

STUDIES ON HYBRIDIZATION IN TUBEROSE (*POLIANTHES TUBEROSA*)

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ABSTRACT

An experiment on tuberose hybridization was carried out by involving crossing programme in the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. Totally ten genotypes were used for this study viz., Calcutta Single, Hyderabad Single, Kahikuchi Single, Mexican Single, Navsari Local, Phule Rajani, Prajwal, Pune Single, Shringar and Variegated Single. Both direct and reciprocal crosses were made, but only fourteen crosses have resulted with successful seed set. In which, most of the successful crosses were resulted by using Variegated Single and Phule Rajani as a pollen parent. Among the successful crosses, the highest percentage of fruit set was noticed in the cross "Variegated Single x Phule Rajani" (78.40 %). Moreover, in none of the direct as well as indirect crosses involving Prajwal as a parent has resulted success. Hence the results of present study suggested that cross compatibility in tuberose is highly based on the selection of parents used in crossing programme.

INTRODUCTION

Artificial hybridization is an important aspect of improving both cross-pollinated and self-pollinated plants which helps for the exploitation of hybrid vigour by involving crossing between parents. The resulting plant had a higher growth rate, was phenotypically superior and had increased yield as compared to the parents. Because one hybrid could not fulfill the current needs like higher yield, pure white flowers, increased concrete content, resistance to pests and diseases, hence different hybrids have to be developed to meet the demand. The basic mechanisms involved in the heterosis are dominance (the dominant allele masks the effect of recessive allele) and over dominance (combination of genotypes from two different parents) which leads to supplementing the effect of each other; therefore, the effects lead to increased vigor (Chahal and Gosal, 2002).

Tuberose (*Polianthes tuberosa* Linn.), is an important commercial flower crop and is extensively cultivated in many sub-tropical and tropical parts of the world including India (Benschop, 1993). It is native of Mexico (Bailey, 1919) and belongs to the family Amaryllidaceae (Bailey, 1930). It is a bulbous perennial plant with tuberous roots producing long spikes, which bear waxy white and fragrant flowers profusely throughout the year. The spikes can be used as whereas the loose flowers are used for making garlands and essential oil extraction. The flowers yield a very valuable floral concrete (0.08 – 0.11 per cent) upon solvent extraction (Singh, 1995). The absolute of tuberose (essential oil) extracted from floral concrete is used in the preparation of various high value perfumes and cosmetics.

Apart from domestic consumption, tuberose cut spikes has got a very good export potential to other countries (Singh and Uma, 1995). Tuberose floral concrete and essential oil are fetching higher price than the other floral concretes and essential oils. However in spite of its importance, adaptability and export potential, only few varieties viz., Calcutta Single, Calcutta Double, Hyderabad Single, Hyderabad Double, Kahikuchi Single, Mexican Single, Navsari Local, Phule Rajani, Prajwal, Pune Single, Shringar, Suvasini, Vaibhav and Variegated Single are under cultivation. Among these only single types can be used for hybridization studies, because in double types pollen development rarely noticed.

Hence, it is important to develop F1 hybrids by using hybrid vigour to improve the yield and concrete recovery. With this in view, attempts were made to identify the compatible parents and successful crosses through crossing programme.

MATERIALS AND METHODS

The 10 single tuberose genotypes viz., Calcutta Single, Hyderabad Single, Kahikuchi Single, Mexican Single, Navsari Local, Phule Rajani, Prajwal, Pune Single, Shringar and Variegated Single were studied for their seed setting behavior by artificial crossing under natural conditions.

Artificial crossing

Four to six mature flower buds of a spike destined to open in next two days were selected, emasculated and bagged as female parent. Two days after emasculation the flowers were pollinated using pollen from bagged spikes of desirable male parent. Pollination was carried out during morning hours

between 6 am to 9 am. After crossing, the flowers were bagged and labeled (Sambandhamurthi and Appavu, 1980).

Seed set was observed a week after pollination and percentage of fruit set was estimated. The data were recorded on five characters *viz.*, days taken for fruit set, number of days taken for fruit maturity, the number of seeds per capsule, percentage of germination and the number of days taken for germination.

