J. Hortic. Sci.
Vol. 20(1), 2025

https://doi.org/10.24154/jhs.v20i1.4029

Original Research Paper

Phenotypic characterization and diversity analysis of single-type tuberose (*Agave amica* syn. *Polianthes tuberosa*)

Bhosale P.[1], Bhagat V.V.[1], Naveen Kumar P.[2*], Saha T. N.[3], Ganesh B. Kadam[3], Kawar P.[3], Gajbhiye N.[3] and Mahesh Reddy D.[2]

[1]Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani - 431 402, Maharashtra, India
[2]ICAR-Indian Institute of Horticultural Research, Bengaluru - 560 089, India
[3]ICAR-Directorate of Floricultural Research, Pune - 411 005, India
*Corresponding author Email: naveeniari@gmail.com

ABSTRACT

Tuberose is a popular ornamental crop valued for its attractive, fragrant white flowers, which are extensively used as cut and loose flowers, and extraction of essential oil. The present study was conducted to evaluate the morphological variability among 14 single-type tuberose varieties based on 27 quantitative traits. Among the evaluated genotypes, the variety Arka Prajwal exhibited superior performance in several floral and vegetative traits such as number of leaves (38.43), leaf length (53.61 cm), leaf width (2.40 cm), plant spread (N-S: 99.57 cm; E–W: 99.20 cm), weight of single floret (2.18 g), floret diameter (6.41 cm), floret weight per spike (115.78 g), flower yield (11.58 t/ha), and bulb diameter (3.71 cm). The variety Bidhan Snigdha excelled in traits like rachis length (44.43 cm), floret length (7.36 cm), floret width (5.10 cm), bulb weight per clump (310.23 g), bulblet weight per clump (210.69 g), individual bulb weight (51.84 g), and bulb length (7.22 cm). The varieties Prajwal, Bidhan Snigdha, and GKTC-4 were identified as high loose flower yielders and are recommended for commercial cultivation. Principal component analysis (PCA) revealed that the first six components (Eigen value >1.0) accounted for 90.48% of the total variation, with PC1 and PC2 contributing 47.97% and 14.42%, respectively. Cluster analysis using Ward's method supported the PCA results, grouping the genotypes into two major clusters based on morphological traits. This study provides valuable insights for tuberose breeding, varietal improvement, and germplasm conservation programs.

Keywords: Cluster analysis, evaluation, principal component analysis, tuberose

INTRODUCTION

Tuberose (*Agave amica* syn. *Polianthes tuberosa*), family Agavaceae, is an important commercial perennial flower crop due to its use as a loose flower, cut flower, for extraction of essential oil; and qualities like longer vase life, ease in cultivation, and nearly year-round production in tropical and sub-tropical climates (Benschop, 1993; Singh, 1995). Commercially tuberose is grown in various countries such as India, France, Morocco, USA, Hawaii, Kenya and South Africa.

It has great economic prospects for the cut flower trade and essential oil industry (Sadhu & Bose, 1973). Its flowers are used in the making of garlands and *veni*, various traditional rituals, floral arrangements and for decoration in various celebrations like weddings. Traditionally tuberose is used in Hawaii for creating leis where lei means a 'Polynesian garland of flowers' and was regarded as a funeral flower in Victorian times (Sheena et al., 2019). Tuberose flowers also used for artistic garland, bouquets, floral ornaments and buttonholes.

Understanding genetic and morphological diversity is crucial for identifying promising genotypes for use in hybridization programs (Reddy et al., 2024). Characterization and evaluation are fundamental steps in varietal development and serve as the foundation for any successful breeding program. Principal component analysis and cluster analysis are two crucial metrics for assessing crop diversity. Given the crop's significance, the current study examined the relative performance of the fourteen tuberose varieties and evaluated the diversity among the 14 genotypes using 27 quantitative variables.

