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Characterization of different tuberose genotypes through DUS testing

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Abstract
Tuberose is commercially significant bulbous ornamental crop, cultivated extensively for its attractive and fragrant cut flowers, as well as loose flower. As there is considerable misunderstanding in the nomenclature of genetic material existing in various Indian states because they are solely referred to as one genotype and all local duplicates are most likely from another. Apart from registration and commercial introduction of new kinds, the main focus at the moment is to maintain their purity. This study aimed to screening and identified the desirable tuberose genotypes from half sib population of ten different tuberose *viz*. Phule Rajani, Arka Shringar, Arka Sugandhi, Arka Nirantara, GKTC- 4, Hyderabad Single, Sikkim Selection, Bidhan Ujjawal, Bidhan Jyoti, Mexican Single. Among the population significant genetic diversity and variability were recorded morphological, flowering and yield parameters. However, distinct differences were noticed in floral and vegetative traits in half-sib genotypes which exhibited diverse characteristics, including yellow and pink flower colors, as well as semi-double and double florets.

Keywords: Bulbous, cut flower, loose flower, semi double

Introduction
Tuberose (*Polianthes tuberosa* L.) is one of the most important tropical ornamental bulbous flowering plants cultivated for production of long-lasting flower spikes. It is popularly known as 'Rajanigandha' or 'Nishigandha'. It belongs to the family Asparagaceae and is native of Mexico from where it was spread to the different parts of the world during the 16th century. It is commercially cultivated in different parts of India. 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. The different varieties in tuberose. These are firstly named on the basis of the number of petals they bear. In the cultivar 'Single', the flowers are pure white with only one whorl of corolla segments. The 'Semi double' type, bear white flower with two to three whorls of corolla. The 'Double' type flowers have more than three whorls of corolla. The flower tinged with red in 'double' type is known as 'Pearl'. As flowers are very popular for its strong fragrance and its essential oil is important component for high grade perfume. 'Single' varieties are more fragrant than 'Double'. The high demand for tuberose concrete and absolute in international market which fetch a very good price. Flower of the single type commonly used for extraction of essential oil, loose flower, pot plant, making garland etc. while that of double type are used as cut flower, garden display and interior decoration. Fragrance of flower is very sweet floral and honey like can help give emotional strength. The flower spike of tuberose remain fresh for long time and finds a distinct place in the flower market.
Due to its immense export potential, cultivation of tuberose is gaining momentum day by day in India. (Bansil, 2018) [1]. In recent years, crop improvement had play important role in producing new types in tuberose and for that the knowledge of genetic base of crop is must. Morphological characterization is the first step in description and classification. With the advent of Protection of Plant Varieties and Farmers Right Act, 2001in India, the potential application of the DUS test guideline to distinguish a candidate variety from reference material was successfully demonstrated.

Table 1: List of sixty variants with 10 genotypes (Check) in experiment

Genotype	Half Sibs of Genotype and check
G1, G2, G3, G4, G5, G6, G7, G8, G9, G10, G11, G12, G13, G14, G15, G16, G17, G18, G19, G20, G21, G22, G23, G24, G25, G26, G27, G28, G29, G30, G31, G32, G33, G34, G35, G36, G37, G38,G39, G40, G41, G42, G43, G44, G45, G46, G48, G49, G50, G51, G52, G56, G57, G58, G59, G60, G61, G62, G63, G65	Selected 60 variants from half sib population of ten genotypes on the basis of desirable morphological characters
G47	Arka Shringar
G53	Arka Sugandhi
G54	GKTC 4
G55	Hyderabad Single
G64	Bidhan Jyoti
G66	Sikkim Selection
G67	Bidhan Ujjwal
G68	Phule Rajani
G69	Mexican Single
G70	Arka Nirantara

