mean sea level and latitude 12^0 58´ North latitude, 78^0 45´ East longitude, respectively. The experiment was laid out in randomized block design with three replications. A total of twenty seven tuberose genotypes which includes18 single and 9 double types were evaluated and the mean performance, phenotypic and genotypic coefficient of variations, heritability and genetic advance as percent of mean of various biometrical traits were assessed. Uniform size of bulbs (2.5cm dia) was planted at a spacing of 30 x 30 cm and standard cultural practices were followed. The observations on quantitative parameters such as plant height, number of leaves per clump, days to spike appearance, spike length, rachis length, number of florets per spike, length of the floret, floret tube length, diameter of the floret, weight of single floret, matured bud weight, duration of flowering and number of spikes per clump were recorded. The data recorded were subjected to statistical analysis. The genetic divergence was estimated using Mahalanobis D^2 statisitcs and the group constellations were formed according to Tochers method as described by Rao (1952) [19].

Results and Discussion

Genetic parameters of single tuberose genotypes for growth, flower and bulb yield traits

Analysis of variance for the 18 tuberose genotypes showed significant differences for all the characters except number of bulblets per clump. The phenotypic coefficient of variance, genotypic coefficient of variance, heritability and genetic advance as percent of mean for twenty two characters of 18 single genotypes of tuberose were presented in the Table 1. The differences between GCV and PCV values were minimum implying least influence of environment and additive gene effects indicating genotypes can be improved and selected for these characters. The phenotypic coefficient of variation was greater than genotypic coefficient of variation and high phenotypic coefficient of variation and genotypic coefficients of variation were recorded for number of leaves (48.38%, 48.18%), spike length (23.52%, 23.39%), rachis length (22.58%, 21.77%), weight of single floret (22.59%, 26.75%), matured bud weight (39.68%, 38.97%) and number of spikes per clump (29.60%, 28.22%), respectively suggesting that these characters are under genetic control. Hence, these characters can be relied upon for further selection and improvement. In accordance to this result, Gurav *et al.* (2005) [6], Ranchana *et al*. (2013) [18], Vanlalruati *et al.* (2013) [29], Ranchana *et al*. (2015) [17] and Gaidhani *et al.* (2016) [5] were also reported higher value of PCV than GCV for different characters in tuberose. However, narrow differences between PCV and GCV were observed for all the attributes under study, indicating a less degree of environmental influence in the expression of the characters which are mostly stable. Moderate phenotypic and genotypic coefficients of variation were recorded for plant height (12.06%, 11.92%), days to spike appearance (13.18%, 13.13%), duration of flowering (12.33%, 11.56%) and number of florets per spike (11.85%, 11.41%), respectively. Whereas Gurav *et al.* (2005) [6] reported low degree of variability in case of days to flowering. Low phenotypic and genotypic coefficients of variation were recorded for length of the floret (7.78%, 7.46%), flower tube length (9.11%, 8.28%), diameter of the floret (9.83%, 9.53%) and matured bud length (8.65%, 8.36%). These findings indicated that very minimum variation existed among the genotypes with respect to these characters. Similar results were observed by Gaidhani *et al.* (2016) [5].

The heritability and genetic advance as percent of mean were registered high for plant height (97.68%, 24.27%), number of leaves per clump (98.19%, 98.86%), days to spike appearance (99.22%, 26.93%), duration of flowering (87.88, 22.32), spike length (98.84%, 47.90%), rachis length (92.98%, 43.25%), number of florets per spike (92.79%, 22.65%), weight of single floret (93.99%, 53.42%), mature bud weight (96.50%, 78.87%), number of spikes per clump (90.89%, 55.12%), respectively. This indicated the lesser influence of environment in the expression of these characters and prevalence of additive gene action in their inheritance. Hence, these traits are found suitable for selection. Similar results were obtained by Gurav *et al.* (2005) [6] and Vanlalrauti *et al.* (2013). Whereas, Gaidhani *et al.* (2016) [5] reported high heritability and low genetic advance as percent mean for number of leaves. High heritability coupled with moderate genetic advance as percent of mean was noticed for length of the floret (91.97%, 14.73%), flower tube length (82.61%, 15.50%), diameter of the floret (93.89%, 19.02%) and matured bud length (93.34%, 16.63%), respectively. Gurav *et al.* (2005) [6] observed high heritability with moderate genetic advance for number of florets per spike and days to flowering, indicating the presence of dominance or epistatic gene effects inferring that these characters could be improved through hybridization.

