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Morphological variations among various single accessions of *Polianthes tuberosa* L. under Punjab conditions

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Abstract

Polianthes Tuberosa L., commonly known as Tuberose is a promising bulbous aromatic plant that is highly valued for its flowers as well as mesmerizing fragrance that makes it highly demanded in global floral markets. There are 2 types of tuberose based on whorls, i.e. single and double with a number of varieties reported in India. There is a great confusion in the naming of tuberose as all the single tepalled tuberose are normally referred to as single tuberose, and double tepalled cultivars are normally referred to as double tuberose irrespective of the huge differences found among these different cultivars. Single tuberose are comparatively more in demand due to their use in perfume industry owing to high level of concrete and absolute in single flowers as compared to double. So, proper keys or characters need to be identified, so as to study and identify these useful cultivars. Moreover as climatic conditions of Punjab are well suited for growing tuberose, there is a great potential of building a cut flower market for tuberose in this region. Cut flower industry is still in its infancy in Punjab and growers are unaware of the importance of different tuberose cultivars as per demand in both local and international market. Therefore there is a need to introduce different tuberose cultivars as a cut flower, source of essential oil and possibly more way towards export in this area. Looking to the potential of some tuberose cultivars there is a dire need to evaluate them under Punjab conditions. In the present studies, various morphological markers were used to study the variations found among seventeen different single tepalled tuberose cultivars under Punjab conditions. The studies were successful as satisfactory results were achieved and various morphological markers were identified, that can be successfully used to mark variations among various cultivars of tuberose in future on the basis of these morphological markers and even in conducting Distinctiveness, Uniformity And Stability (DUS) testing on different cultivars as these studies have not been conducted on Tuberose as yet under Punjab conditions. The analysis of data indicated that the cultivars did not differ significantly in a two traits i.e. leaf waxiness and flower colour. However, marked differences were seen in 24/26 characters, which makes these morphological markers of potential use for future research.

Keywords: Tuberose, *Polianthes tuberosa* L., morphological markers, morphological variations, DUS testing. Loose flower, cut flower

Introduction

Tuberose is a promising bulbous aromatic plant that has high market demand in global floral markets (Asif *et al.*, 2016) [1]. Tuberose occupies a special place in world market for its loose flower and cut flower (Navabi *et al.*, 2016) [6]. Tuberose also attains a prime position in perfume industry owing to its aromatic properties as well as a source of essential oils (Dudareva and Negre, 2005) [5].

There are 2 types of tuberose based on whorls, i.e. single and double with a number of varieties reported in India (Biswas *et al.*, 2002) [3]. There is a great confusion in the naming of tuberose as all the single tepalled tuberose are normally referred to as single tuberose, and double tepalled cultivars are normally referred to as double tuberose irrespective of the huge differences found among these different cultivars. (Bharti *et al.*, 2015) [2]. Single tuberose are comparatively more in demand due to their use in perfume industry owing to high level of concrete and absolute in single flowers as compared to double (Singh *et al.*, 2010) [7]. So, proper keys or morphological characters need to be identified, so as to study these useful cultivars. Moreover, Tuberose is widely cultivated for its flowers to be used as loose flowers, cut flowers, and also for its aromatic/ essential oil all over the world (Datta, 2017) [4]. Even in India, 30,000 hectare of land is under tuberose cultivation. Major tuberose producing states of India include Andhra Pradesh, Assam, Gujarat, Haryana, Karnataka, Maharashtra, Tamil Nadu, Uttar Pradesh, Uttarakhand and Orissa (Singh *et al.*, 2010) [7].

