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Ratna Priyanka R
Ph.D. Scholar, Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

M Kannan
Professor, Directorate of Research, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

M Ganga
Associate Professor (Hort.), Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

N Kumaravadivel
Professor, Department of Plant Molecular Biology and Bioinformatics, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
Ratna Priyanka R
Ph.D. Scholar, Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Variability, heritability and genetic advance studies in single type genotypes of tuberose (*Agave amica* (Medik.) Syn. *Polianthes tuberosa* L.)

Ratna Priyanka R, M Kannan, M Ganga and N Kumaravadivel

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Abstract
The present investigation on performance and genetic variability studies in tuberose (*Agave amica* (Medik.) Syn. *Polianthes tuberosa* L.) Genotypes was conducted at Botanical Garden, Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University during the year 2018-2020. Among seventeen single type genotypes, Prajwal and Bidhan Rajani-I showed better performance in vegetative and flowering characters and recorded comparatively high loose flower yield of 1.05 and 1.00 kg/m^2 respectively. Among different vegetative and flowering parameters recorded, high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded in weight of ten florets and loose flower yield per square meter whereas moderate values were observed in spike length, rachis length, number of florets per spike and spike weight were recorded moderate. However, in all the parameters PCV is more than GCV. High estimates of heritability coupled with high genetic advance as percent of mean was recorded for number of leaves, leaf width, spike length, rachis length, florets per spike, spike weight, weight of ten florets and flower yield per square meter which indicate comparatively more genetic influence on these characters and the selection based on these characters will be profitable.

Keywords: Tuberose, genotypes, variability, heritability and genetic advance

Introduction
In Indian culture flowers play very important role as both cut and loose flowers. Among the major flowers under cultivation, few of them are used for multiple purposes. Tuberose is one among them. Tuberose is botanically known as *Agave amica* (Medik.) (Syn. *Polianthes tuberosa* L.), belongs to the family Asparagaceae (Thiede and Govaerts, 2017) [24]. It is a native of Mexico (Bailey, 1919) [1] and grows in tropical and subtropical climates (Benschop, 1993) [2]. In India tuberose is one of the most important bulbous perennial crops that gives white waxy flowers with delightful fragrance on long spikes. The florets are arranged as pairs on long spikes and they open in pairs in acropetal succession every day. This character helps to increase the span of cut spikes in vase. Another advantage is that flowers remain fresh for quite a long time and stand distance transportation (Desai, 1957; Patil *et al.*, 1999) [5, 17]. Tuberose gained importance as cut flower, loose flower and also as concrete yielding plant. It also grows as pot plant and used for garden purpose. It is cultivated in several states of India like Tamil Nadu, Karnataka, West Bengal, Maharastra, Andhra Pradesh, Telangana, Haryana, Delhi, Uttar Pradesh and Punjab.

There are mainly two types in tuberose classified based on the number of whorls of tepals. The plant that produces florets with one whorl of petal are said to be single types and the double types have more than three whorls of tepals. The double types are mostly used for cut flower purpose and single types have variety of uses. They are used as cut flowers, loose flowers, as garden/pot plant and also for concrete extraction. The loose flowers are used in worship, garlands, veni and other hair decorations. Single types are preferred over double type's concrete extraction as they yield more concrete (0.08 to 0.11 per cent) than double types. Compared to other flower crops, the available varieties in tuberose are few. Apart from that many are grown as local cultivars: Calcutta Single, Hyderabad Single, Pune Single, Mexican Single, Kahikuchi Single to name a few. So, there is ample scope for improvement in this crop.

For any improvement programme the basic requirement is variation in the germplasm/population. Selection is generally based on the phenotypic expression of a character which, in general, is collective result of its genetic make-up and the environment in which it is grown. The characters that are largely influenced by environment are said to have low heritability while those which are less susceptible to environment variation shows high heritability (Paroda and Joshi, 1970) [15] and the genetic gain of selecting a particular character can be known through assessing the genetic advance. The genotype of a plant is also controlled in several ways like additive gene effects (heritable), non-additive gene effects (non-heritable) and epistasis (non-allelic interaction). Assigning of the phenotypic variability into its heritable and its non-heritable components with suitable genetic parameters is necessary (Murthy and Srinivas, 1997; Kannan *et al*., 1998) [12, 8]. Therefore, the present study was undertaken to know the genetic variability in tuberose for the advantage of tuberose improvement programme.