Genetic parameters of double tuberose genotypes for growth, flower and bulb yield traits

The analysis of variance for the nine double tuberose genotypes showed significant differences for all the characters. The phenotypic coefficient of variance, genotypic coefficient of variance, heritability and genetic advance as percent of mean for twenty characters of nine double genotypes of tuberose were presented in the Table 2. High phenotypic coefficient of variation and genotypic coefficients of variation were recorded for number of leaves per clump (28.62%, 28.28%), duration of flowering (22.98%, 22.98%), number of spikes per clump (36.00%, 33.80%), weight of florets per spike (26.71%, 25.24%), respectively. This indicated that these characters are under genetic control and lesser influence of environment in the expression of these characters and prevalence of additive gene action in their inheritance. High GCV and PCV indicated the scope for selection in favour of further improvement. Generally PCV's were higher than the corresponding GCV's for all the attributes under study, indicating that traits interacted with environment. Results are in line with reports of Gurav *et al.* (2005) [6] in tuberose. Similar results were also found by, Janakiram and Rao (1991) [7] in African marigold for total flower yield per plant and Katwate *et al.* (2002) [6] in gladiolus. High phenotypic and moderate genotypic coefficients of variation were recorded for weight of single floret (20.09%, 18.10%), respectively. Moderate phenotypic coefficient of variation and genotypic coefficients of variation were recorded for plant height (11.71%, 10.75%), days to spike appearance (13.39%, 10.51%), spike length (15.89%, 15.77%), rachis length (18.29%, 15.60%), number of florets per spike (11.92%, 10.98%), flower tube length (15.62%, 15.37%), matured bud weight (14.63%, 12.62%), respectively indicating the possibility of further improvement of genotypes through these characters. Low phenotypic and genotypic coefficients of variation were recorded for length of the floret (7.92%, 7.36%), diameter of the floret (6.71%, 5.75%) and matured bud length (7.16%, 6.81%), respectively. The present findings indicating that very minimum variation existed among the genotypes with respect to these characters. Similar results were observed by Ranchana *et al.* (2013) [18] in tuberose. The phenotypic coefficients of variation were higher than the genetic coefficients of variation, indicating the role of environment in expression of genotype. Similar results were obtained by Kishore and Raghava (2001) [11] and Namita *et al*. (2008) [15] in marigold. Narrow differences between genotypic and phenotypic coefficient of variation revealed that variability existing among different genotypes of tuberose was mainly due to genetic makeup and there is less environmental influence on the expression of these traits, Singh and Misra (2008) [15, 25].

The heritability and genetic advance as percent of mean were registered high for plant height (84.27%, 20.32%), number of leaves per clump (97.63%, 57.56%), duration of flowering (99.71%, 47.20%), spike length (98.54%, 32.25%), rachis length (72.77%, 27.42%), number of florets per spike (84.78%, 20.82%), flower tube length (96.86%, 31.17%), weight of single floret (89.42%, 37.01%), matured bud weight (74.44%, 22.44%), number of spikes per clump (88.13%, 65.37%), weight of florets per spike (89.34%, 49.16%), respectively. The high heritability coupled with high genetic advance confirmed the prevalence of additive gene action and lesser influence of environment in the expression of these characters. Hence, these traits are found suitable for selection. Results are in line with the observations of, Gurav *et al.* (2005) [6] in tuberose, Nair and Dwivedi (2006) [14] in gladiolus and Ranchana *et al.* (2013) [18] in tuberose. High heritability coupled with moderate genetic advance as percent mean of percent was noticed for days to spike appearance (61.60%, 16.99%), length of the floret (86.52%, 14.11), diameter of the floret (73.35%, 10.14%) and matured bud length (90.38%, 13.33%), respectively suggesting the presence of both additive and non-additive gene actions and simple selection offers best possibility of improvement of this trait. Results are in line with the observations of Ranchana *et al.* (2013) [18].