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As climatic conditions of Punjab are well suited for growing tuberose, there is a great potential of building a cut flower market for tuberose in this region. Cut flower industry is still in its infancy in Punjab and growers are unaware of the importance of different tuberose cultivars as per demand in both local and international market. Therefore there is a need to introduce different tuberose cultivars as a cut flower, loose flower, source of essential oil and possibly more way towards export in this area. Looking to the potential of some tuberose cultivars there is a dire need to evaluate them under Punjab conditions. In the present studies, various morphological markers were used to study the variations found among seventeen different single tepalled tuberose cultivars under Punjab conditions. The studies were successful as satisfactory results were achieved and various morphological markers were identified, that can be successfully used to mark variations among various cultivars of tuberose in future on the basis of these morphological markers and even in conducting Distinctiveness, Uniformity And Stability (DUS) testing on different cultivars as these studies have not been conducted on Tuberose as yet under Punjab conditions.

Materials and Methods

Germplasm of seventeen cultivars of tuberose was cultivated in the Plant Conservatory, Punjabi University, Patiala as per the guidelines of Protection of Plant Varieties and Farmers' Rights Authority, India. The present study is being carried out for years 2017-18 and 2018-19 to characterize the collected germplasm. The experimental material comprised of 17 accessions i.e. Prajwal, Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Kalyani Single, Vidhan Ujwal, Single, STR-505, Sikkim Selection, Hyderabad Single, Mexican Single, Vidhan Sugandha, Sardar Local, Calcutta single, Pune Single and Arka Sugandhi. All accessions were evaluated using twenty eight morphological parameters related to vegetative and floral morphology. Observations were made in each accession on 10 plants or parts of 10 plants at random, excluding the plants in border rows.

Results and Conclusion

The morphological characters of seventeen germplasm accessions have been observed to be clearly different. Differences were seen in various characters. Leaf colour is found to be light green in Prajwal, Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Vidhan Ujwal, Single, STR-505, Sikkim Selection, Hyderabad Single, Mexican Single, Calcutta Single while dark in Pune Single, Dark Green In Kalyani Single, Vidhan Suganda, Sardar Local, and Arka Sugandhi.

Similarly Leaf variegation is present only in Sikkim selection while it is absent in all the rest of the accessions, i.e. Prajwal, Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Vidhan Ujwal, Single, STR-505, Hyderabad Single, Mexican Single, Calcutta Single while Dark, Pune Single, Kalyani Single, Vidhan Suganda, Sardar Local, and Arka Sugandhi.

Leaf Waxiness is present in all accessions. Long leaf length is found in Prajwal, Shringar, GKTC-4, Arka Nirantar while medium leaf length is present in Phule Rajani, Vidhan Ujwal, Single, STR-505, Sikkim Selection, Hyderabad Single, Mexican Single, Calcutta Single, Pune Single, Kalyani Single, Vidhan Suganda, Sardar Local and Arka Sugandhi.

Similarly, leaf breath is found to be broad in Prajwal, medium in GKTC-4, Mexican Single, Calcutta Single, Arka Sugandhi and narrow leaf breadth is seen in Shringar, Phule Rajani,

Arka Nirantar, Kalyani Single Vidhan Ujwal, Single, STR-505, Sikkim Selection, Hyderabad Single, Vidhan Suganda, Sardar Local and Pune Single.

Strong pigmentation at leaf base on abaxial side is seen in Pune Single, Medium in Vidhan Ujwal, Sikkim Selection, Hyderabad Single, Calcutta Single while its quite weak in all the rest of accessions i.e. Prajwal, Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Kalyani Single, Single, Mexican Single, Vidhan Suganda and Sardar Local, Arka Sugandhi.

Long bud length is present in Prajwal while bud length was found to be Medium in Shringar, Single, Mexican Single, Vidhan suganda, Calcutta Single, Pune Single and Arka Sugandhi. Bud length was found to be short in GKTC-4, Phule Rajani, Arka Nirantar, Kalyani Single, Vidhan Ujwal, STR-505, Sikkim Selection, Mexican Single and Sardar Local.

