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RESEARCH ARTICLE :

Evaluation of hybrids for heterosis breeding in tuberose (*Polianthes tuberosa* L.)

K. KAYALVIZHI, M. KANNAN AND M. GANGA

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SUMMARY : An investigation was carried out on evaluation of F_1 population (eight hybrids and three open pollinated seedlings) of tuberose to assess the relationship between yield and yield contributing characters. From the data on standard heterosis it could be inferred that positive and highly significant for two cross *viz.*, $P_4 \times P_1$ (119.10 %) and $P_1 \times P_7$ (400.56 %) over standard check I (Nilakottai local). The standard heterosis over check II (Prajwal) was highly significant and positive for two crosses *viz.*, $P_4 \times P_1$ (11.43 %) and $P_1 \times P_7$ (154.57 %). The $P_4 \times P_1$ and $P_1 \times P_7$ with higher standard heterosis for yield offered greater scope for exploitation for further breeding programmes.

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KEY WORDS :
Tuberose, F_1 population, Standard heterosis, Floret weight, Yield

Author for correspondence :

K. KAYALVIZHI
Department of Floriculture and Landscaping, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA
Email: kkayal.flori@gmail.com

See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

Floriculture in India is estimated to cover an area of 2.55 lakh ha with a production of 17,54,000 MT of loose flowers. Nearly 77 per cent of the area under floricultural crops is concentrated in seven states comprising Tamil Nadu, Karnataka, West Bengal, Maharashtra, Haryana, Uttar Pradesh and Delhi. Among different states, Tamil Nadu ranks first in area followed by Karnataka, West Bengal and Maharastra. In Tamil Nadu 3,43,650 MT of loose flowers are produced in an area of about 55,000 hectares. (Anonymous, 2015).

Tuberose (*Polianthes tuberosa* L.) is one of the most important flowers used for both cut and loose flower purpose. It is extensively cultivated in many sub-tropical and tropical parts of the world including India. It is a native of Mexico and belongs to the family Amaryllidaceae. It is a bulbous perennial plant with tuberous roots producing long spikes, bearing waxy white fragrant flowers. It is a crop which flowers profusely throughout the year. Due to the longer keeping quality of flower spikes (Sadhu and Bose, 1973; Benschop, 1993), they are in great demand for making floral arrangements and bouquets in major cities of India. Three types of tuberose which are used in cultivation are single type with one row of corolla segments, semi- Double type with two to three rows of corolla segments and double type with more than three rows of corolla segments.

The spikes as a whole in double types can be used as cut flowers whereas the florets

of single varieties are used for making garlands, veni, gajra, bangles, etc. and also for essential oil extraction. The flower yields a very valuable floral concrete (0.08 – 0.11%) 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. (Ranchana, 2013). Very little work on this aspect has been reported in tuberose. Hence, the present study was undertaken to find out the association among important quantitative characters in F_1 hybrid progenies and open pollinated seedlings of tuberose.

RESOURCES AND METHODS

The present study was carried out at the Department of Floriculture and Landscaping, Tamil Nadu Agricultural University, Coimbatore during the year 2014. The region is situated at 110 02" N latitude, 760 57" E longitude and 426.76 m above mean sea level. The F_1 population of eight different cross combinations ((P_1 X P_2) Phule Rajani x Variegated Single, (P_2 X P_3) Variegated Single x Shringar, (P_4 X P_2) Hyderabad Single x Variegated Single, (P_3 X P_5) Shringar x Kahikuchi Single, (P_6 X P_2) Calcutta Single x Variegated Single, (P_8 X P_2) Pune Single x Variegated Single, (P_4 X P_1) Hyderabad Single x Phule Rajani, (P_1 X P_7) Phule Rajani x Mexican Single) and three open pollinated seedlings of Shringar, Variegated Single, Phule Rajani and two checks namely, Nilakottai Local (Local check I) and Prajwal (Commercial check II) were evaluated in the study. The soil of the experimental field was brought to a fine tilth by giving four deep ploughings. Weeds, stubbles, roots etc. were removed. At the time of last ploughing, FYM was applied at the rate of 25 tonnes per hectare. After leveling, raised beds were formed over which black mulching sheets were spread. The F_1 hybrid progenies and open pollinated seedlings were planted in the field at a spacing of 45 x 25 cm in paired rows. Uniform cultural practices were followed throughout the experimentation. Observations were recorded on single plant of plant height (cm), number of leaves (nos.), leaf length (cm), leaf width (cm), number of spikes per plant (nos.), spike length (cm), rachis length (cm), floret length (cm), floret diameter (cm), weight of single floret (g), number of florets per spike (nos.), floret yield/plant (g) and yield/m^2 (kg). F_1 hybrid progenies of tuberose generated through intervarietal hybridization involving eight hybrids and three open pollinated seedlings were evaluated and the results are presented in this paper.

