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Hybridization and evaluation of hybrids in tuberose (*Polianthes tuberosa* L.)

T Usha Bharathi and SP Kirthishree**Abstract**

Tuberose (*Polianthes tuberosa* Linn.) is an bulbous ornamental plant and its flowers are highly fragrant, used as loose flower and cut flower. In the present study intervarietal hybridization is attempted in tuberose to develop new cultivars with improved growth, yield, and quality parameters such as green tinge on flower buds. Hybridization was carried out in eleven different cross combinations using single cultivars as female as well as male parent and double cultivars as male parent. Hybrids obtained were evaluated for flowering and yield parameters and green tinge on flower bud which is preferred for the garland preparation. Among the 224 hybrid seedlings of eleven cross combinations evaluated, the flower buds with green tinge were noticed on sixteen hybrids produced in five cross combinations. Double cultivars were used as pollen parent and the resulting hybrids were of single and double flower types are not observed. The cross Variegated x Arka Suvasini resulted in maximum number of hybrids with green tinge on flower bud. A total of sixteen hybrids with green tinge on flower bud were subjected to performance evaluation. The tuberose hybrids viz., IIHR-15-2-13 from the cross Arka Niranantara x Arka Vaibhav with more rachis length (19.08), number of florets per spike (50.75), bud weight (1.13), number of matured buds in spike (2.50), number of spikes per plant (4.00) and straight spike, hybrid IIHR 15-3-2 from the cross Arka Niranantara x IIHR-2 with the highest rachis length (25.10 cm), flower diameter (4.12 cm), number of florets per spike (72.00), number of matured buds per spike (4.00), number of spikes per plant (4.20) and slight bent, hybrid IIHR 15-4-10 from the cross Variegated x Arka Suvasini with the highest number of spikes per plant (4.00), straight spike and reflexed petal were selected for further multiplication and evaluation. The hybrids selected are cross fertile and can be utilized for the creation of variability in future breeding programme.

Keywords: tuberose, inter varietal hybridization, single, double type, garland purpose

Introduction

Tuberose (*Polianthes tuberosa* Linn.) is one of the most important tropical ornamental bulbous flowering plant belonging to the family 'Asperagaceae' (Gutierrez and Garay, 2016)^[5] and is native to Mexico (Bailey, 1919)^[2]. The flowers of tuberose are highly fragrant and used as loose flower and cut flower. The absolute of tuberose is one of the most expensive of the fragrant oils used in perfumes and have high demand in international market. The commercial cultivation of tuberose in India is mainly confined to West Bengal, Karnataka, Tamil Nadu, Maharashtra, Andhra Pradesh, Uttar Pradesh, Chhattisgarh and areas around Delhi. The flowers of tuberose are highly fragrant and contain 0.08 to 0.14 % of concrete and have high demand in the international market. Tuberose absolute is one of the most expensive of the fragrant oils used in perfumes, and is valued at more than \$2,000.00 per pound (Hodges, 2010)^[6]. It is commercially cultivated in India in an area of about 16,190 ha, with a loose flower production of 107910 metric tons and cut flower production of 89.29 lakh numbers of cut stems (Anon, 2016)^[1]. Tuberose has limited genetic variability due to mechanisms like self incompatibility, dichogamy and poor seed setting (Shen *et al.*, 1987)^[12] resulting in few improved cultivars. Seed setting upon hybridization in tuberose is quite erratic in the single flowered cultivars while in double type no seed set was observed. Two types of cultivars of tuberose 'single' and 'double' are in commercial cultivation which are white in colour. The colour variation is present on the tip of flower bud which ranges from greenish to pinkish tinge. Arka Prajwal is the popular variety of single tuberose released from ICAR-IIHR, Bengaluru has pinkish tinge on flower bud and mainly used as loose flower for garland preparation. Economic impact assessment study conducted at ICAR-IIHR on this tuberose variety indicated a net economic benefit of Rs. 880 crores (2009-2015) across growing regions

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with an adoption of 38%. At present, the increasing demand was noticed for the flower buds with green tinge on tip which fetches higher price in the market than the flower buds with pinkish tinge. Keeping this in view and in order to meet out the market demand and preference of the farmers, research work on development of tuberose flowers with greenish tinge buds especially for garland purpose was carried out. Hybridization was carried out using single and double cultivars of tuberose. The segregating population raised through intervarietal hybridization with wide variations can be used for the creation of variability in future breeding programme.