Bud colour was found to be Pink in case of Prajwal, Shrinagar, Phule Rajani, Arka Nirantar, Vidhanujwal, Single, STR-505, Sikkim Selection, Vidhan Sugandi, Calcutta Single, Pune Single, Arka sugandhi while green in GKTC-4, Kalyani Single, Hyderabad Single, Mexican Single and Sardar Local.

Long Flower length is present in Prajwal, Medium flower length is present in Single, Vidhan Suganda, Pune Single and Mexican Single while short flower length is found in Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Kalyani Single, Vidhan Ujwal, STR-505, Sikkim Selection, Hyderabad Single, Sardar Local, Calcutta Single and Arka Sugandhi. Flower colour was white in all the accessions.

Larger flower diameter found in Prajwal, Arka Nirantar, Kalyani Single, Vidhan Ujwal, Single, Hyderabad Single, Vidhan Sugandha, medium in Mexican single and Small flower diameter found in Shringar, GKTC-4, Phule Rajani, STR-505, Sikkim Selection, Sardar Local, Pune Single, Arka Sugandhi and Medium flower diameter present in Mexican Single, Calcutta single.

Tepal tip is acute in case of Prajwal, GKTC-4, Arka Nirantar, Vidhan Ujwal, STR-505, Sikkim Selection, Sardar Local, Calcutta single, Arka Sugandhi, obtuse in case of Shringar, Hyderabad Single, Mexican Single Phule Rajani, apiculate in case of Kalyani Single, Single, Vidhan Sugandha, Pune Single.

Straight inflorescence is found in case of Prajwal, Shringar, Phule Rajani, Vidhan Ujwal, STR-505, Hyderabad Single, Mexican Single, Slightly bent inflorescence found in case of Prajwal, Kalyani Single, GKTC-4, Sardar Local and Crooked inflorescence found in case of Arka Nirantar, Prajwal, Single, Sikkim Selection, Vidhan Sugandha, Calcutta single, Pune Single and Arka Sugandhi.

Short inflorescence axis is found to be short in Calcutta Single, Pune Single, Arka Sugandhi, while medium inflorescence axis is present in Prajwal, GKTC-4, Kalyani Single, STR-505, Hyderabad Single, Mexican Single, Sardar Local while long inflorescence axis is present in rest of all i.e. Shringar, Phule Rajani, Arka Nirantar, Vidhan Ujwal, Single, Sikkim Selection, Vidhan Sugandha.

In most of accessions tubular flower shape is present as in Shringar, Vidhan Ujwal, Sikkim Selection, Hyderabad Single, Mexican Single, Vidhan Sugandha, Sardar Local, Calcutta single, Pune Single, Arka Sugandhi, Flower shape is broad funnel in Prajwal, GKTC-4, Phule Rajani, Single and is narrow funnel in Arka Nirantar, Kalyani Single, STR-505.

Flower tube shape is straight in case of STR-505, Sardar Local, Pune Single, Arka Sugandhi, and Calcutta Single and Bent shaped flower tube is found in Prajwal, Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Kalyani Single,

Vidhan Ujwal, Single, Sikkim Selection, Hyderabad Single, Mexican Single, Vidhan Sugandha.

Flower opening is wide in case of Prajwal, Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Kalyani Single, Vidhan Ujwal, Single, Sikkim Selection, Calcutta single while shy flower opening is present in STR-505, Hyderabad Single, Mexican Single, Vidhan Sugandha, Sardar Local, Pune Single, Arka Sugandhi.

Inflorescence length is long in Prajwal, Sikkim Selection and short in Calcutta single, Pune Single, Arka Sugandhi, GKTC-4, while medium Inflorescence length is found in rest of all accessions i.e. Shringar, Phule Rajani, Arka Nirantar, Kalyani Single, Vidhan Ujwal, Single, STR-505, Hyderabad Single, Mexican Single, Vidhan Sugandha, Sardar Local.