RESULTS AND DISCUSSION

It was observed from the table (1 and 2) that, by using Variegated Single as a pollen parent, the highest percentage of fruit set was recorded in the cross (Phule Rajani X Variegated Single) (50.40 %) followed by cross (Pune Single X Variegated Single) (28.07 %). Further the genotypes involved in crosses by using Variegated Single as pollen parent which found to be successful are Calcutta Single, Kahikuchi Single, Mexican Single and Navsari Local (24.00 %, 25.00 %, 21.42 % and 25.02 %).

This shows that when 'Variegated Single' was used as a pollen parent, it was found to be compatible for most of the single genotypes. On third day after anthesis, the maximum percentage of fruit set was noticed in the crosses involving Phule Rajani as a pollen parent. The cross (Variegated Single X Phule Rajani) has shown 78.40 % of fruit set which is

Table 1: Successful crosses

S.No	Crosses
1	Calcutta Single x Variegated Single
2	Kahikuchi Single x Variegated Single
3	Mexican Single x Variegated Single
4	Navsari Local x Variegated Single
5	Pune Single x Variegated Single
6	Phule Rajani x Variegated Single
7	Kahikuchi Single x Phule Rajani
8	Mexican Single x Phule Rajani
9	Hyderabad Single x Phule Rajani
10	Variegated Single x Phule Rajani
11	Kahikuchi Single x Shringar
12	Variegated Single x Shringar
13	Variegated Single x Hyderabad Single
14	Variegated Single x Navsari Local

Table 2: Cross compatibility studies in hybrids and cultivars of tuberose pollinated on fourth day after anthesis (Single x Single)

S.No	Crosses	Percent success
1	Calcutta Single x Variegated Single	24.00
2	Kahikuchi Single x Variegated Single	25.00
3	Mexican Single x Variegated Single	21.42
4	Navsari Local x Variegated Single	25.02
5	Pune Single x Variegated Single	28.07
6	Phule Rajani x Variegated Single	50.40
7	Kahikuchi Single x Phule Rajani	10.00
8	Mexican Single x Phule Rajani	70.00
9	Hyderabad Single x Phule Rajani	6.66
10	Variegated Single x Phule Rajani	78.40
11	Kahikuchi Single x Shringar	29.10
12	Variegated Single x Shringar	19.71
13	Variegated Single x Hyderabad Single	13.84
14	Variegated Single x Navsari Local	50.98

followed by the cross (Mexican Single X Phule Rajani) (70.00 %). However, minimum fruit set was noticed in the crosses involving Hyderabad Single X Phule Rajani (6.66 %) and Kahikuchi Single X Phule Rajani (10.00 %). But in other single genotypes, the crosses made with Phule Rajani as pollen parent failed to set fruits. By using Shringar as a pollen parent, fruit set of 29.10 percentage was recorded in the cross (Variegated Single X Shringar) followed by the cross (Kahikuchi Single X Shringar) (19.71). Other crosses using Shringar as pollen parent did not set fruits. The successful fruit set noticed in cross between Variegated Single X Hyderabad Single and Variegated Single X Navsari Local was 13.84 and 50.98 % respectively. The crosses in other single types using Hyderabad Single and Navsari Local as pollen parents did not set fruits. This result is in accordance with the result of Krishnamurthy, 2000 in tuberose and Bhujbal *et al.*, 2013 in *Gladiolus* and Airadevi *et al.*, 2014 in *Bird-of-paradise*.

The study revealed that the pollination carried out on fourth day after anthesis, there was normal development of the fruit, in the crossed materials. Normal development of fruit was evident from the healthy development of ovule, embryo sac and fruit wall. However fusion nucleus did not undergo any divisions. On seventh DAA, all the tissues showed symptoms of degeneration and resulted in drooping of the fruits because of complete degeneration. This may be because of lack of pollen germination, pollen tube growth and lack of fertilization. Similar display in seed set after cross pollinations has been reported in *Narcissus* by Tammy *et al.*, 1999 and in tuberose by Krishnamurthy, 2000 wherein they have attributed the lack of seed set due to the absence of required stimulus for normal seed development.

In the successful crosses, by 30th DAA, there was complete differentiation of embryo and endosperm. Embryo was torpedo shaped. During this stage, there was intense accumulation of polysaccharides, RNA and proteins in embryo and endosperm indicating that they are metabolically highly acute. Major developmental stages occurred between 20th and 30th DAA. Further, development of embryo and endosperm continued till 40th DAA. Thus the size of embryo and endosperm also got increased with the intense accumulation of polysaccharides, RNA and proteins. This represents a completely developed seed.