Diversity analysis for single and double tuberose genotypes

The genetic divergence analysis showed highly significant differences among the genotypes for all the thirteen growth characters studied, indicating appreciable amount of variability among the genotypes.

Clustering based on D^2 statistics grouped tuberose genotypes into nine clusters, indicating the presence of wide range of genetic diversity among the genotypes under investigation. The details regarding each cluster, source of origin of the types included in each cluster are furnished in Table 3. The maximum numbers of eight genotypes were grouped into cluster IV followed by cluster III comprising of five genotypes, cluster I with four genotypes and other four clusters (II, V, VI and VII) include each of two genotypes, Cluster VIII and IX were solitary. It was observed that genotypes representing diversified geographic regions of their adoption were grouped together, even though their area of adoption is different. This may be the result of unidirectional selection practiced by plant breeders of different states, Singh and Bains, (1968) [26] or exchange of materials between various regions. Similar results were observed by Walia and Garg (1996) [30], Dotlacil *et al.* (2000) [4] and Bergale *et al.* (2001) [2] who reported non-parallelism between geographic and genetic diversity. Sharma *et al.* (1998) [23] also reported that the genotypes of heterogeneous origin or place of release and of different ploidy levels often grouped together in the same cluster, suggesting some degree of ancestral relationship between the genotypes. But, Murthy and Arunachalam (1966) [13] were of the opinion that the wide adaptability would be possible due to factors like heterogeneity, genetic architecture of populations, past selection history, developmental traits and degrees of general combining ability. The results are in consonance with the findings of Bharathi and Jawaharlal (2014) [3] in marigold and Ranchana *et al.* (2015) [17] in tuberose.

The intra- and inter cluster D^2 values among 27 genotypes of tuberose is presented in Table 4. The intra cluster distances ranged from 0.00 to 33.80. The highest intra cluster distance was recorded in Cluster IV (33.80) followed by cluster I (29.45) and lowest intra cluster distance was shown by cluster VIII and IX (0.00). The inter cluster distance was noticed maximum (75.98) between the cluster VIII and IX, indicating that the genotypes belonging to these groups were genetically most divergent and the genotypes included in these clusters can be used as parents in hybridization programmes to get higher heterotic hybrids (Mehta and Asati, 2008) [12]. Simultaneously, the cluster V recorded higher inter cluster distance with Cluster VIII (64.08) which indicates that genotypes included in these clusters also possess considerable genetic diversity among themselves. Such genetically diverse tuberose genotypes can be effectively utilized as parents in hybridization programmes followed by cluster VII and VIII (55.77) while it was minimum between cluster II and VI (15.26). It is desirable to select genotypes from clusters showing high inter cluster distance with high yield as parents in recombination breeding programmes for obtaining desirable segregants. This type of hybridization would be useful for obtaining highest number of valuable segregants along with maximized vigour (Shinde *et al*. 2013) [24]. Minimum cluster distance was observed between the Clusters II and VII and null intra cluster distances were recorded by the clusters having single genotype. The results are in conformity with the findings of Karuppaiah *et al*. (2006) [9]; Nimbalkar *et al*. (2005) [16], Kavitha and Anburani (2009) [10].