Materials and Methods

The present investigation was conducted at the Floriculture Research Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari (Gujarat) for two successive years 2023- 24 to 2024-25. Tuberose uniform size bulbs were obtained from half-sib progenies of 10 different genotypes at Floriculture Research Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari. The data for present investigation were recorded by following guidelines of "Protection of Plant Varieties and Farmers' Right Authority" in which ICAR- Indian Institute of Horticultural Research, Hessarghatta, Bengaluru was nodal DUS testing center. All half sibs of 10 genotypes and check were planted at 5.00 -7.00 cm depth with a spacing of 30 cm × 30 cm ridges. Among them screening and identification of desirable tuberose genotypes from half sib population of ten genotypes were done. The experiment material for the present investigation consisted half sibs of ten genotypes of tuberose are presented in Table 1**.** All ten check varieties were mentioned in Photo 1.

Results and Discussion

Morphological characters were prioritized due to their predominant genetic expression
and stability across generation. An effort was made to characterise the half sibs of tuberose genotypes exhibiting superior characteristics, including leaf colour, leaf variation, flower colour, flower type, tepal arrangement and flower length. The characterization was made as per PPV and FRA's DUS guideline on tuberose (2013) and presented in Table 2.

Moreover, origin of genotypes was also documented and presented in Table 3.

In case of leaf colour, dark green leaves were observed in 51 genotypes *viz*. Arka Nirantara, Arka Shringar, GKTC-4, Bidhan Jyoti, Bidhan Ujjawal, Mexican Single and other half sibs, however rest of genotypes showed light green coloured leaves which are mentioned in Table 3.

Among 70 genotype, Sikkim selection (G^{66}) and G^{56} recorded leaf variation whereas, it was absent in rest of the genotypes.

Table 2: Morphological Characterization using DUS Guideline

Sr. No.	Character	State	Note	Stage of observation	Types of assessment
1. (+) PQ	Leaf colour Ref. RHS colour Chart	Light green	3	02	VS
		Dark green	5		
2. (+) QL	Leaf variegation	Absent	1	02	VG
		Present	9		
3 (+) QL	Flower colour	White	3	05	VG
		Yellow	5		
		Pink	7		
4. (+) QL	Flower type	Single	3	05	VG
		Double	5		
5. (+) QN	Flower length	Short < 6 cm	3	05	MS
		Medium 6-7 cm	5		
		Long >7 cm	7		
6. (+) QN	Flower diameter	Short < 4 cm	3	05	MS
		Medium 4-4.5 cm	5		
		Long >4.5	7		
7. (+) QN	Rows of tepal	1	3	05	VG
		>3	5		
8 (+) QL	Inflorescence	Straight	3	05	VG
		Crooked	5		
		Slightly bent	7		
9 (+) QN	Inflorescence axis	Short < 20 cm	3	05	MS
		Medium 20-30 cm	5		
		Long > 30 cm	7		
10 (+) QN	Inflorescence length	Short < 70 cm	3	05	MS
		Medium 70-105 cm	5		
		Long > 105 cm	7		

11 (+) QN	No. of flowers per inflorescence	Few < 40 Nos Medium 42-52 Many > 52 Nos	3 5 7	05	MG
12 (+) QN	Days taken for flowering	Early 90 - 100 Late > 100	3 5	05	MG
Note	QL= Qualitative characteristics				
	QN= Quantitative characteristics				
	PQ= Pseudo qualitative characteristics				
	MS= Measurement of a number of individual plants or parts plant				
	VG= Visual assessment by a single observation on group of plants or parts of plants				
	MG= Measurement by a single observation of group of plants part of plant				

With respect to flower color, all genotype produced white color flower except G^4, G^5 had pink color flowers and yellow color in the following half sib genotypes of tuberose G^8, G^{10}, G^{14}, G^{16}, G^{19}, G^{21}, G^{26}, G^2, G^{38}, G^{41}, G^{60}, G^{61}, G^{62}, G^{63}.