MATERIALS AND METHODS

The study was conducted at the experimental farm, ICAR-Directorate of Floricultural Research, Pune during 2020-21 and 2021-22, geographically located at 18° 322 North latitude and 73° 512 East longitude and an elevation of 569 m above mean sea level. The soil of the experimental site was shallow well drained, clayey soils on gently sloping lands with mesas and buttes with moderate erosion and slight stoniness. A total of 14 varieties were evaluated for vegetative growth, flowering, yield and bulb parameters in randomized block design with three replications. For each replication 20 plants were planted on raised beds with a spacing of 30 x 30 cm. The recommended package of practices were adopted to raise the crop. Six random plants per replication were selected for recording the various phenotypic traits *viz*., plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm), plant spread (N-S) (cm), plant spread (E-W) (cm), days to spike emergence, days to first floret open, spike length (cm), rachis length (cm), length of floret (cm), width of floret (cm), diameter of florets (cm), diameter of cut spike (cm), number of spikes /clump, number of florets per spike, weight of single floret (g), weight of florets per spike (g), flower yield per ha (q), number of bulbs per clump, number of bulblets per clump, weight of bulbs per clump (g), weight of bulblets per clump (g), weight of individual bulb (g), length of bulb (cm), diameter of bulb (cm).

The statistical analysis of the data was carried out by the standard method of analysis of variance described by Panse & Sukhathme (1985). The quantitative data were subjected to multivariate cluster analysis based on ward's method and principal component analysis were carried out using JMP 17 Pro (JMP, 2022).

RESULTS AND DISCUSSION

Growth parameters

The maximum plant height (124.21 cm) was recorded with the variety Variegated Local single and minimum plant height in Bidhan Ujjwal (70.56 cm). A maximum number of leaves (38.43cm), leaf length (53.61 cm), leaf width (2.40 cm), and plant spread N-S (99.57 cm) and E-W (99.20 cm) was recorded in variety Arka Prajwal (Table 1). The existence of significant variation at all growth stages regarding plant height might be due to the genetic makeup and varietal differences in the source where they are produced. Similar variation in plant height was also reported by Ramachandrudu & Thangam (2008) in gladiolus and Dogra et al. (2020) in tuberose.

Table 1 : Performance of single type tuberose varieties for growth parameters

Varieties	Plant height (cm)	No. of leaves/ plant	Leaf length (cm)	Leaf width (cm)	Plant spread (N-S) (cm)	Plant spread (E-W) (cm)
Mexican Single	110.26	22.29	36.20	1.36	72.67	74.18
Shringar	86.01	21.22	43.61	1.56	55.52	58.66
Arka Nirantara	96.79	24.93	51.38	1.78	81.90	88.32
Bidhan Snigdha	102.11	32.19	51.32	2.27	92.13	87.15
Bidhan Ujjwal	70.56	29.69	40.34	1.33	82.44	77.86
Arka Prajwal	106.25	38.43	53.61	2.40	99.57	99.20
GKTC-4	84.07	21.71	46.79	2.15	84.27	85.50
Hyderabad Single	90.80	21.08	39.72	1.39	74.29	78.03
Pune Local Single	110.37	21.14	42.20	1.29	81.85	83.88
Variegated Local Single	124.21	23.24	40.98	1.41	86.97	85.29
Arka Sugandhi	64.94	17.75	33.23	1.21	57.65	52.12
STR-501	95.42	25.45	37.89	1.84	71.59	72.58
Sikkim selection	115.53	23.78	46.73	1.72	87.12	89.59
Phule Rajani	88.42	28.10	30.59	1.33	74.07	78.43
SEm (±)	1.61	1.55	1.24	0.07	2.24	2.98
C.D. (0.05)	4.72	4.53	3.61	0.20	6.56	8.71

Flowering and yield parameters

Flowering parameters like the number of florets/spike, length, diameter, and weight of florets play an important role when the quality of the flower is concerned. The early spike emergence (69.04) was recorded var. Sikkim Selection, whereas, Hyderabad Single recorded early opening of the first floret (89.69), while, it was maximum in Phule Rajani (105.97 days) (Table 2). The variation among flowering period was also reported by Ramachandrudu & Thangam (2009) and Singh et al. (2018) in tuberose.