Similarly Peduncle thickness is thin in most of accessions i.e. Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Kalyani Single, Vidhan Ujwal, Vidhan Sugandha, Pune Single, Arka Sugandhi and medium in Single, STR-505, Sardar Local, Calcutta single and Mexican Single while thick peduncle is found in Prajwal, Sikkim Selection, Hyderabad Single.

Many flowers are present in Prajwal, Vidhan Sugandha, Phule Rajani, Arka Nirantar, Sardar Local and Arka Sugandhi.

Medium number of flowers are found in Shringar, Vidhan Ujwal, and few in GKTC-4, Kalyani Single, Single, STR-505, Sikkim Selection, Hyderabad Single, Mexican Single, Calcutta single, Pune Single.

Perianth tube length is Long in case of Prajwal, Kalyani Single, Single, STR-505, Sikkim Selection, Hyderabad Single, Mexican Single, Vidhan Sugandha, Calcutta single, Pune Single, Arka Sugandhi and medium in Shringar, GKTC-4, Phule Rajani, Arka Nirantar, Vidhan Ujwal, Sardar Local.

Perianth tube diameter is thick in Prajwal, Arka Sungdhi, Medium in Phule Rajani, while thin in case of Calcutta single, Pune Single, Shringar, Arka Nirantar, Kalyani Single, Vidhan Ujwal, Single, STR-505, Sikkim Selection, Hyderabad Single, Mexican Single, Vidhan Sugandha, Sardar Local GKTC-4.

Perianth lobe is thick in Prajwal, Arka Sungdhi, Medium in Phule Rajani, Calcutta single, Pune Single, Shringar, Arka Nirantar, Kalyani Single, Vidhan Ujwal, Single, STR-505, Sikkim Selection, Hyderabad Single, Mexican Single, Vidhan Sugandha, Sardar Local while thin in case of GKTC-4. Similarly, variations were seen in anthers and stigma type also.

Table 1: Variation in 17 single tepalled cultivars based on 6 foliage characters i.e. Leaf colour, Leaf variegation, Leaf Waxiness, Leaf length, Leaf breadth and Pigmentation at leaf base on Abaxial side

S. No.	Cultivars	Leaf colour	Leaf variegation	Leaf Waxiness	Leaf length	Leaf breadth	Pigmentation at leaf base on Abaxial side
1.	Prajwal	Light Green	Absent	Present	Long	Broad	Weak
2.	Shringar	Light Green	Absent	Present	Long	Narrow	Weak
3.	GKTC-4	Light Green	Absent	Present	Long	Medium	Weak
4.	Phule Rajani	Light Green	Absent	Present	Medium	Narrow	Weak
5.	Arka Nirantar	Light Green	Absent	Present	Long	Narrow	Weak
6.	Kalyani Single	Dark Green	Absent	Present	Medium	Narrow	Weak
7.	Vidhan Ujwal	Light Green	Absent	Present	Medium	Narrow	Medium
8.	Single	Light Green	Absent	Present	Medium	Narrow	Weak
9.	STR-505	Light Green	Absent	Present	Medium	Narrow	Medium
10.	Sikkim Selection	Light Green	Present	Present	Medium	Narrow	Medium
11.	Hyderabad Single	Light Green	Absent	Present	Medium	Narrow	Medium
12.	Mexican Single	Light Green	Absent	Present	Medium	Medium	Weak
13.	Vidhan Sugandha	Dark Green	Absent	Present	Medium	Narrow	Weak
14.	Sardar Local	Dark Green	Absent	Present	Medium	Narrow	Weak
15.	Calcutta single	Light Green	Absent	Present	Medium	Medium	Medium
16.	Pune Single	Light Green	Absent	Present	Medium	Narrow	Strong
17.	Arka Sugandhi	Dark Green	Absent	Present	Medium	Medium	Weak

Table 2: Variation in 17 single tepalled cultivars based on 7 floral characters i.e. Bud length, Bud colour, Flower colour, Flower length, Flower diameter, Tepal tip and Inflorescence