In case of flower types single and double, G^5, G^9, G^{18}, G^{20} found with double and semidouble type while rest of all genotypes were observed with single type of tuberose represented in Table 3.

In case flower length maximum length, among the 70 genotypes 46 genotypes were recorded with short flower length which was shorter than 6 cm *viz*. Arka Shringar, GKTC-4, Hyderabad Single, Bidhan Ujjawal and other half sib of tuberose mentioned in the Table 3.and rest of all had medium length of flower ranges in 6-7 cm including check verities *viz.* Phule Rajani, Mexican Single, Arka Nirantara, Bidhan Jyoti, Sikkim Selection. While Maximum range, more than 4.5 cm flower diameter recorded in 17 half sib of tuberose.

With respect to row of tepals only four half sib genotypes tuberose had more than three row of petal in flower *viz* G^5, G^9, G^{18}, G^{40} which is mentioned in Table 3.

Straightness in spike is very important character and among all genotypes, 66 genotypes exhibited straight inflorescence except Arka Nirantara, Sikkim Selection and G^{20}, G^{31} with crocked and slightly bend spike respectively.

In case of inflorescence axis, among all the genotype studied, 17 genotypes including different half-sib of 10 genotypes and check *viz.* Hyderabad Single, Arka Sungadhi, Sikkim Selection, Arka Nirantara had short inflorescence axis short (< 20 cm), thirty seven genotypes including different half-sib of 10 genotypes and check *viz.* GKTC-4, Bidhan Jyoti had medium inflorescence axis medium (20-30 cm) and rest of all having long inflorescence axis (> 30 cm) with Sikkim Selection, Bidhan Ujjawal checks and half-sib of tuberose.

In case of inflorescence length, nine genotype of half sib including Sikkim Selection, Bidhan Jyoti had long inflorescence length (> 105 cm), while short range of inflorescence (< 70 cm) was recorded in twenty-eight genotype including Arka Sugandhi, Hyderabad Single check and other selected half sib of tuberose mentioned in Table 3.

As tuberose used as loose flower and cut flower number of flower per spike is very important character for the crop. Half sib of tuberose genotypes had maximum number of flower per spike than rest of all seventy genotypes including checks.

In case of days taken to flowering all genotypes noted late varieties for flowering.

Table 3: Morphological Characterization using DUS Guideline

Sr. no.	Character	State	Note	G^1	G^2	G^3	G^4	G^5	G^6	G^7	G^8	G^9	G^{10}
1	Leaf colour Ref. RHS colour Chart	Light green Dark green	3 5	5	5	5	5	5	5	5	3	5	3
2	Leaf variegation	Absent Present	1 9	1	1	1	1	1	1	1	1	1	1
3	Flower colour	White Yellow Pink	3 5 7	3	3	3	7	7	3	3	5	5	3
4	Flower type	Single Double	3 5	3	3	3	3	5	3	3	3	5	3
5	Flower length	Short < 6 cm Medium 6-7 cm Long >7 cm	3 5 7	3	3	3	3	3	5	5	3	3	5
6	Flower diameter	Short < 4 cm Medium 4-4.5 cm Long >4.5	3 5 7	3	7	5	3	3	7	7	5	3	3
7	Rows of tepal	1 >3	3 5	3	3	3	3	5	3	3	3	5	3
8	Inflorescence	Straight Crooked Slightly bent	3 5 7	3	3	3	3	3	3	3	3	3	3
9	Inflorescence axis	Short < 20 cm Medium 20-30 cm Long > 30 cm	3 5 7	3	3	7	3	7	3	7	3	7	3
10	Inflorescence length	Short < 70 cm Medium 70-105 cm Long > 105 cm	3 5 7	3	3	5	3	5	3	7	3	7	5
11	No. of flowers per inflorescence	Few < 40 Nos	3	3	5	5	3	7	3	5	3	3	3