Estimation of standard heterosis :

Heterosis in F_1 hybrids was estimated by adopting the following formula (Gowen, 1952) for each trait based on the criteria using the mean values as detailed below:

$$\text{Standard heterosis } (d_{iii}) = \frac{\overline{F_1} - \overline{SC}}{\overline{SC}} \times 100$$

where,

$\overline{F_1}$ = Mean value of hybrid

$\overline{SC}$ = mean value of the standard check

The significance of standard heterosis was tested by the following formulae (Snedecor and Cochran, 1967).

$$t = \frac{\overline{F_1} - \overline{SC}}{SEd}$$

$SEd = \sqrt{SE_1^2 + SE_2^2}$

SE_1 = Standard error of cross

SE_2 = Standard error of better parent / check

Calculated 't' value was tested against the table 't' value at error degrees of freedom for 5 and 1 per cent levels of probability.

OBSERVATIONS AND ANALYSIS

Heterosis was computed for all the thirteen characters studied in the eight cross combinations and expressed in percentage over the standard check (standard heterosis d_{iii}) (check I - Nilakkottai Local and check II – Prajwal). Data on heterosis for all the characters are presented in Tables 1 to 3.

Plant height :

The standard heterosis for plant height was recorded negative and highly significant for the six crosses which varied from -9.63 (P_1 X P_2) to -31.85 % (P_8 X P_2) over check I. Likewise, all the eight cross combinations was recorded negative and highly significant which varied from -12.73 (P_4 X P_1) to -44.24 % (P_8 x P_2) over check II (Table 1).

Number of leaves :

The standard heterosis for this trait was negative and significant for all the crosses over two checks and it was ranged from -6.21, -22.36 % in P_4 X P_1 (check I, II) to -58.34, -65.51 % in (P_8 X P_2) (check I, II) (Table 1).

Leaf length :

The standard heterosis was significant and positive in four crosses *viz*., $P_4 \times P_1$ (34.63 %), $P_1 \times P_7$ (23.31 %), $P_6 \times P_2$ (16.39 %) and $P_1 \times P_2$ (11.51 %). Negative and significant standard heterosis was recorded for two crosses *viz*., $P_3 \times P_5$ (-14.73 %) and $P_8 \times P_2$ (-19.10 %) over check I.

The heterosis over the standard check II was found to be negative and significant for all the cross combinations which ranged from -16.22 % in ($P_4 \times P_1$) to -49.66 % in ($P_8 \times P_2$.) (Table 1).

Leaf width :

Leaf width recorded significant and negative standard heterosis in two crosses $P_4 \times P_2$ (-12.93 %) and $P_6 \times P_2$ (-12.07 %) over check I. This trait was negative and significant for all the crosses over check II and it ranged from -26.36 % in $P_1 \times P_2$ to -41.28 % in P_4 X P_2 (Table 1).

No. of spike per plant :

The standard heterosis was positive and significant for five crosses *viz*., $P_1 \times P_7$ (2.78 %) $P_2 \times P_3$ (3.64 %), $P_6 \times P_2$ (14.66 %), $P_4 \times P_2$ (152.78 %) and $P_4 \times P_1$ (160.34 %) while significant and negative for three crosses *viz*., $P_8 \times P_2$ (-23.37 %), $P_3 \times P_5$ (-32.95) and $P_1 \times P_2$ (-42.53 %) over check I (Nilakkottai Local).