Material and Methods

The studies on the intervarietal hybridization of tuberose for the development of improved varieties with green tinge on flower buds for garland purpose was conducted during the year 2015-18 in the field of Division of Floriculture and Medicinal Crops, ICAR- Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru. Hybridization was carried out in eleven different cross combinations viz., Arka Nirantara x IIHR-4, Arka Nirantara x Arka Vaibhav, Arka Nirantara x IIHR-2, Variegated x Arka Suvasini, Arka Nirantara x Mexican Single, Arka Nirantara x 1 x 6-2, Arka Nirantara x Arka Shringar, Arka Vaibhav x Arka Shringar, Arka Shringar x IIHR-6, Arka Shringar x Mexican Single, Mexican Single x Arka Nirantara. The matured buds were emasculated removing anthers manually, bagged and labeled to avoid contamination with foreign pollen. The pollen were collected from the bagged male parent and dusted on the receptive stigma of the female parent after three to four days after emasculation. Repeated crossing for three to four days was carried out to ensure seed set. Matured pods were harvested after three months; seeds were extracted and sown in the trays to raise the segregating seedling population. Healthy seedlings of six months old were transplanted to field with the spacing of 30 x 30 cm and standard cultural practices were followed. The observations on flowering parameters viz., spike length (cm), rachis length (cm), number of florets per spike, floret length (cm), floret diameter (cm), floret tube length (cm), bud length (cm), bud weight (g), single flower weight (g), internodal length (cm), number of petals, matured bud at a time, number of spikes per clump and nature of spike were recorded for the hybrids and parents. The hybrids were evaluated using local tuberose variety Mexican Single as standard check which produces flowers with green tinge on flower bud. The data observed were analysed statistically by descriptive statistics using MS Excel software and means were compared between treatments by least significant difference at $p < 0.05$ confidence level using Student's *t*-test.

Results and Discussion

Hybrids from eleven different cross combinations were raised to observe the type of flowers produced with pink or green tinge on flower bud. (Table 1). Among the 224 hybrids evaluated from eleven different cross combinations, the flowers produced are of only single type and double type of flowers were not noticed. The result of the present study

indicates that the single type of florets might be controlled by dominant gene. Among the eleven cross combinations studied, the flower buds with green tinge was noticed only on five cross combinations viz., Arka Nirantara x Arka Vaibhav (2.0), Arka Nirantara x IIHR-2 (3.0), Variegated x Arka Suvasini (7.0), Arka Nirantara x Mexican Single (2.0) and Arka Nirantara x Arka Shringar (2.0). Among the cross combinations, Variegated x Arka Suvasini (31.82%) was promising and recorded the maximum percentage of hybrid flower buds with green tinge whereas the cross Arka Nirantara x Arka Vaibhav (5.71%) registered minimum percentage of hybrid flower buds with green tinge. The result shows that the numbers of flower buds with green tinge are very less in the hybrid population studied and this particular character might be governed by recessive genes.