		Medium 42-52	5										
		Many > 52 Nos	7										
12	Days taken for flowering	Early 90 - 100	3	5	5	5	5	5	5	5	5	5	5
		Late > 100	5										
Sr. no.	**Character**	**State**	**Note**	**G^{11}**	**G^{12}**	**G^{13}**	**G^{14}**	**G^{15}**	**G^{16}**	**G^{17}**	**G^{18}**	**G^{19}**	**G^{20}**
1	Leaf colour Ref. RHS colour Chart	Light green	3	5	5	5	3	5	3	5	5	3	5
		Dark green	5										
2	Leaf variegation	Absent	1	1	1	1	1	1	1	1	1	1	1
		Present	9										
3	Flower colour	White	3	3	3	3	5	3	5	3	3	5	3
		Yellow	5										
		Pink	7										
4	Flower type	Single	3	3	3	3	3	3	3	3	3	3	3
		Double	5										
5	Flower length	Short < 6 cm	3	3	5	3	3	3	5	5	5	3	3
		Medium 6-7 cm	5										
		Long >7 cm	7										
6	Flower diameter	Short < 4 cm	3	5	3	5	5	7	7	7	7	7	5
		Medium 4-4.5 cm	5										
		Long >4.5	7										
7	Rows of tepal	1	3	3	3	3	3	3	3	3	3	3	3
		>3	5										
8	Inflorescence	Straight	3	3	3	3	3	3	3	3	3	3	7
		Crooked	5										
		Slightly bent	7										
9	Inflorescence axis	Short < 20 cm	3	3	3	7	7	5	5	5	7	5	5
		Medium 20-30 cm	5										
		Long > 30 cm	7										
10	Inflorescence length	Short < 70 cm	3	5	5	5	3	3	3	5	7	5	5
		Medium 70-105 cm	5										
		Long > 105 cm	7										
11	No. of flowers per inflorescence	Few < 40 Nos	3	3	3	5	3	3	3	5	5	3	3
		Medium 42-52	5										
		Many > 52 Nos	7										
12	Days taken for flowering	Early 90 - 100	3	5	5	5	5	5	5	5	5	5	5
		Late > 100	5										
Sr. no.	**Character**	**State**	**Note**	**G^{21}**	**G^{22}**	**G^{23}**	**G^{24}**	**G^{25}**	**G^{26}**	**G^{27}**	**G^{28}**	**G^{29}**	**G^{30}**
1	Leaf colour Ref. RHS colour Chart	Light green	3	3	5	5	5	5	3	5	3	5	5
		Dark green	5										
2	Leaf variegation	Absent	1	1	1	1	1	1	1	1	1	1	1
		Present	9										
3	Flower colour	White	3	5	3	3	3	3	5	3	5	3	3
		Yellow	5										
		Pink	7										
4	Flower type	Single	3	3	3	3	3	3	3	3	3	3	3
		Double	5										
5	Flower length	Short < 6 cm	3	3	5	3	3	3	3	5	3	5	3
		Medium 6-7 cm	5										
		Long >7 cm	7										
6	Flower diameter	Short < 4 cm	3	5	3	7	5	3	3	5	3	7	7
		Medium 4-4.5 cm	5										
		Long >4.5	7										
7	Rows of tepal	1	3	3	3	3	3	3	3	3	3	3	3
		>3	5										
8	Inflorescence	Straight	3	3	3	3	3	3	3	3	3	3	3
		Crooked	5										
		Slightly bent	7										
9	Inflorescence axis	Short < 20 cm	3	5	7	3	5	5	7	5	5	7	5
		Medium 20-30 cm	5										
		Long > 30 cm	7										
10	Inflorescence length	Short < 70 cm	3	5	5	3	5	3	5	5	5	7	5
		Medium 70-105 cm	5										
		Long > 105 cm	7										
11	No. of flowers per inflorescence	Few < 40 Nos	3	3	5	3	3	3	5	3	5	7	5
		Medium 42-52	5										
		Many > 52 Nos	7										
12	Days taken for flowering	Early 90 - 100	3	5	5	5	5	5	5	5	5	5	5
		Late > 100	5										