Materials and methods

The present study was conducted at Botanical Gardens, Department of Floriculture and Landscape Architecture, Tamil Nadu Agricultural University, Coimbatore during the year 2018-2020. The geographical location of the experimental site is at about 11° 02" N latitude and 76° 57" E longitude with an average altitude of 426.76 above mean sea level. The land was ploughed thoroughly to fine tilt and was laid out with ridges and furrows in plots of 3 m x 3 m. Planting was done with 45×30cm spacing. The experimental design followed for the study was randomized block design with two replications. A total of seventeen single type tuberose genotypes were used for the present study, the details of which were furnished in table 1.

The observations were taken for the following parameters: plant height (cm), leaf length (cm), leaf breadth (cm), number of leaves per plant, floret length (cm), floret diameter (cm), weight of ten florets (g), spike length (cm), spike diameter (mm), rachis length (cm), spike weight (g), number of florets per spike, number of spikes per square meter and loose flower yield (kg/m^2). The observations were taken from five randomly selected plants in each genotype and replication and the mean was computed.

Statistical analysis

The mean performance of genotypes indifferent characters under study was subjected to statistical analysis as described by Panse and Sukhatme (1967) [14]. The analysis of the data was as. The phenotypic and genotypic coefficient of variation were worked out as per the methods suggested by Burton (1952) [4] and were classified as low (<10%), moderate (10-20%) and high (>20%) as suggested by Sivasubramanian and Menon (1973) [23]. Heritability in the broad sense (h^2) was derived based on the following formula proposed by Lush (1940) [9].

$$\text{Heritability } (h^2) = \frac{(\sigma^2 g)}{(\sigma^2 p)} \times 100$$

It was expressed in percentage (%) and classified as low, moderate and high as suggested by Johnson and Bernard (1962) [7]. Genetic advance as per cent of mean was calculated and classified according to Johnson and Bernard (1962) [7].

Results and discussion

Vegetative parameters

The vegetative parameters *viz.*, plant height, number of leaves per plant, leaf length and leaf width were found to be significantly varied among the 17 genotypes under study (table 2). The highest plant height (57.17cm) was recorded in Bidhan Rajani-I which was on par with Prajwal (54.32cm). The maximum leaf length and leaf width were observed in Prajwal (54.86cm and 2.18cm respectively) which was on par with Bidhan Rajani-I (54.55cm and 2.15cm). Highest number of leaves were produced in Prajwal (163.50) followed by Bidhan Rajani-I (162.58). The differences among genotypes for their morphological characters in vegetative parts may be due to their origin from different geographical regions and also differences in their genetic makeup. Prajwal and Bidhan Rajani-I being hybrids showed superiority over other hybrids and cultivars. The superiority of Prajwal is reported by several authors (Ranchana, 2013; Patil *et al*., 2009) [20, 18].

Reproductive parameters

The flowering parameters were observed to be statistically significant. Among 22 genotypes Bidhan Rajani-1 was recorded highest values in many flowering characters such as length of spike (93.90cm), spike diameter (7.85 mm), rachis length (34.00cm), floret length (6.89cm), floret diameter (4.36cm) and ten floret weight (17.53 g) and it was followed by Prajwal (91.95cm, 7.76 mm, 33.66cm, 6.51cm and 15.84 g respectively) except in case of floret diameter which was followed by Bidhan Rajani-III (4.01cm). The florets produced in a spike were recorded maximum in Bidhan Rajani-II (58.50) followed by GK-T-C-4 (50.25), Bidhan Rajani-I (49.98) and Prajwal (46.76).

The yield parameters such as number of spikes per square meter and loose flower yield were observed to be highest in the genotype Prajwal (21.32 and 1.05 kg/m^2). It was followed by Bidhan Rajani-I (1.00 kg/m^2) and Arka Nirantara (0.88 kg/m^2) in case of flower yield whereas Arka Nirantara recorded more number of spikes (20.85/m^2) after Prajwal.