Maximum spike length (120.78 cm) was recorded in Variegated Local Single, while the minimum (46.63 cm) in Arka Sugandhi. The variety Bidhan Snigdha showed the maximum rachis length (44.43 cm), floret length (7.36 cm), and width (5.10 cm), whereas, Bidhan Ujjwal, Arka Sugandhi, and Sikkim Selection recorded minimum values for rachis length (23.04 cm), floret length (5.64 cm), and floret width (3.41 cm), respectively. Arka Prajwal exhibited the largest floret diameter (6.41 cm), statistically at par with Phule Rajani (6.02 cm) and Bidhan Snigdha (5.84 cm), while Arka Sugandhi had the minimum (3.35 cm). The variety Sikkim Selection had the highest diameter of cut spike (1.25 cm), and Arka Sugandhi the lowest (0.66 cm). Arka Prajwal recorded maximum number of spikes per clump (7.04), while, Arka Sugandhi had the minimum (3.00). GKTC-4 produced the maximum number of florets per spike (58.83), with Mexican Single recording the least (42.76). Arka Prajwal also had the highest weight of single floret (2.18 g) and weight of florets per spike (115.78 g), and maximum loose flower yield (115.80 q/ha), with Arka Sugandhi recording the lowest (32.30 q/ha). Higher flower yield in Prajwal is attributed to better vegetative growth, increased spike count, and larger, heavier florets, consistent with the reports of Mahovia (2003) and Gupta et al. (2004).

Bulb parameters

The number of bulbs per clump of tuberose plant was influenced by tuberose varieties were found significant (Table 3). Maximum number of bulbs per clump (9.85) was recorded with the Phule Rajani, while minimum (5.38) were recorded in Arka Sugandhi. Number of bulblets per clump was maximum in Shringar (27.61) and minimum in Mexican Single (13.68). In Bidhan Snigdha recorded a significant maximum weight of bulbs per clump (301.28 g), weight of bulblets per clump (210.69 g), and weight of individual bulbs (51.84 g). Maximum length of bulb (7.22 cm) was observed in Bidhan Snigdha and minimum in Arka Sugandhi (5.28). Diameter of bulb was maximum in Arka Prajwal (3.71 cm) and minimum in Pune Local Single (2.49). The variation in number of bulbs produced per clump might be due to genetic factor which is further modified by preponderating environmental condition and the results are in accordance with the finding of Mahawer et al. (2013), Chaturvedi et al. (2014) and Naik et al. (2018) in tuberose.

Table 2 : Performance of single type tuberose varieties for flowering and yield parameters