S. No.	Cultivars	Bud length	Bud colour	Flower colour	Flower length	Flower diameter	Tepal tip	Inflorescence
1	Prajwal	Long	Pink	White	Long	Large	Apiculate	Straight
2	Shringar	Medium	Pink	White	Short	Small	Obtuse	Straight
3	GKTC-4	Short	Green	White	Short	Small	Acute	Slightly bent
4	Phule Rajani	Short	Pink	White	Short	Small	Apiculate	Straight
5	Arka Nirantar	Short	Pink	White	Long	Large	Acute	Crooked
6	Kalyani Single	Short	Green	White	Short	Large	Apiculate	Slightly bent
7	Vidhan Ujwal	Short	Pink	White	Short	Large	Acute	Straight
8	Single	Medium	Pink	White	Medium	Large	Apiculate	Crooked
9	STR-505	Short	Pink	White	Short	Small	Acute	Straight
10	Sikkim Selection	Short	Pink	White	Short	Small	Acute	crooked
11	Hyderabad Single	Medium	Green	White	Short	Large	obtuse	Straight
12	Mexican Single	Short	Green	White	Medium	Medium	Obtuse	Straight
13	Vidhan Sugandha	Medium	Pink	White	Medium	Large	Apiculate	Crooked
14	Sardar Local	Short	Green	White	Short	Small	Acute	Slightly bent
15	Calcutta single	Medium	Pink	White	Small	Small	Acute	Crooked
16	Pune Single	Medium	Pink	White	Medium	Small	Apiculate	Crooked
17	Arka Sugandhi	Short	Pink	White	Short	Small	Acute	Crooked

Table 3: Variation in 17 single tepalled cultivars based on 6 floral characters i.e. Inflorescence axis, Flower shape, Flower tube shape, Flower opening, Inflorescence length and Peduncle thickness

S. No.	Cultivars	Inflorescence axis	Flower shape	Flower tube shape	Flower opening	Inflorescence length	Peduncle thickness
1	Prajwal	Medium	Broad funnel	Bent	Wide open	Long	Thick
2	Shringar	Long	Tubular	Bent	Wide open	Medium	Thin
3	GKTC-4	Medium	Broad funnel	Bent	Wide open	Short	Thin
4	Phule Rajani	Short	Broad funnel	Bent	Wide open	Medium	Thin
5	Arka Nirantar	Long	Narrow funnel	Bent	Wide open	Medium	Thin
6	Kalyani Single	Medium	Narrow funnel	Bent	Wide open	Medium	Thin
7	Vidhan Ujwal	Long	Tubular	Bent	Wide open	Medium	Thin
8	Single	Long	Broad funnel	bent	Wide open	Medium	Medium
9	STR-505	Medium	Narrow funnel	straight	shy	Medium	Medium
10	Sikkim Selection	Long	tubular	bent	Wide open	Long	Thick
11	Hyderabad Single	Medium	tubular	Bent	shy	Medium	Thick
12	Mexican Single	Medium	Tubular	Bent	Shy	Medium	Medium
13	Vidhan Sugandha	Long	Tubular	Bent	Shy	Medium	Thin
14	Sardar Local	Medium	Tubular	Straight	Shy	Medium	Medium
15	Calcutta single	Short	Tubular	Straight	Wide open	Short	Medium
16	Pune Single	Short	Tubular	Straight	Shy	Short	Thin
17	Arka Sugandhi	Short	Tubular	Straight	Shy	Short	Thin

Table 4: Variation in 17 single tepalled cultivars based on 7 floral characters i.e. No of flowers/ inflorescence, Perianth tube length excluding tepals, Perianth tube diameter, Perianth lobe thickness, Tepal colour on abaxial side, Anthers and Stigma type