Sr. no.	Character	State	Note	G^{31}	G^{32}	G^{33}	G^{34}	G^{35}	G^{36}	G^{37}	G^{38}	G^{39}	G^{40}
1	Leaf colour Ref. RHS colour Chart	Light green	3	5	5	5	5	5	5	5	3	5	5
		Dark green	5										
2	Leaf variegation	Absent	1	1	1	1	1	1	1	1	1	1	1
		Present	9										
3	Flower colour	White	3	3	3	3	3	3	3	3	5	3	3
		Yellow	5										
		Pink	7										
4	Flower type	Single	3	3	3	3	3	3	3	3	5	3	3
		Double	5										
5	Flower length	Short < 6 cm	3	3	3	3	5	5	3	3	5	5	3
		Medium 6-7 cm	5										
		Long >7 cm	7										
6	Flower diameter	Short < 4 cm	3	5	5	5	5	3	7	5	7	5	3
		Medium 4-4.5 cm	5										
		Long >4.5	7										
7	Rows of tepal	1	3	3	3	3	3	3	3	3	5	3	3
		>3	5										
8	Inflorescence	Straight	3	7	3	3	3	3	3	3	3	3	3
		Crooked	5										
		Slightly bent	7										
9	Inflorescence axis	Short < 20 cm	3	3	5	5	5	.3	5	5	7	5	5
		Medium 20-30 cm	5										
		Long > 30 cm	7										
10	Inflorescence length	Short < 70 cm	3	3	5	5	3	3	3	3	7	5	5
		Medium 70-105 cm	5										
		Long > 105 cm	7										
11	No. of flowers per inflorescence	Few < 40 Nos	3	3	3	3	3	5	3	3	5	3	5
		Medium 42-52	5										
		Many > 52 Nos	7										
12	Days taken for flowering	Early 90 - 100	3	5	5	5	5	5	5	5	5	5	5
		Late > 100	5										
Sr. no.	**Character**	**State**	**Note**	G^{41}	G^{42}	G^{43}	G^{44}	G^{45}	G^{46}	G^{47}	G^{48}	G^{49}	G^{50}
1	Leaf colour Ref. RHS colour Chart	Light green	3	3	5	5	5	5	5	5	5	3	5
		Dark green	5										
2	Leaf variegation	Absent	1	1	1	1	1	1	1	1	1	1	1
		Present	9										
3	Flower colour	White	3	5	3	3	3	3	3	3	3	3	3
		Yellow	5										
		Pink	7										
4	Flower type	Single	3	3	3	3	3	3	3	3	3	3	3
		Double	5										
5	Flower length	Short < 6 cm	3	5	3	5	3	3	3	3	3	3	3
		Medium 6-7 cm	5										
		Long >7 cm	7										
6	Flower diameter	Short < 4 cm	3	5	3	3	3	3	3	3	3	3	3
		Medium 4-4.5 cm	5										
		Long >4.5	7										
7	Rows of tepal	1	3	5	3	3	3	3	3	3	3	3	5
		>3	5										
8	Inflorescence	Straight	3	3	3	7	3	3	3	3	3	3	5
		Crooked	5										
		Slightly bent	7										
9	Inflorescence axis	Short < 20 cm	3	3	3	5	5	3	7	5	5	3	5
		Medium 20-30 cm	5										
		Long > 30 cm	7										
10	Inflorescence length	Short < 70 cm	3	5	5	5	5	3	5	5	5	3	5
		Medium 70-105 cm	5										
		Long > 105 cm	7										
11	No. of flowers per inflorescence	Few < 40 Nos	3	3	5	5	5	7	7	3	3	5	3
		Medium 42-52	5										
		Many > 52 Nos	7										
12	Days taken for flowering	Early 90 - 100	3	5	5	5	5	5	5	5	5	5	5
		Late > 100	5										
Sr. no.	**Character**	**State**	**Note**	G^{51}	G^{52}	G^{53}	G^{54}	G^{55}	G^{56}	G^{57}	G^{58}	G^{59}	G^{60}
1	Leaf colour Ref. RHS colour Chart	Light green	3	5	5	3	5	3	5	5	5	5	3
		Dark green	5										
2	Leaf variegation	Absent	1	1	1	1	1	1	9	1	1	1	1