Varieties	Days to spike emergence	Days to First floret open	Spike length (cm)	Rachis length (cm)	Length of floret (cm)	Width of floret (cm)	Diameter of florets (cm)	Diameter of cut spike (cm)	No. of spikes / clump	No. of florets / spike	Weight of single floret (g)	Weight of florets / spike (g)	Flower yield / ha (q)
Mexican Single	73.02	104.02	103.68	25.25	7.12	4.01	4.06	0.73	3.92	42.76	1.33	53.22	53.20
Shringar	70.30	96.50	77.25	28.17	6.53	3.88	4.28	0.76	5.65	51.84	1.39	71.68	71.70
Arka Nirantara	69.40	96.04	89.60	35.76	6.87	4.53	4.62	0.83	5.72	50.46	1.49	70.55	70.50
Bidhan Snigdha	69.45	93.34	94.91	44.43	7.36	5.10	5.84	1.24	6.11	45.56	2.14	97.45	97.50
Bidhan Ujjwal	80.38	98.77	63.09	23.04	6.12	3.87	4.30	0.84	4.91	50.21	1.37	74.14	74.10
Arka Prajwal	78.99	101.98	98.88	32.61	7.15	4.79	6.41	0.90	7.04	54.6	2.18	115.78	115.80
GKTC-4	77.83	98.18	66.40	23.95	7.09	4.56	5.33	0.79	6.75	58.83	1.37	78.71	78.70
Hyderabad Single	70.82	89.69	72.15	24.89	6.42	4.01	4.65	0.80	4.93	54.30	1.25	69.13	69.10
Pune Local Single	75.13	98.61	93.79	20.98	6.87	3.81	4.63	0.72	5.57	46.41	1.08	44.81	44.80
Variegated Local Single	70.65	99.50	120.78	29.81	6.33	3.65	3.93	0.92	4.28	47.73	1.25	53.74	53.70
Arka Sugandhi	74.17	94.17	46.63	26.33	5.64	3.54	3.35	0.66	3.00	44.75	0.78	32.27	32.30
STR-501	72.93	97.28	75.31	26.91	6.60	4.19	4.18	0.75	5.04	42.34	1.40	48.49	48.50
Sikkim selection	69.04	99.61	107.59	34.47	6.47	3.41	3.63	1.25	6.09	42.97	1.08	54.96	55.00
Phule Rajani	81.55	105.97	67.21	26.67	6.11	4.39	6.02	0.84	6.43	44.43	1.28	61.28	61.30
SEm (±)	1.49	1.49	2.15	1.61	0.12	0.13	0.22	0.04	0.38	1.71	0.08	4.84	4.80
C.D. (0.05)	4.34	4.35	6.28	4.71	0.34	0.37	0.64	0.13	1.11	5.01	0.24	14.14	14.10

Clustering

To identify potential groups within the populations, cluster analysis was performed using the Ward approach (Fig. 1). Fourteen genotypes were divided into two primary clusters using agglomerative hierarchical clustering (AHC) based on the correlation between the genotypes morphological features. Twelve genotypes were categorised in cluster I, while, two genotypes in cluster II. The genotypes grown in different parts of the country were named differently for fixing the location where they are grown, but they may not be so diverse in their genetic constitution. Hence, many genotypes falling in same cluster I. The genotypes in cluster II which indicates that possess considerable genetic diversity among themselves. Such genetically diverse genotypes can be effectively utilized as parents in hybridization programmes. Kavitha & Anburani (2009) and Gandhi & Bharathi (2021) also reported similar results in tuberose.

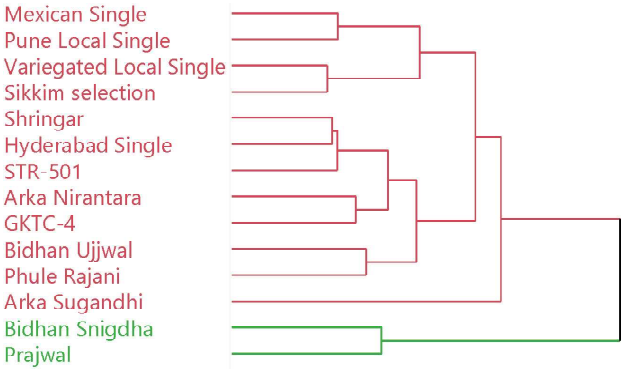

Fig. 1 : Dendrogram based on morphological data illustrates the genetic relationships of 14 tuberose genotypes

Principal component analysis

Principal component analysis (PCA) was used to a set of 14 genotypes used for cluster analysis in order to identify the most important features of the data set and to calculate the distances between the genotypes based on the data collected on morphological variables (Table 4). The contribution of morphological traits across genotypes was also clarified by the investigation. Of the seven factors taken into consideration, the first two explained the majority of the variation. The first principal component (PC1) explained 47.97% of the total variation and was positively correlated to all the traits; highly correlated to weight of single floret, weight of florets/spike and flower yield. The PC2 explained 14.40% of total variation and was highly positively correlated to days to spike emergence, number of florets/spike and negatively to plant height (Table 4). The genotypes with comparable traits group together, whereas those with different traits are positioned farther away, as the