In this trait, standard heterosis was positive and significant for two crosses $P_4 \times P_2$ (59.94 %) and $P_4 \times P_1$ (64.73 %), while, negative and significant was observed for all other crosses which ranged from -27.45 % in $P_6 \times P_2$ to -63.64 % in $P_1 \times P_2$ over check II (Prajwal) (Table 2).

Spike length :

The heterosis over standard check I (Nilakkottai Local) and II (Prajwal) were significant and positive for five crosses *viz*., $P_8 \times P_2$ (14.68, 11.00 %), $P_4 \times P_1$ (24.02, 20.04 %), $P_2 \times P_3$ (29.46, 25.30 %), $P_6 \times P_2$ (25.90, 21.86 %) and $P_1 \times P_7$ (30.26, 26.08 %), whereas, negative and

Table 1: Standard heterosis over check I and check II for plant height, number of leaves, leaf length and leaf width

Hybrids	Plant height (cm)		Number of leaves		Leaf length (cm)		Leaf width (cm)	
	% over check I	% over check II	% over check I	% over check II	% over check I	% over check II	% over check I	% over check II
$P_1 \times P_2$	-9.63 *	-26.06 **	-37.58 **	-48.33 **	11.51 **	-30.61 **	9.20	-26.36 **
$P_2 \times P_3$	-22.96 **	-36.97 **	-49.93 **	-58.56 **	-4.31	-40.46 **	-0.86	-33.14 **
$P_4 \times P_2$	-16.30 **	-31.52 **	-42.03 **	-52.02 **	-0.24	-37.93 **	-12.93 *	-41.28 **
$P_3 \times P_5$	-24.44 **	-38.18 **	-53.07 **	-61.15 **	-14.73 **	-46.94 **	-7.76	-37.79 **
$P_6 \times P_2$	-18.52 **	-33.33 **	-47.59 **	-56.62 **	16.39 **	-27.58 **	-12.07 *	-40.70 **
$P_8 \times P_2$	-31.85 **	-44.24 **	-58.34 **	-65.51 **	-19.10 **	-49.66 **	3.45	-30.23 **
$P_4 \times P_1$	6.67	-12.73 **	-6.21 **	-22.36 **	34.63 **	-16.22 **	-8.91	-38.57 **
$P_1 \times P_7$	0.74	-17.58 **	-48.93 **	-57.72 **	23.31 **	-23.27 **	-4.60	-35.66 **

* and ** indicate significance of values at P=0.05 and 0.01, respectively Check I (Nilakkottai Local) and Check II (Prajwal)

Table 2 : Standard heterosis over check I and check II for number of spike per plant, spike length, rachis length, floret length and floret diameter

Hybrids	No. of spike per plant (Nos.)		Spike length (cm)		Rachis length (cm)		Floret length (cm)		Floret diameter (cm)	
	% over check I	% over check II	% over check I	% over check II	% over check I	% over check II	% over check I	% over check II	% over check I	% over check II
$P_1 \times P_2$	-42.53 **	-63.64 **	-5.13 **	-8.17 **	-5.15 **	-28.38 **	-9.09 **	-10.55 **	-28.89 **	-36.00 **
$P_2 \times P_3$	3.64 **	-34.42 **	29.46 **	25.30 **	-19.17 **	-38.96 **	8.48 **	6.74 **	-24.07 **	-31.67 **
$P_4 \times P_2$	152.78 **	59.94 **	-12.37 **	-15.18 **	5.04 **	-20.68 **	1.03 **	-0.60 **	-28.74 **	-35.87 **
$P_3 \times P_5$	-32.95 **	-57.58 **	-2.35 **	-5.48 **	24.96 **	-5.64 **	-12.73 **	-14.13 **	-32.67 **	-39.40 **
$P_6 \times P_2$	14.66 **	-27.45 **	25.90 **	21.86 **	13.04 **	-14.64 **	4.36 **	2.68 **	-22.07 **	-29.87 **
$P_8 \times P_2$	-23.37 **	-51.52 **	14.68 **	11.00 *	5.39 **	-20.42 **	-18.18 **	-19.50 **	-34.89 **	-41.40 **
$P_4 \times P_1$	160.34 **	64.73 **	24.02 **	20.04 **	17.25 **	-11.46 **	-3.21 **	-4.77 **	-23.19 **	-30.87 **
$P_1 \times P_7$	2.78 *	-34.97 **	30.26 **	26.08 **	195.84 **	123.40 **	16.55 **	14.67 **	-22.74 **	-30.47 **