The cluster means of 27 genotypes (Table 5) showed that the mean value of clusters varied in magnitude for all the thirteen characters. Cluster III had the highest cluster mean values for flower tube length (4.38), Cluster IV had the highest mean values for plant height (42.68), duration of flowering (178.70) and spike yield per plant/spikes per clump (3.65). Cluster V had the highest mean values for rachis length (27.88) and least mean value for length of the floret (5.60). Cluster VI had the highest mean value for number of florets per spike (53.80) and length of the floret (6.26) and least mean value for plant height (35.33) and spike length (58.67). Cluster VII had highest mean values for diameter of the floret (4.80) and weight of single floret (3.27). Cluster VIII had the highest mean values for number of leaves (165.10), duration of flowering (171.80) and least mean value for days to spike appearance (112.02), rachis length (13.20), number of florets per spike (43.10), diameter of the floret (3.97), weight of single floret (1.14) and matured bud weight (0.81). Cluster IX had the highest mean values for days to spike appearance (176.50), spike length (95.25), weight of single floret (3.27), matured bud weight (2.25) and least mean value for number of leaves (32.90), flower tube length (2.28), duration of flowering (68.20) and spike yield per plant (1.20). Depending upon the aim of breeding, the potential lines are to be selected based on the distance from different clusters as parents in a hybridization programme. The clustering pattern could be utilized in choosing parents for cross combinations likely to generate the highest possible variability for various economic characters. The results indicated that the spike yield per plant contributed the maximum towards genetic divergence. These findings derive support from the results of Saravanakumar (2000) [21] and Ranchana *et al.* (2015) [17] in tuberose.

The rank given to each character in each combination was utilized for estimating the relative contribution of each character. The number of times each character appeared in the first rank is presented in Table 6. Spike yield per plant contributed the highest (36.75%) towards genetic divergence followed by number of leaves (20.22%), spike length (11.96%), duration of flowering (7.40%), flower tube length (6.26%), number of florets per spike (5.98%), diameter of the floret (4.27%), length of the floret (2.27%), weight of single floret (1.99%), matured bud weight (1.99%) and plant height (0.85%). These traits could be used in selecting desired genotypes for further selection and choice of parents for hybridization and creation of more variability. There was no genetic diversity towards days to spike appearance and rachis length.

It is concluded from the present study that the considerable amount of heritable genetic variation is present in tuberose genotypes. High heritability and genetic advance as percent of mean were registered for plant height, number of leaves per clump, duration of flowering, spike length, rachis length, number of florets per spike, weight of single floret, mature bud weight and number of spikes per clump confirmed the prevalence of additive gene action and lesser influence of environment in the expression of these characters. Genetic diversity study revealed that the genotypes belongs to Cluster VIII and IX, were genetically most divergent. Further for generating wider genetic variability the genotypes included in these clusters can be used as parents in hybridization.

Table 1: Mean performance and variability of tuberose genotypes single for growth, flowering and yield parameters