Table 3 : Performance of single type tuberose varieties for bulb parameters

Varieties	No. of bulbs / clump	No. of bulblets / clump	Weight of bulbs / clump (g)	Weight of bulblets / clump (g)	Weight of individual bulb (g)	Length of bulb (cm)	Diameter of bulb (cm)
Mexican Single	6.55	13.68	167.49	119.22	28.01	6.64	3.12
Shringar	8.68	27.61	186.27	168.98	30.52	5.91	3.08
Arka Nirantara	8.25	18.29	267.67	120.39	33.37	6.45	3.24
Bidhan Snigdha	8.72	19.72	310.23	210.69	51.84	7.22	3.58
Bidhan Ujjwal	6.17	20.69	166.27	143.09	33.44	5.90	3.43
Arka Prajwal	8.40	18.67	245.22	165.39	42.17	6.58	3.71
GKTC-4	8.48	20.19	201.45	185.40	33.20	6.01	3.23
Hyderabad Single	8.33	22.10	241.59	178.34	38.10	6.00	3.33
Pune Local Single	7.67	17.29	131.44	109.33	21.57	6.81	2.49
Variegated Local Single	6.30	19.12	205.11	159.85	34.97	6.20	3.44
Arka Sugandhi	5.38	15.51	105.14	80.59	18.79	5.28	2.97
STR-501	8.13	22.96	235.61	191.01	34.09	6.32	3.16
Sikkim selection	6.59	24.14	170.60	142.43	33.07	6.17	3.56
Phule Rajani	9.85	24.79	178.18	132.92	27.86	5.81	3.37
SEm (±)	0.62	1.61	26.97	16.67	3.17	0.22	0.14
C.D. (0.05)	1.80	4.70	78.84	48.73	9.26	0.63	0.42