The high rate of growth of pollen tube during the initial period was evident in all successful crosses. The faster germination brought about by the strong coordination between the pollen and pistil proteins. The less number of pollen tubes was resulted in the ovary regions (Table 3).

In the unsuccessful crosses, arrest of pollen tubes at different levels in crosses was resulted in addition to several abnormalities. In incompatible matings, there will be dense accumulation of callose at the tips which prevents further growth of pollen tube (Shivanna and Heslop-Harrison, 1978). The strength of callose thickening in crosses depends on the taxonomic distance between the pollen and pistil genotypes as reported by de Nattancourt, 1977.

The number of days taken for fruit set was less in crosses between Mexican Single X Variegated Single (7.45) followed by Calcutta Single X Variegated Single (7.50), Kahikuchi Single x Phule Rajani (7.50) and Variegated Single X Phule Rajani

Table 3: Number and percentage of ovules with pollen tube at micropylar end after 14/24 HAP in crosses

S.No	Cross combinations	Number of ovules in the ovary	Number of ovules with pollen tube at micropylar end	Percentage
1	Variegated Single x Calcutta Single	16	12	75
2	Variegated Single x Kahikuchi Single	14	8	57
3	Variegated Single x Mexican Single	16	13	81
4	Variegated Single x Navsari Local	16	8	50
5	Variegated Single x Pune Single	16	12	75
6	Variegated Single x Phule Rajani	17	15	88
7	Phule Rajani x Kahikuchi Single	15	12	80
8	Phule Rajani x Mexican Single	16	15	94
9	Phule Rajani x Hyderabad Single	16	12	75
10	Phule Rajani x Variegated Single	17	16	94
11	Shringar x Kahikuchi Single	15	8	53
12	Shringar x Variegated Single	16	12	75
13	Hyderabad Single x Variegated Single	14	8	57
14	Navsari Local x Variegated Single	14	9	64

Table 4: Hybridization in tuberose genotypes (Single x Single)

S.No	Crosses	Mean no. of days taken of for fruit set	Mean number days taken for fruit maturity	Mean number of seeds/capsule
1	C.S X V.S	7.50	80.21	17.75
2	K.S X V.S	7.75	78.97	20.00
3	M.S X V.S	7.45	80.75	21.25
4	N.L X V.S	8.25	76.75	22.75
5	P.S X V.S	7.96	81.86	32.96
6	P.R X V.S	7.85	81.00	38.00
7	K.S X P.R	7.50	80.00	19.00
8	M.S X P.R	8.45	85.08	16.23
9	H.S X P.R	8.07	82.13	28.97
10	V.S X P.R	7.75	81.00	41.00
11	V.S X Sr	8.50	81.50	24.00
12	K.S X Sr	8.76	83.74	25.00
13	V.S X H.S	8.95	85.98	26.00
14	V.S X N.L	8.76	85.43	32.00

C.S X V.S	Calcutta Single x Variegated Single	M.S X P.R	Mexican Single x Phule Rajani
K.S X V.S	Kahikuchi Single x Variegated Single	H.S X P.R	Hyderabad Single x Phule Rajani
M.S X V.S	Mexican Single x Variegated Single	K.S X Sr	Kahikuchi Single x Shringar
N.L X V.S	Navsari Local x Variegated Single	V.S X P.R	Variegated Single x Phule Rajani
P.S X V.S	Pune Single x Variegated Single	V.S X Sr	variegated Single x Shringar
P.R X V.S	Phule Rajani x Variegated Single	V.S X H.S	Variegated Single x Hyderabad Single
K.S X P.R	Kahikuchi Single x Phule Rajani	V.S X N.L	Variegated Single x Navsari Local

Table 5: Seed germination of different crosses in tuberose genotypes (Single x Single)