Character	Range	Mean	S.Ed	CD (P=0.05)	Significance level	PCV (%)	GCV (%)	Heritability (%)	GA as percent of mean
Plant height (cm)	31.96 -53.72	41.76	0.77	1.62	**	12.06	11.92	97.68	24.27
Number of leaves per clump	16.10-165.10	73.14	3.19	6.73	**	48.38	48.18	99.19	98.86
Days to spike appearance	100.24-165.16	125.61	1.47	3.09	**	13.18	13.13	99.22	26.93
Days to first floret opening	17.33- 30.14	22.62	0.93	1.97	**	15.65	15.10	93.05	29.10
Duration of flowering (days)	128.50 -203.90	166.32	7.14	15.06	**	12.33	11.56	87.88	22.32
Spike length (cm)	52.35 -108.52	77.43	1.96	4.13	**	23.52	23.39	98.84	47.90
Rachis length (cm)	13.20 - 28.40	19.83	1.19	2.50	**	22.58	21.77	92.98	43.25
Diameter of cut spike (cm)	4.32 -12.53	9.44	0.73	1.53	**	23.76	22.48	89.52	43.81
Number of florets per spike	37.40 -55.90	48.44	1.54	3.25	**	11.85	11.41	92.79	22.65
Length of the floret (cm)	5.51 -7.07	6.10	0.14	0.28	**	7.78	7.46	91.97	14.73
Flower tube length (cm)	3.54 -4.90	4.23	0.16	0.34	**	9.11	8.28	82.61	15.50
Diameter of floret (cm)	3.75 -5.32	4.46	0.11	0.23	**	9.83	9.53	93.89	19.02
Tetal thickness (mm)	0.89 -1.85	1.24	0.02	0.03	**	18.17	18.14	99.59	37.27
Weight of single floret (g)	0.99 -2.27	1.44	0.10	0.21	**	27.59	26.75	93.99	53.42
Weight of 100 florets (g)	98.58 -226.95	143.88	9.74	20.50	**	27.57	26.72	93.97	53.36
Matured bud length (cm)	5.04 -6.80	5.67	0.13	0.27	**	8.65	8.36	93.34	16.63
Matured bud weight (g)	0.72 -2.21	1.13	0.09	0.18	**	39.68	38.97	96.50	78.87
Number of spikes per clump	1.50 -5.10	3.29	0.29	0.62	**	29.60	28.22	90.89	55.12
Flower yield per ha/year (tonnes)	5.63 - 38.26	15.38	1.54	3.25	**	58.47	57.61	97.08	64.94
Number of bulbs per clump	2.00 -9.50	5.06	1.23	2.59	**	43.24	35.79	68.54	61.04
Weight of the bulb (g)	14.71 -52.63	28.50	2.00	4.22	**	36.72	36.05	96.34	72.89
Number of bulblets per clump	14.50-43.50	28.97	10.17	NS	NS	42.00	23.06	30.15	26.09

Table 2: Mean performance and variability of double tuberose genotypes for growth, flowering and yield parameters

Character	Range	Mean	S.Ed	CD (P=0.05)	Significance level	PCV (%)	GCV (%)	Heritability (%)	GA as percent mean
Plant height (cm)	33.32-45.96	39.98	1.18	2.51	**	11.71	10.75	84.27	20.32
Number of leaves per clump	33.67-73.80	45.53	1.64	3.47	**	28.62	28.28	97.63	57.56
Days to spike appearance	136.53- 177.13	151.92	10.29	21.81	**	13.39	10.51	61.60	16.99
Days to opening of first floret	18.13-43.20	32.16	0.96	2.03	**	29.15	28.92	98.43	59.11
Duration of flowering (days)	67.93-183.98	152.64	1.55	3.28	**	22.98	22.98	99.71	47.20
Spike length (cm)	61.38-105.49	84.81	1.33	2.82	**	15.89	15.77	98.54	32.25
Rachis length (cm)	18.70-34.60	26.73	2.08	4.42	**	18.29	15.60	72.77	27.42
Diameter of cut spike (mm)	8.70-10.94	9.76	0.47	1.00	**	9.387	7.29	60.30	11.66
Number of florets per spike	37.53-56.33	49.05	1.86	3.95	**	11.92	10.98	84.78	20.82
Length of the floret (cm)	5.38-6.92	5.97	0.14	0.30	**	7.92	7.36	86.52	14.11
Flower tube length (cm)	2.25-3.91	3.27	0.07	0.16	**	15.62	15.37	96.86	31.17
Diameter of floret (cm)	4.24-5.15	4.58	0.13	0.28	**	6.71	5.75	73.35	10.14
Tetal thickness (mm)	1.02-1.36	1.22	0.11	NS	-	12.40	4.67	14.20	3.63
Weight of single floret (g)	2.07-3.61	2.72	0.15	0.31	**	20.09	18.10	89.42	37.01
Matured bud length (cm)	4.75-6.00	5.26	0.10	0.20	**	7.16	6.81	90.38	13.33

Number of spikes per clump	1.13-3.93	2.53	0.26	0.54	**	36.00	33.80	88.13	65.37
Weight of florets per spike (g)	85.59-203.33	133.90	9.53	20.21	**	26.71	25.24	89.34	49.16
Number of bulbs per clump	1.67-8.33	4.67	0.55	1.17	**	45.74	43.37	89.94	84.74
Weight of the bulb (g)	20.55-39.13	30.10	2.13	4.51	**	16.82	13.24	81.36	33.57
Number of bulblets per clump	17.67-82.67	47.52	3.10	6.58	**	43.92	43.19	96.68	87.48