The parameters like spike length, spike diameter, rachis length, floret length and floret diameter were maximum in case of Bidhan Rajani-I because it produces long sturdy spikes with long and bold buds than Prajwal. In Bidhan Rajani-II though the spike length is less, it produces small florets at close intervals on relatively small spikes which is almost similar conditions in case of GK-T-C-4. Hence, the other parameters like spike length, floret weight and flower yield recorded less in this genotype. The superiority of Prajwal and Bidhan Rajani-I in flowering characters may be due to their genetic makeup and adaptability to environmental conditions which helped them to have good vegetative growth which in turn helped to produce good quality spikes and florets. The implication of better vegetative growth on flowering parameters was reported previously by Patil *et al.*, (1987) [16], Meenakshi and Niranjanmurthy (1997) [10], Gupta *et al.*, (2004) [6] and Bindiya *et al.* (2018) [3] in tuberose.

Variability, heritability and genetic advance (%)

From the data presented in table 3, it can be denoted that in all the characters under study the phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) indicating the interference of environment on the phenotypic expression of the plant. Among vegetative parameters phenotypic coefficient of variation and genotypic coefficient of variation were found to be moderate in all

characters except for leaf length. High PCV and GCV values were observed for weight of ten florets and flower yield per square meter whereas spike length, rachis length, number of florets per spike and spike weight were recorded moderate PCV and GCV. This implies that these traits contain considerable variability and scope of selection and improvement. These results are in line with the findings of Vanlalruati *et al*. (2013) [26] in tuberose, Mishra *et al*. (1987) [11] in dahlia and Sheela *et al*. (2005) [21] in *heliconia*.

High heritability coupled with high genetic advance as percent of mean was recorded for number of leaves, leaf width, spike length, rachis length, florets per spike, spike weight, weight of ten florets and flower yield per square meter. This indicates that the influence of environment in expression of these characters is comparatively low and shows prevalence of additive gene action in their inheritance. Hence, selection pressure could be profitably applied on these characters to enhance the yield.The remaining traits showed high heritability with moderate genetic advance except plant height which recorded low heritability. This indicates that the traits are under non-additive gene affect and not reliable for selection. Pant and Lal (1991) [19] also suggested that high heritability is not always associated with high genetic advance. Similar genetic behavior has been reported by Panse (1957) [13] and Sheikh *et al*. (1995) [22] in Iris, Sirohi *et al*. (2018) [25] in tuberose.

Table 1: Details of genotypes of tuberose selected for the present study

S. No	Genotype	Source
1.	Prajwal	Indian Institute of Horticultural Research (IIHR), Bengaluru
2.	Shringar	
3.	Mexican Single	
4.	Arka Sugandhi	
5.	Arka Nirantara	
6.	Phule Rajani	Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharastra
7.	Variegated Single	
8.	Pune Single	
9.	GK-T-C-4	
10.	Nilakottai Local	HC & RI, Periyakulam, Tamil Nadu Agricultural University, Tamil Nadu
11.	Bidhan Rajani I	Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani, West Bengal
12.	Bidhan Rajani II	
13.	Bidhan Rajani III	
14.	Calcutta Single	
15.	Navsari Local	Navsari Agricultural University (NAU), Gujarat
16.	Hyderabad Single	Dr. Y.S.R.H.U., Andhra Pradesh
17.	Kahikuchi Single	Assam Agricultural University, Assam

Table 2: Mean performance of tuberose genotypes (single types) based on vegetative and flowering parameters