S. No.	Cultivars	No of flowers/ inflorescence	Perianth tube length excluding tepals	Perianth tube diameter	Perianth lobe thickness	Tepal colour on abaxial side	Anthers	Stigma type
1	Prajwal	Many	Long	Thick	Thick	Pinkish tinge	Normal	Thrum
2	Shringar	Medium	Medium	Thick	Thick	Pinkish tinge	Normal	Thrum
3	GKTC-4	Few	Short	Thin	Thin	Pinkish tinge	Normal	Thrum
4	Phule Rajani	Many	Medium	Medium	Thick	Greenish tinge	Normal	Thrum
5	Arka Nirantar	Many	Medium	Thin	Thick	Pinkish tinge	Normal	Thrum
6	Kalyani Single	Few	Long	Thin	Thick	Greenish tinge	Normal	Thrum
7	Vidhan Ujwal	Medium	Medium	Thin	Thick	Pinkish tinge	Malformed	Thrum
8	Single	Few	Long	Thin	Thick	pinkish tinge	normal	Thrum type
9	STR-505	Few	Long	Thin	Thick	Pinkish tinge	Malformed	Thrum type
10	Sikkim Selection	Few	Long	Thin	Thick	Pinkish tinge	normal	Pin type
11	Hyderabad Single	Few	Long	Thin	Thick	Pinkish tinge	Malformed	Thrum type
12	Mexican Single	Few	Long	Thin	Thick	Greenish tinge	Malformed	Thrum type
13	Vidhan Sugandha	Many	Long	Thin	Thick	Pinkish tinge	Normal	Pin type
14	Sardar Local	Many	Long	Thin	Thick	Pinkish tinge	Normal	Thrum type
15	Calcutta single	Few	Long	Medium	Thick	Greenish tinge	Normal	Thrum type
16	Pune Single	Few	Long	Medium	Thick	Pinkish tinge	Malformed	Thrum type
17	Arka Sugandhi	Many	Long	Thick	Thick	Pinkish tinge	Normal	Pin type



Light green leaves in Phule Rajani cultivar



Dark green leaves in Kalyani Single

Fig 1: Variation in Colour of Leaves



Shringar showing Pink buds Mexican Single showing Green buds

Fig 2: Variation in bud colour

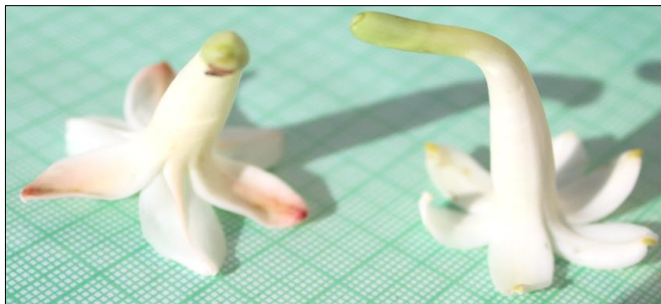


Crooked Inflorescence in Sikkim Selection

Straight Inflorescence in Shringar

Bent Inflorescence in Sardar Local

Fig 3: Inflorescence



Calcutta Single and Hyderabad Single showing Pinkish tinge and greenish tinge on abaxial side of tepals. Straight and Bent flower tube shape can also be seen.

Fig 4: Variation in pigmentation on abaxial side of tepals and flower tube shape

Conclusion

The morphological characterization of seventeen cultivars depicted clear differences. The analysis of data indicated that the cultivars did not differ significantly in a two traits i.e. leaf waxiness and flower colour. However, marked differences were seen in 24/26 characters, which makes these morphological markers of potential use for future research. Clear differences were recorded in twenty floral characters and six foliage characters. Bharti *et al.*, (2015) [2] also got similar results and noticed distinct differences in thirteen floral and ten foliage characters in tuberose. So, the studies successfully reveal that the present morphological markers can be used to study variations among various cultivars of

tuberose efficiently, and hence can be of great help for the future researchers for studying variation as well as for performing DUS characterization of tuberose.

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