Five different crosses produced sixteen hybrids with green tinge on flower bud which registered wide variations among themselves for the flowering and yield characters (Table 2). The cross Arka Nirantara x Arka Vaibhav found to be superior than the standard check for Mexican Single for the traits rachis length (22.24 cm), floret length (5.75 cm) and bud length (5.42 cm). The traits viz., spike length (77.16 cm), rachis length (23.58 cm), floret length (5.49 cm), floret diameter (3.42 cm), bud length (5.24 cm), internodal length of rachis (2.81 cm) and number of matured buds per spike (4.18) were recorded to be superior than the standard check Mexican Single in the cross Arka Nirantara x IIHR-2. The cross Variegated x Arka Suvasini found to be superior than the standard check Mexican Single for the traits days to first flower opening (28.23), spike length (64.02 cm), number of flowers per spike (43.78), floret length (5.42 cm), bud length (5.25 cm), single flower weight (0.87g) and number of matured buds per spike (2.73). The traits days to first flower opening (25.56), spike length (64.02 cm), number of flowers per spike (43.78), floret length (5.42 cm), bud length (5.26 cm), single flower weight (1.14g) and number of matured buds per spike (3.72) were found to be superior than the standard check Mexican Single in the cross Arka Nirantara x Mexican Single. The cross Arka Nirantara x Arka Shringar registered to be superior than the standard check Mexican Single for the traits viz., days to flower bud appearance (143.93), days to first floret opening (28.72), spike length (76.69 cm), rachis length (20.57 cm), number of flowers per spike (47.41), floret diameter (3.44 cm), single flower weight (2.88g) and number of matured buds per spike (3.07). Wide variations were observed for flowering and yield parameters of resulted hybrids of tuberose. The parents used for this study were highly heterozygous in nature and the range of variation occurring in the progenies is greater than the parent populations in the selected superior plants may be attributed to new combinations of genes from each parent as well as to gene rearrangements. Similar results were observed by Dhiman *et al.* (2012)^[4] in intervarietal hybridization of Asiatic lily. Similar results were observed in intervarietal hybridization of tuberose by Shen *et al.* (1987)^[12] gerbera by Singh *et al.* (2009)^[16], Lilium by Dhiman *et al.* (2012)^[4] and marigold by Singh and Misra (2012)^[12] and Bharathi and Jawaharlal (2014)^[13].

Table 1: Flower characteristics of tuberose hybrids

Intervarietal cross combination	No. of hybrids	No. of hybrids flower bud with green tinge	Percentage of hybrids flower bud with green tinge	No. of hybrids flower bud with pink tinge	Percentage of hybrids flower bud with pink tinge	Type of flower
Arka Nirantara x IIHR-4	63	-	0	63	100.0	Single
Arka Nirantara x Arka Vaibhav	35	02	5.71	33	94.29	Single
Arka Nirantara x IIHR-2	20	03	15.00	17	85.00	Single
Variegated x Arka Suvasini	22	07	31.82	15	68.18	Single
Arka Nirantara x Mexican Single	12	02	18.18	10	83.33	Single
Arka Nirantara x 1 x 6-2	08	-	0	08	100.00	Single
Arka Nirantara x Arka Shringar	29	02	6.67	27	93.10	Single
Arka Vaibhav x Arka Shringar	09	-	0	09	100.00	Single
Arka Shringar x IIHR-6	04	-	0	04	100.00	Single
Arka Shringar x Mexican Single	12	-	0	12	100.00	Single
Mexican Single x Arka Nirantara	12	-	0	12	100.00	Single

Table 2: Significant test for floral and yield parameters of five cross combination of tuberose

Cross combination	Days to flower bud appearance	Days to first flower opening	Spike length (cm)	Rachis length (cm)	No. of flowers per spike	Floret length (cm)	Floret diameter (cm)
Arka Nirantara x Arka Vaibhav	128.54±6.8 ns	27.8±0.97 ns	76.03±2.82 ns	22.24±1.08*	48.54±1.91 ns	5.75±0.14*	3.82±0.13 ns
Arka Nirantara x IIHR-2	128.83±6.63 ns	28.28±0.87 ns	77.16±3.70*	23.58±1.46*	48.67±2.32 ns	5.49±0.16*	3.42±0.22*
Variegated x Arka Suvasini	149.41± 4.19ns	28.23±0.81*	85.62±4.82*	18.04±1.18 ns	42.34±2.19*	5.56±0.36*	3.29±0.12 ns
Arka Nirantara x Mexican Single	135.28±8.91 ns	25.56±0.82*	64.02±4.57*	17.02±1.77 ns	43.78±2.78*	5.42±0.15*	3.78±0.19 ns
Arka Nirantara x Arka Shringar	143.93±6.34*	28.72±2.58*	76.69±3.38*	20.57±1.05*	47.41±1.93 ns	5.43±0.11 ns	3.44±0.08*