S. No	Crosses	Mean no. of seeds sown	No. of seeds germinated	Germination percentage	Mean no. of days taken for germination
1	C.SXV.S	40	05	12.50	35.68
2	K.SXV.S	48	01	12.43	38.25
3	M.SXV.S	47	06	12.45	34.00
4	N.LXV.S	45	06	12.32	32.21
5	P.SXV.S	56	07	12.23	30.21
6	P.RXV.S	40	05	12.43	28.96
7	K.SXP.R	20	2	12.50	31.67
8	M.SXP.R	10	1	12.52	36.82
9	H.SXP.R	25	3	12.45	35.42
10	V.SXP.R	836	105	12.56	28.96
11	V.SXSr	46	6	12.50	32.98
12	K.SXSr	45	6	12.51	34.72
13	V.SXH.S	40	5	12.54	35.98
14	V.SXN.L	40	5	12.43	32.87

(7.75), while it was more in Variegated Single X Hyderabad Single (8.95), Variegated Single X Navsari Local (8.76), Kahikuchi Single X Shringar (8.76), Variegated Single X Shringar (8.50), Mexican Single X Phule Rajani (8.45) and Navsari Local X Variegated Single (8.25). Similar results were obtained by Sitharamu, 1993 in tuberose (Table 4).

The minimum number of days taken for fruit maturity was recorded in crosses between Navsari Local X Variegated Single (76.75) and Kahikuchi Single X Variegated Single (78.97), while the maximum number of days taken for fruit maturity was noticed in Variegated Single X Hyderabad Single (85.98), Variegated Single X Navsari Local (85.43), Mexican Single X Phule Rajani (85.08), Kahikuchi Single X Shringar (83.74), Pune Single X Variegated Single (81.86), Variegated Single X Phule Rajani (81.00) and Kahikuchi Single x Phule Rajani (80.00). Similar results were obtained by Sitharamu, 1993 in

C.S X V.S	Calcutta Single x Variegated Single	M.S X P.R	Mexican Single x Phule Rajani
K.S X V.S	Kahikuchi Single x Variegated Single	H.S X P.R	Hyderabad Single x Phule Rajani
M.S X V.S	Mexican Single x Variegated Single	K.S X Sr	Kahikuchi Single x Shringar
N.L X V.S	Navsari Local x Variegated Single	V.S X P.R	Variegated Single x Phule Rajani
P.S X V.S	Pune Single x Variegated Single	V.S X Sr	variegated Single x Shringar
P.R X V.S	Phule Rajani x Variegated Single	V.S X H.S	Variegated Single x Hyderabad Single
K.S X P.R	Kahikuchi Single x Phule Rajani	V.S X N.L	Variegated Single x Navsari Local

tuberosa (Table 4).

The number of seeds per capsule was higher in crosses between Variegated Single x Phule Rajani (41.00), Phule Rajani X Variegated Single (38.00) followed by crosses between Pune Single X Variegated Single (32.96), Variegated Single X Navsari Local (32.00), while it was less in number per capsule in the crosses between Mexican Single X Phule Rajani (16.23), Kahikuchi Single X Variegated Single (20.00), Variegated Single X Shringar (24.00), Kahikuchi Single X Shringar (25.00), Variegated Single X Hyderabad Single (26.00) and Hyderabad Single X Phule Rajani (28.97). Similar results were obtained by Sitharamu, 1993 in tuberosa cv, 'Variegated Single' under crossing (Table 4).

The highest percentage of germination was recorded in crosses between Variegated Single x Phule Rajani (12.56 %), followed by crosses between Variegated Single X Hyderabad Single (12.54 %), Mexican Single X Phule Rajani (12.52 %), Calcutta Single X Variegated Single (12.50 %), Variegated Single X Shringar (12.50 %), Kahikuchi Single X Shringar (12.51 %), Mexican Single X Variegated Single (12.45 %), Hyderabad Single X Phule Rajani (12.45 %) and Variegated Single X Navsari Local (12.43 %) while the lowest germination was recorded in Pune Single X Variegated Single (12.23 %). Similar results were obtained by Sitharamu, 1993 in tuberosa (Table 5).

The number of days taken for germination was less in crosses using Variegated Single as pollen parent is between Phule Rajani X Variegated Single and Variegated Single x Phule Rajani (28.96) followed by crosses between Pune Single X Variegated Single (30.21), Kahikuchi Single X Phule Rajani (31.67), Variegated Single X Navsari Local (32.87), Variegated Single X Shringar (32.98), Kahikuchi Single X Shringar (34.72), Variegated Single X Hyderabad Single (35.98), while it was more (38.25) in Kahikuchi Single X Variegated Single. Similar results were obtained by Sitharamu, 1993 in tuberosa (Table 5).

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