		Present	9										
3	Flower colour	White	3	3	3	3	3	3	3	3	3	3	5
		Yellow	5										
		Pink	7										
4	Flower type	Single	3	3	3	3	3	3	3	3	3	3	3
		Double	5										
5	Flower length	Short < 6 cm	3	3	3	3	3	3	3	5	3	3	5
		Medium 6-7 cm	5										
		Long >7 cm	7										
6	Flower diameter	Short < 4 cm	3	7	3	3	3	5	7	7	3	3	3
		Medium 4-4.5 cm	5										
		Long >4.5	7										
7	Rows of tepal	1	3	3	3	3	3	3	3	3	3	3	3
		>3	5										
8	Inflorescence	Straight	3	3	7	3	3	3	3	3	3	3	3
		Crooked	5										
		Slightly bent	7										
9	Inflorescence axis	Short < 20 cm	3	5	5	3	3	5	3	7	7	5	5
		Medium 20-30 cm	5										
		Long > 30 cm	7										
10	Inflorescence length	Short < 70 cm	3	5	5	3	5	7	3	3	3	3	3
		Medium 70-105 cm	5										
		Long > 105 cm	7										
11	No. of flowers per inflorescence	Few < 40 Nos	3	5	5	5	3	3	3	3	5	5	5
		Medium 42-52	5										
		Many > 52 Nos	7										
12	Days taken for flowering	Early 90 - 100	3	5	5	5	5	5	5	5	5	5	5
		Late > 100	5										
Sr. no.	**Character**	**State**	**Note**	**G^{61}**	**G^{62}**	**G^{63}**	**G^{64}**	**G^{65}**	**G^{66}**	**G^{67}**	**G^{68}**	**G^{69}**	**G^{70}**
1	Leaf colour Ref. RHS colour Chart	Light green	3	3	3	3	5	3	3	5	3	5	5
		Dark green	5										
2	Leaf variegation	Absent	1	1	1	1	1	1	9	1	1	1	1
		Present	9										
3	Flower colour	White	3	5	5	5	3	3	3	3	3	3	3
		Yellow	5										
		Pink	7										
4	Flower type	Single	3	3	3	3	3	3	3	3	3	3	3
		Double	5										
5	Flower length	Short < 6 cm	3	5	3	5	5	3	5	3	5	5	5
		Medium 6-7 cm	5										
		Long >7 cm	7										
6	Flower diameter	Short < 4 cm	3	3	3	5	5	3	3	3	3	5	5
		Medium 4-4.5 cm	5										
		Long >4.5	7										
7	Rows of tepal	1	3	3	3	3	3	3	3	3	3	3	3
		>3	5										
8	Inflorescence	Straight	3	3	3	3	3	3	7	3	3	3	5
		Crooked	5										
		Slightly bent	7										
9	Inflorescence axis	Short < 20 cm	3	5	5	5	5	5	7	7	5	5	3
		Medium 20-30 cm	5										
		Long > 30 cm	7										
10	Inflorescence length	Short < 70 cm	3	3	5	3	7	5	7	5	5	5	5
		Medium 70-105 cm	5										
		Long > 105 cm	7										
11	No. of flowers per inflorescence	Few < 40 Nos	3	3	3	5	3	3	3	3	5	5	5
		Medium 42-52	5										
		Many > 52 Nos	7										
12	Days taken for flowering	Early 90 - 100	3	5	5	5	5	5	5	5	5	5	5
		Late > 100	5										