Significant at p<0.05

Cross combination	Flower tube length (cm)	Bud length (cm)	Bud weight (g)	Single flower weight (g)	Internodal length of rachis (cm)	Number of matured buds per spike	Number of spikes per plant
Arka Nirantara x Arka Vaibhav	3.68±0.08 ns	5.42±0.13*	0.96±0.05 ns	1.2±0.06 ns	7.75±4.54 ns	3.57±0.31 ns	2.64±0.10 ns
Arka Nirantara x IIHR-2	3.59±0.11 ns	5.24±0.16*	0.90±0.07 ns	1.14±0.09 ns	2.81±0.18*	4.18±0.49*	2.68±0.15 ns
Variegated x Arka Suvasini	3.54±0.1 ns	5.25±0.10*	0.73±0.06 ns	0.87±0.06*	2.87±0.58 ns	2.73±0.26*	2.50±0.10 ns
Arka Nirantara x Mexican Single	3.65±0.13 ns	5.26±0.18*	0.93±0.06 ns	1.14±0.06*	3.31±0.48 ns	3.72±0.63*	2.33±0.17 ns
Arka Nirantara x Arka Shringar	3.57±0.08 ns	4.94±0.25	0.88±0.05 ns	2.88±1.30*	2.57±0.17 ns	3.07±0.28*	2.73±0.11 ns

Significant at p<0.05

Performance of tuberose hybrids with green tinge on flower bud

The mean performance of the sixteen hybrids produced green tinge on flower bud from the five different combinations studied showed wide variation (Table 3). The spike length for the hybrids with green tinge on flower bud ranged from 37.93 to 127.40 cm. This trait was found to be superior to the commercial check Mexican Single (102.29 cm) in the hybrid 15-4-3 (121.10 cm) and 15-4-42(127.40 cm). The hybrid 15-5-7 found to be with shorter spike which recorded the spike length of 37.93 cm. The trait rachis length varied from 7.40 – 25.01 and it was recorded to be superior than the standard check in the hybrids 15-2-13 (19.08 cm), 15-3-1(23.05 cm) and 15-3-2 (25.01 cm). The hybrids 15-3-2 (72.00), 15-2-13 (50.75), 15-4-3 (51.50), 15-4-42 (52.00) and 15-5-7 (50.00) were registered to be superior than the standard check Mexican Single (46.90) for number of flowers per spike. The variation in number of flowers per plant and flower size in these hybrids may be attributed to the inherent genetic characters and environmental factors. Variations in floral characters were assessed in tuberose by Shen *et al.* (1987) [12] and marigold by Patnaik and Mohanty (2002) [12], Mohanty *et al.* (2003) [8], Singh *et al.* (2003) [14] and Singh *et al.* (2008) [15].

Floret length ranged from 4.77 – 7.5 cm and this trait was found to be the superior in the hybrids 15-3-2 (6.32 cm), 15-4-1 (6.67 cm) and 15-5-2 (7.15 cm) than the standard check Mexican Single (6.30). The hybrids 15-2-32 (4.16), 15-3-2 (4.12), 15-4-3 (4.13) and 15-5-2 (4.10) were recorded to be superior than the commercial check Mexican Single for floret diameter. This trait varied from 3.09 - 4.16 cm. Floret tube length was found to be superior than the standard check Mexican single (3.66 cm) in the hybrids 15-4-3 (4.22 cm), 15-4-9 (4.13cm), 15-4-1 (4.13 cm), 15-4-10 (4.15 cm) and 15-5-2 (4.82 cm). The hybrids 15-4-3 (6.40), 15-4-9 (6.40), 15-4-1 (6.48), 15-4-10 (6.15), 15-5-2 (6.88) were found to superior than the standard check Mexican Single for bud length. This trait ranged from 5.30-6.88 cm. Bud weight varied from 0.70-1.30 g and this trait was registered to be superior in the hybrids 15-2-32 (0.96g), 15-2-13 (1.13g), 15-4-3 (1.19 g), 15-4-9 (1.08 g), 15-4-1 (0.99 g), 15-4-10 (0.96 g) and 15-5-2 (1.30 g) than the standard check Mexican Single (1.26 g). The differences among the genotypes for floral parameters are attributed to their genetic makeup.