* and ** indicate significance of values at P=0.05 and 0.01, respectively Check I (Nilakkottai Local) and Check II (Prajwal)

significant for three crosses *viz.*, $P_{3} \times P_{5}$ (-2.35, -5.48 %), $P_{1} \times P_{2}$ (-5.13, -8.17 %) and $P_{4} \times P_{2}$ (-12.37, -15.18 %) over check I and II (Table 2).

Rachis length :

Rachis length recorded significant and positive standard heterosis in five crosses *viz.*, $P_{4} \times P_{2}$ (5.04 %), $P_{8} \times P_{2}$ (5.39 %), $P_{6} \times P_{2}$ (13.04 %), $P_{4} \times P_{1}$ (17.25 %), $P_{3} \times P_{5}$ (24.96) and $P_{1} \times P_{7}$ (195.84 %) over check I (Nilakkottai Local) while, negative and significant for two crosses *viz.*, $P_{1} \times P_{2}$ (-5.15 %) and $P_{2} \times P_{3}$ (-19.17 %).

In this trait, standard heterosis was positive and significant for $P_{1} \times P_{7}$ (123.40 %) While, negative and significant was observed in all other crosses which ranged from -5.64 % in $P_{2} \times P_{3}$ to -38.96 % in $P_{3} \times P_{5}$ over check II (Prajwal) (Table 2).

Floret length :

The heterosis over standard check I (Nilakottai local) and II (Prajwal) were significant and positive for three crosses *viz*., $P_{6} \times P_{2}$ (4.36, 2.68 %), $P_{2} \times P_{3}$ (8.48, 6.74 %) and $P_{1} \times P_{7}$ (16.55, 14.67 %), whereas, negative and significant for all other crosses which varied from $P_{4} \times P_{1}$ (-3.21, -4.77 %) to $P_{8} \times P_{2}$ (-18.18, -19.50 %) over check I and check II, respectively (Table 2).

Floret diameter :

The heterosis over the standard check I (Nilakottai local) and II (Prajwal) was found to be negative and significant in all the cross combinations which ranged from (-22.07, -29.87 %) in $P_{6} \times P_{2}$ to (-34.89, -41.40 %) in $P_{8} \times P_{2}$, respectively (Table 2).

Weight of single floret:

In this trait, heterosis over standard check I (Nilakottai local) and II (Prajwal) were significant and positive for the cross $P_{1} \times P_{7}$ (34.48, 25.00 %), respectively. Whereas, negative and significant for all other the crosses which varied from $P_{1}\times P_{2}$ (-17.24, -23.08 %) to $P_{2} \times P_{3}$ (-31.95, -36.75 %) over check I and II, respectively (Table 3).

No. of florets per spike :

The standard heterosis was significant and negative in two crosses *viz.*, $P_{2} \times P_{3}$ (-26.32 %) and $P_{4} \times P_{2}$ (-21.05 %). Positive and significant standard heterosis was recorded for all other crosses which ranged from (11.40 %) in $P_{3} \times P_{5}$ to and (281.71 %) in $P_{1} \times P_{7}$ over check I (Nilakottai local).

The heterosis over the standard check II (Prajwal) was found to be negative and significant for five cross combinations *viz.*, $P_{8} \times P_{2}$ (-4.17 %), $P_{1} \times P_{2}$ (-8.33 %), $P_{3} \times P_{5}$ (-11.81 %), $P_{4} \times P_{2}$ (-37.50 %) and $P_{2} \times P_{3}$ (-41.67 %) (Table 3).