Genotype	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	No. of leaves/ plant	Spike length (cm)	Rachis length (cm)	Spike diameter (mm)	Florets per spike	Floret diameter (cm)	Floret length (cm)	Spike weight (g)	10 floret weight (g)	Spikes per m^2	flower yield (kg/m^2)
Prajwal	54.32	54.86	2.18	163.50	91.95	33.66	7.76	46.76	3.93	6.51	95.40	15.84	21.32	1.05
ArkaNirantara	50.00	53.68	1.79	133.00	83.04	29.10	6.06	44.35	3.99	5.91	78.50	13.66	20.85	0.88
ArkaSugandhi	42.80	45.42	1.62	112.00	66.80	24.19	6.05	39.25	3.55	5.61	63.10	9.03	17.59	0.48
Shringar	46.59	45.38	1.46	108.18	74.83	27.00	6.45	43.00	3.83	6.42	71.13	10.85	19.98	0.71
BidhanRajani-I	57.17	54.55	2.15	162.58	93.90	34.00	7.85	49.98	4.36	6.89	100.13	17.53	17.42	1.00
BidhanRajani-II	38.38	38.05	1.41	159.25	38.63	17.63	6.03	58.50	3.28	5.44	42.57	8.87	18.87	0.67
BidhanRajani-III	45.97	46.78	2.05	123.40	74.65	21.08	7.47	33.25	4.01	5.82	77.95	10.93	17.45	0.48
GK-T-C-4	44.98	43.35	1.62	127.33	57.80	21.15	5.37	50.25	3.46	5.95	67.37	9.02	17.38	0.64
PhuleRajani	49.25	52.48	1.65	144.05	87.59	27.03	7.37	44.17	3.52	6.13	69.59	14.53	16.01	0.75
Variegated Single	44.88	42.77	1.33	117.60	85.85	26.80	6.83	38.50	3.58	5.78	58.53	7.51	17.38	0.43
Calcutta Single	48.13	48.37	1.74	120.13	76.45	24.76	6.91	38.48	3.73	6.37	65.73	15.44	18.62	0.85
Hyderabad Single	48.30	47.71	2.09	122.55	74.09	25.40	7.09	46.42	3.54	6.26	68.40	15.15	16.56	0.80
Mexican Single	47.24	48.44	2.03	107.30	76.68	26.68	6.51	40.75	3.73	6.18	67.28	11.21	14.96	0.53
Pune Single	49.34	47.99	1.46	123.65	74.13	25.60	5.73	44.34	3.53	6.23	65.31	11.61	19.60	0.75
Kahikuchi Single	44.47	46.79	1.85	125.50	75.92	24.49	6.96	42.45	3.92	6.21	70.69	13.70	20.16	0.79
Navasari Local	50.75	50.13	1.46	114.75	76.00	21.47	6.36	43.50	3.58	6.34	59.00	12.43	16.21	0.64
Nilakottai Local	54.09	52.27	1.98	137.58	74.37	24.95	6.69	38.03	3.83	6.30	71.38	14.06	17.32	0.73
Mean	48.04	48.18	1.75	129.55	75.45	25.59	6.67	43.64	3.72	6.14	70.12	12.43	18.10	0.71
S.E.	1.67	1.31	0.09	2.68	1.97	0.86	0.24	1.33	0.11	0.11	1.74	0.73	0.25	0.01
C.D. (5%)	5.01	3.94	0.28	8.05	5.92	2.58	0.73	3.99	0.33	0.32	5.21	2.19	0.74	0.03

Table 3: Variability, heritability and genetic advance in tuberose single type genotypes

S. No.	Character	PV	GV	PCV	GCV	h^2	GA	GA (%)
1.	Plant height	23.66	18.07	10.13	8.85	76.40	7.65	15.94
2.	Leaf length	22.30	18.86	9.80	9.01	84.55	8.23	17.07
3.	Leaf width	0.09	0.07	16.88	15.17	80.75	0.49	28.08
4.	No of leaves	336.29	321.89	14.16	13.85	95.72	36.16	27.91
5.	Spike length	171.19	163.40	17.34	16.94	95.45	25.73	34.10
6.	Rachis length	18.21	16.74	16.68	15.99	91.90	8.08	31.58
7.	Spike diameter	0.56	0.44	11.19	9.93	78.75	1.21	18.16
8.	Florets/spike	35.86	32.32	13.72	13.03	90.11	11.12	25.47

9.	Floret diameter	0.08	0.06	7.68	6.41	69.61	0.41	11.01
10.	Floret length	0.14	0.11	6.04	5.52	83.34	0.64	10.37
11.	Spike weight	178.13	172.09	19.03	18.71	96.61	26.56	37.88
12.	10 floret weight	8.73	7.67	23.77	22.27	87.81	5.35	43.00
13.	Number of spikes per m^2	3.30	3.18	10.04	9.85	96.26	3.60	19.90
14.	Flower yield (kg/m^2)	0.03	0.03	25.18	25.11	99.42	0.37	51.57

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