The hybrids 15-4-3 (1.49) and 15-5-2 (1.43) are recorded to be superior than the standard check Mexican Single (1.26) for single flower weight. This trait ranged from 0.94 to 1.49g. Number of petals per floret was found to be 6.00 in all the

hybrids as like standard check Mexican Single (6.00) except the hybrid 15-7-19 (6.67). The hybrids 15-2-32 (3.00), 15-2-13 (2.50), 15-3-2 (4.00), 15-4-12 (3.00), 15-5-2 (4.00) were found to be superior than the standard check Mexican Single (2.00) and this trait ranged from 2.00- 4.00. Number of spikes per clump was varied from 2.00 to 4.00 and this trait was found to be superior in the hybrids 15-2-13 (4.00), 15-3-32 (4.00), 15-3-2 (4.20) and 15-4-10 (4.00) than the standard check Mexican Single (3.90). This may be due to varied growth rates and genetic make-up. Similar results were obtained by Namita *et al.* (2008) [9] and Singh and Singh (2010) [11] in marigold.

Among the sixteen hybrids evaluated, nature of spike of nine hybrids was found to be straight, six hybrids were recorded to be bending and the nature of spikes of two hybrids was registered to be slight bent. The spikes which are exhibiting the bending nature are not suitable as loose flower, cut flower and potted plant. The nature of petal was found to be straight in all the hybrids except 15-4-10 which was having reflexed petal and less prone to petal breakage. The heterozygous population presents in each intervarietal cross caused wide variation in the flowering and yield traits which resulted in both low and high yielding plants from a single cross. The heterozygous population presents in each intervarietal cross caused wide variation in the flowering and yield traits which resulted in both low and high yielding hybrids from a single

cross. The results are in corroboration with the findings of Shen *et al.* (1987) [12] in tuberose, Singh *et al.* (2009) [16] in gerbera Dhiman *et al.* (2012) [4] in Lilium and Singh and Misra (2012) [13] and Bharathi and Jawaharlal (2014) [3] in marigold. The heterozygous nature of the hybrids paves the way for single plant selection on the basis of flowering and yield for further advancement.

It is concluded from the study that among the hybrids evaluated for their performance on flowering and yield parameters, the following hybrids *viz.*, hybrid 15-2-13 from the cross Arka Nirantara x Arka Vaibhav with more rachis length (19.08), number of florets per spike (50.75), bud weight (1.13), number of matured buds in spike (4.00), number of spikes per plant (4.00) and straight spike, hybrid 15-3-2 from the cross Arka Nirantara x IHR-2 with the highest rachis length (25.10 cm), flower diameter (4.12 cm), number of florets per spike (72.00), number of matured buds per spike (4.00), number of spikes per plant (4.20) and straight spike, hybrid 15-4-10 from the cross Variegated x Arka Suvasini with the highest number of spikes per plant (4.00), straight spike and reflexed petal were selected for further multiplication and evaluation (Fig 1). Creation of variability is a prerequisite for the development of new variety and these selected hybrids may be used as base line material for further increase of genetic variability and crop improvement.