Weight of florets/plant:

The standard heterosis was positive and highly significant for three crosses *viz*., $P_{4} \times P_{1}$ (122.89 %), $P_{1} \times P_{7}$ (400.94 %) and $P_{4} \times P_{2}$ (30.60 %). Negative and significant heterosis over standard check I (Nilakottai local) was recorded for three cross combinations $P_{1} \times P_{2}$ (-47.76 %), $P_{2} \times P_{3}$ (-50.13 %) and $P_{3} \times P_{5}$ (-66.05 %) whereas the standard heterosis was not significant for these two crosses *viz.*, ($P_{6} \times P_{2}$ and $P_{8} \times P_{2}$). (Table 3).

Highly significant and positive heterosis over

Table 3 : Standard heterosis over check I and check II for weight of single floret, number of florets per spike, weight of florets/plant and yield/m^2

Hybrids	Weight of single floret (g)		No. of florets per spike		Weight of florets/plant (g)		Yield/m^2 (kg)	
	% over check I	% over check II	% over check I	% over check II	% over check I	% over check II	% over check I	% over check II
$P_{1} \times P_{2}$	-17.24 **	-23.08 **	15.79 **	-8.33 **	-47.76 **	-73.48 **	-47.75 **	-73.43 **
$P_{2} \times P_{3}$	-31.95 **	-36.75 **	-26.32 **	-41.67 **	-50.13 **	-74.68 **	-50.00 **	-74.57 **
$P_{4} \times P_{2}$	-31.03 **	-35.90 **	-21.05 **	-37.50 **	30.60 **	-33.69 **	29.21 **	-34.29 **
$P_{3} \times P_{5}$	-31.03 **	-35.90 **	11.40 **	-11.81 **	-66.05 **	-82.76 **	-51.12 **	-75.14 **
$P_{6} \times P_{2}$	-31.26 **	-36.11 **	32.89 **	5.21 **	-0.32	-49.39 **	-0.56	-49.43 **
$P_{8} \times P_{2}$	-28.97 **	-33.97 **	21.05 **	-4.17 **	-37.42	-68.23 **	-37.64 **	-68.29 **
$P_{4} \times P_{1}$	-28.97 **	-33.97 **	27.47 **	0.92	122.89 **	13.16 **	119.10 **	11.43 **
$P_{1} \times P_{7}$	34.48 **	25.00 **	281.71 **	202.19 **	400.94 **	154.34 **	400.56 **	154.57 **

*and ** indicate significance of values at P=0.05 and 0.01, respectively Check I (Nilakkottai Local) and Check II (Prajwal)

standard check II (Prajwal) was recorded for two crosses *viz.*, $P_4 \times P_1$ (13.16 %), $P_1 \times P_7$ (154.34 %). Whereas significant and negative heterosis for all other crosses which varied from $P_4 \times P_2$ (-33.69 %) to $P_3 \times P_5$ (-82.76 %).

Yield / m²:

The standard heterosis was positive and highly significant for two cross *viz.*, $P_4 \times P_1$ (119.10 %) and $P_1 \times P_7$ (400.56 %). Negative and highly significant for the four crosses *viz.*, $P_8 \times P_2$ (-37.64 %), $P_1 \times P_2$ (-47.75 %), $P_2 \times P_3$ (-50.00 %) and $P_3 \times P_5$ (-51.12 %), whereas, the standard heterosis was not significant in $P_6 \times P_2$ over standard check I (Nilakottai local).

The standard heterosis over check II (Prajwal) was highly significant and positive for two crosses *viz*., $P_4 \times P_1$ (11.43 %) and $P_1 \times P_7$ (154.57 %). Whereas negative and highly significant for six crosses which range varied from $P_4 \times P_2$ (-34.29 %) to $P_3 \times P_5$ (-75.14 %) (Table 3). Heterosis is a direct property of heterozygosity and is due to superior gene content possible in a hybrid contributed by both the parents (Mather, 1955).

Conclusion :

Heterosis is directly proportional to the existence of additive genetic variation in a population. The hybrids developed through this study can be directly exploited as base material for further breeding programmes.

Authors' affiliations :

M. KANNAN AND M. GANGA, Department of Floriculture and Landscaping, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

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