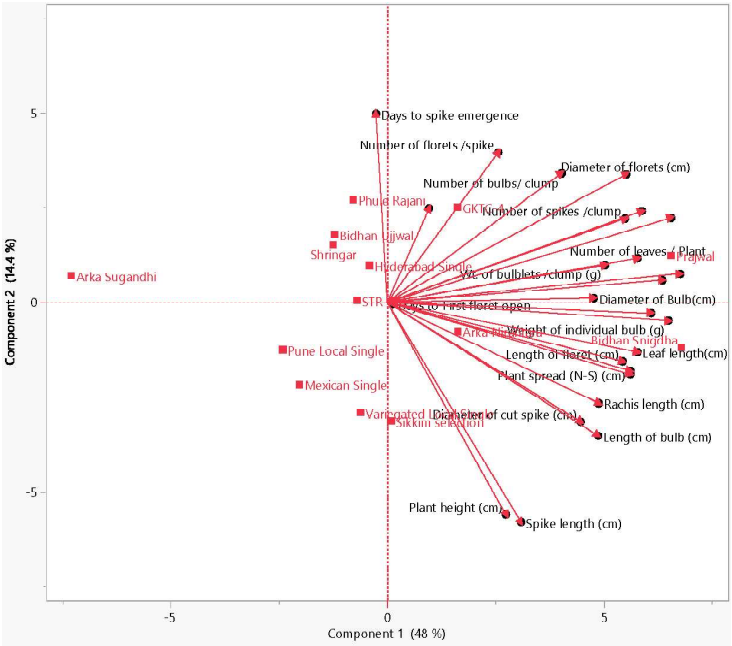

Fig. 2: PCA biplot of tuberose varieties based on phenotypic traits

Table 4 : Principal component analysis in single type tuberose varieties

Trait	PC1	PC2	PC3	PC4	PC5	PC6
Plant height (cm)	0.106	-0.397	0.171	0.010	0.248	0.137
Number of leaves/plant	0.225	0.082	0.174	0.212	-0.168	-0.213
Leaf length (cm)	0.224	-0.094	-0.083	-0.161	-0.140	0.295
Leaf width (cm)	0.247	0.040	-0.059	-0.081	-0.054	0.025
Plant spread (N-S) (cm)	0.218	-0.135	0.224	0.076	-0.185	0.190
Plant spread (E-W) (cm)	0.218	-0.128	0.237	0.048	-0.024	0.264
Days to spike emergence	-0.010	0.352	0.409	0.129	-0.114	-0.036
Days to first floret open	0.005	-0.004	0.512	0.254	0.166	-0.099
Spike length (cm)	0.120	-0.411	0.143	0.035	0.118	0.142
Rachis length (cm)	0.190	-0.189	-0.225	0.132	-0.074	-0.265
Length of floret (cm)	0.211	-0.111	0.098	-0.376	0.127	-0.011
Width of floret (cm)	0.228	0.170	0.025	-0.201	0.016	-0.310
Diameter of florets (cm)	0.214	0.239	0.188	-0.033	0.112	-0.135
Diameter of cut spike (cm)	0.174	-0.224	-0.127	0.363	-0.009	0.020
Number of spikes/clump	0.213	0.156	0.114	0.079	0.290	0.241
Number of florets/spike	0.100	0.280	-0.064	-0.225	-0.162	0.548
Weight of single floret (g)	0.263	0.053	0.010	-0.058	-0.082	-0.211
Weight of florets/spike (g)	0.255	0.157	0.001	-0.003	-0.155	0.060
Flower yield/ha (q)	0.255	0.157	0.001	-0.003	-0.155	0.060
Number of bulbs/clump	0.157	0.241	-0.020	-0.073	0.509	-0.095
Number of bulblets/clump	0.038	0.175	-0.248	0.382	0.468	0.201
Wt. of bulbs/clump (g)	0.237	-0.020	-0.230	-0.081	0.042	-0.151
Wt. of bulblets/clump (g)	0.195	0.070	-0.262	0.036	0.185	0.053
Weight of individual bulb (g)	0.252	-0.034	-0.202	0.081	-0.088	-0.075
Length of bulb (cm)	0.189	-0.250	0.115	-0.273	0.134	-0.186
Diameter of bulb (cm)	0.185	0.007	-0.087	0.447	-0.243	-0.007
Eigen value	12.475	3.751	2.629	1.853	1.551	1.269
Cumulative variance (%)	47.979	62.406	72.516	79.642	85.606	90.488

biplot illustrates. Therefore, the biplot helps to identify the patterns and links in the dataset by clearly visualising the relationships between multiple genotypes depending on different features. A similar pattern was also observed in aster (Bhargav et al., 2023) and in *Dendrobium* species (Reddy et al., 2024).

CONCLUSION

Out of fourteen varieties of single-type tuberose, the varieties Prajwal, Bidhan Snigdha, and GKTC-4 were found to be superior in terms of growth and flower yield as compared to Pune Local Single, however, the varieties Prajwal, Bidhan Snigdha and GKTC-4 were found to be the high loose flower yielders, hence, these can be recommended for commercial loose flower production. Additionally, the study examined agro-morphological differentiation among tuberose genotypes using agglomerative hierarchical clustering and principal component analysis.

REFERENCES

Benschop, M. (1993). Polianthes. In: The physiology of flower bulbs (De Hertogh A., Le Nard M., Eds). Elsevier Publication, Amsterdam, the Netherlands. pp. 589-601.

Bhargav, V., Kumar, R., Bharathi, T. U., Dhananjaya, M. V., & Rao, T. M. (2023). Assessment of genetic diversity in China aster [*Callistephus chinensis* (L.) Nees. *Journal of Horticultural Sciences*, *18*(1), 84-89. https://doi.org/10.24154/jhs.v18i1.2138

Chaturvedi, A., Mishra, T. S., Kumar, N., & Singh, S. S. (2014). Screening of different cultivars of tuberose (*Polianthes tuberosa* L.) under agro-climatic condition of Allahabad. *Progressive Horticulture*, *46*(1), 146-148.