Table 3: Constitution of D2 of tuberose genotypes

Cluster	Number of genotypes	Name of the genotypes
I	4	Arka Shringar, IIHR-6, Pearl Double, Hyderabad Double
II	2	Hyderabad Single, Phule Rajani
III	5	Mexican Single, 1x6(1), 1x6(2), IIHR-11, Arka Vaibhav
IV	8	Variegated, Arka Sugandhi, Arka Prajwal, Arka Nirantara, IIHR-12, Bidhan Rajani-1, Bidhan Rajani-3, IIHR-2
V	2	IIHR-5, Calcutta Double
VI	2	Bidhan Rajani-2, GK-T-C4
VII	2	Arka Suvasini, IIHR-4
VIII	1	Calcutta Single
IX	1	Suarna Rekha

Table 4: Intra and inter cluster distance variation for different traits in tuberose genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	29.457	29.516	32.812	31.168	26.019	32.767	28.240	53.575	36.604
II		8.592	27.750	29.173	34.091	15.260	25.771	50.332	48.127
III			28.486	33.796	39.581	31.632	32.967	38.495	53.564
IV				33.820	31.474	30.898	31.352	54.995	45.527
V					20.061	34.989	28.479	64.080	28.105
VI						21.185	28.364	55.476	49.390
VII							23.017	55.770	40.950
VIII								0.000	75.986
IX									0.000

Table 5: Cluster means for different traits in tuberose genotypes

Cluster	Plant height (cm)	No. of leaves per clump	Days to spike appearance	Spike length (cm)	Rachis length (cm)	No. of florets per spike	Length of the floret (cm)	Flower tube length (cm)	Floret diameter (cm)	Weight of single floret (g)	Matured bud weight (g)	Duration of flowering (days)	No. of spikes per clump
I	42.46	60.57	155.95	88.98	22.24	49.00	5.79	3.89	4.58	2.05	1.38	145.60	2.40
II	40.82	62.90	140.85	59.89	17.68	43.95	5.77	3.66	4.34	1.19	0.86	158.65	2.85
III	42.07	90.54	130.52	77.56	22.77	50.20	6.12	4.38	4.38	1.52	1.13	161.76	3.20
IV	42.68	54.43	121.12	83.32	21.81	46.91	6.20	4.15	4.55	1.74	1.45	178.70	3.65
V	38.96	36.65	140.15	95.00	27.88	50.30	5.60	3.50	4.39	2.29	1.62	168.85	2.25
VI	35.33	48.09	123.00	58.67	17.67	53.80	6.26	4.00	4.65	1.32	0.94	157.20	3.05
VII	42.18	50.35	150.85	71.00	26.92	53.50	6.24	3.04	4.80	3.27	1.90	171.50	3.00
VIII	40.10	165.10	112.02	80.09	13.20	43.10	6.14	4.20	3.97	1.14	0.81	171.80	3.20
IX	35.58	32.90	176.50	95.25	26.18	47.50	6.15	2.28	4.11	3.27	2.25	68.20	1.20

Table 6: Relative contribution of each character towards divergence in tuberose genotypes

Character	Number of first rank	Percentage of contribution
Plant height (cm)	3	0.85
Number of leaves per clump	71	20.22
Days to spike appearance	0	0.00
Spike length (cm)	42	11.96
Rachis length (cm)	0	0.00
Number of florets per spike	21	5.98
Length of the floret (cm)	8	2.27
Flower tube length (cm)	22	6.26
Diameter of the floret (cm)	15	4.27
Single flower weight (g)	7	1.99
Matured bud weight (cm)	7	1.99
Duration of flowering (days)	26	7.40
Number of spikes per clump	129	36.75
Total	351	100

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