Table 3: Performance of tuberose hybrids from different cross combinations with green tinge on flower bud

Genotype no.	Spike length (cm)	Rachis length (cm)	No. of florets per spike	Floret length (cm)	Flower diameter (cm)	Floret tube length (cm)	Bud length (cm)	Bud weight (g)	Single flower weight (g)	Internodal length of rachis (cm)	No. of petals	Number of matured buds per spike	No. of spikes per clump	Nature of spike	Nature of petal
Arka Nirantara x Arka Vaibhav															
15-2-32	59.70	15.90	33.00	5.84	4.16*	3.38	5.90	0.96*	1.08	1.86	6.00	3.00*	3.00	Bending	Straight
15-2-13	81.88	19.08*	50.75*	5.24	3.72	3.48	5.43	1.13*	1.15	3.02	6.00	2.50*	4.00*	Straight	Straight
Arka Nirantara x IHR-2															
15-3-32	69.30	17.13	47.33	4.77	3.30	3.56	5.23	0.84	0.94	2.00	6.00	1.67	4.00*	Straight	Straight
15-3-1	89.35	23.05*	49.00	5.12	3.57	3.92	5.65	0.87	1.08	2.54	6.00	2.00	3.00	Straight	Straight
15-3-2	97.70	25.10*	72.00*	5.98	4.12*	3.76	5.93	0.81	0.94	3.32	6.00	4.00*	4.20*	Slight bent	Straight
Variegated x Arka Suvasini															
15-4-3	121.10*	18.35	51.50*	6.32*	4.13*	4.22*	6.40*	1.19*	1.49*	2.97	6.00	1.50	3.00	Straight	Straight
15-4-9	88.65	17.40	34.00	5.28	3.21	4.13*	6.40*	1.08*	1.26	3.05	6.00	1.50	2.20	Straight	Straight
15-4-1	86.35	11.80	28.50	6.67*	3.20	4.77*	6.48*	0.99*	1.22	1.77	6.00	1.50	2.50	Bending	Straight
15-4-12	67.80	12.10	39.00	5.66	3.42	3.72	5.83	0.95	1.10	1.88	6.00	3.00*	2.17	Bending	Straight
15-4-42	127.40*	7.40	52.00*	5.87	3.93	3.93	5.75	0.70	0.90	2.50	6.00	2.00	3.20	Bending	Straight
15-4-10	76.25	15.25	31.00	4.88	3.09	4.15*	6.15*	0.96*	1.23	2.26	6.00	2.00	4.00*	Straight	Reflexed
15-4-22	68.50	17.60	44.00	5.40	3.48	3.55	5.60	0.78	0.91	1.80	6.00	1.00	2.67	Straight	Straight
15-5-2	78.60	14.30	43.00	7.15*	4.10*	4.83*	6.88*	1.30*	1.43*	1.88	6.00	4.00*	2.00	Bending	Straight
Arka Nirantara x Mexican Single															

15-5-7	37.93	10.53	50.00*	5.91	3.79	3.99	5.53	0.92	1.08	1.90	6.00	1.67	3.00	Bending	Straight
Arka Nirantara x Arka Shringar															
15-7-19	88.67	13.07	40.00	5.21	3.72	3.91	5.67	0.93	1.13	2.28	6.67*	2.00	2.13	Straight	Straight
15-7-15	76.35	11.93	34.25	5.22	3.37	3.60	5.30	0.81	0.94	1.86	6.00	2.00	2.50	Straight	Straight
Mexican Single	102.29	18.25	46.90	6.30	3.93	4.90*	6.13	0.93	1.26	3.65	6.00	2.00	3.90	Slight bent	Straight
Mean	83.40	15.78	43.90	5.76	3.66	3.99	6.49	0.95	1.13	2.38	6.04	2.20	3.03	-	-
Range	37.93-127.40	7.40-25.10	28.50-72.00	4.77-7.15	3.09-4.16	3.38 – 4.83	5.30-6.88	0.70-1.30	0.94 – 1.49	1.77- 3.65	6.00-6.67	1.00 - 4.00	2.00-4.00	-	-
Sem±	5.23	1.09	2.57	0.19	0.09	0.11	0.58	0.04	0.04	0.15	0.04	0.21	0.18	-	-

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