Dogra, S., Pandey, R. K., Laishram, N., & Singh, A. (2020). Varietal evaluation of tuberose under agro climatic conditions of Jammu. *Pharma Innovation Journal*, *9*(2), 499-501.

Gandhi, D. P., & Bharathi, T. U. (2021). Genetic variability and diversity study in tuberose (*Polianthes tuberosa* L.). *International Journal of Chemical Studies*, 9(3), 235-240.

Gupta, N. K., Rakesh, K. S., & Mahobla, R. (2004). Performance of tuberose (*Polianthes tuberosa* L.) cultivars and their vase life in Malwa region of Madhya Pradesh. *National Symposium on Recent Trends and Future Strategies in Ornamental Horticulture*, Dharwad. p. 19.

JMP (2022). JMP® 17.1.0. Statistical analysis software system. Cary, NC, USA: SAS Institute.

Kavitha, R., & Anburani, A. (2009). Genetic diversity in African marigold (*Tagetes erecta* L.) genotypes. *Journal of Ornamental Horticulture*, *12*(3), 198-201.

Mahawer, L. N., Bairwa, H. L., & Shukla, A. K. (2013). Field performance of tuberose cultivar for growth, floral and economic characters under sub-humid southern plains and Aravalli hills of Rajasthan. *Indian Journal of Horticulture*, *70*(3), 411-416.

Mahovia, R. (2003). Studies on the performance of different tuberose (*Polianthes tuberosa* Linn) cultivars and their vase life. M.Sc. Thesis. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, p.107

Naik, B., Kamble, B. S., Tirakannanavar, S., & Parit, S. (2018). Evaluation of different genotypes of tuberose (*Polianthes tuberosa* L.) for growth, flowering and yield characters, *International Journal of Current Microbiology and Applied Sciences*, *7*(07), 4135- 4141. https://doi.org/10.20546/ijcmas.2018.707.482

Panse, V. C., & Sukhatme, P. V. (1985). Statistical methods for agricultural workers. ICAR publication, New Delhi. 1-35.

Ramachandrudu, K., & Thangam, M. (2008). Performance of gladiolus varieties under agro-climatic conditions of Goa. *Journal of Ornamental Horticulture*, *11*(2), 91-97.

Ramchandrudu, K., & Thangam, M. (2009). Performance of tuberose (*Polianthes tuberosa* L.) cultivars in Goa. *Journal of Horticultural Sciences*, *4*(1), 76-77.

Reddy, D. M., Momin, K. C., Bhargav, V., Kumar, S., Singh, A., & Phurailatpam, A. (2024). Morphological characterization of Dendrobium orchid species of East Siang district of Arunachal Pradesh. *Journal of Horticultural Sciences*, *19*(2). https://doi.org/10.24154/jhs.v19i2.1621

Sadhu, M. K., & Bose, T. K. (1973). Tuberose for artistic garlands. *Indian Horticulture*, *18*(3), 17-20.

Sheena, N., Beniwal B. S., Dalal R. P. S. & Shiwani. (2019). Studies on the effect of nitrogen and phosphorus on flowering and spike yield of tuberose (*Polianthes tuberosa* L.) cv. Prajwal. *Journal of Pharmacognosy and Phytochemistry*, *SP1*, 109-112.

Singh, A. K., Sisodia A., & Padh M. (2018). Performance of tuberose varieties for flowering and flower yield parameters under indo-gangetic plains of eastern Uttar Pradesh, India, *International Journal of Current Microbiology and Applied Sciences*, *7*(8), 1129-1133. https://doi.org/10.20546/ijcmas.2018.708.128

Singh, K.P. (1995). Improved production technologies for tuberose (*Polianthes tuberosa* L.), a review of research done in India. Indian Institute of Horticultural Research, Hessargarhatta, Bangalore, India (CAB Abstract, 1996-1998/07).

(Received : 7.2.2025; Revised : 25.6.2025; Accepted : 28.6.2025)