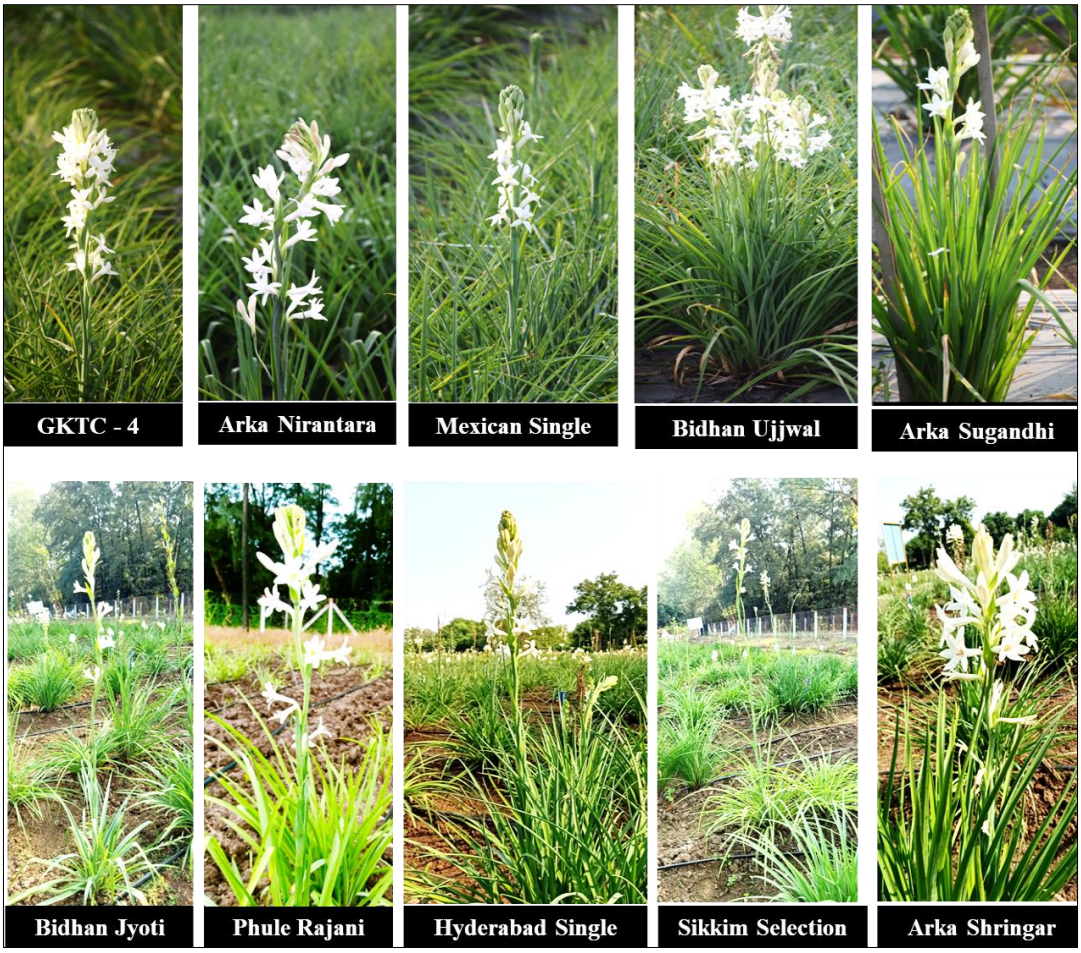

Photo 1: Ten check varieties of tuberose from experiment

Photo 2: Tuberose spike with different flower color ((a) Pale Yellow (b) Yellow with Pink tinge (c) Pink flower (d) White flower with slightly pink tinge)

Conclusion

The morphological characterization of seventy genotypes including sixty half-sib and ten checks clearly brought out the difference as per the PPVFRA given DUS guideline. The data represented indicate that these genotypes differed highly.

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