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Correlation and path analysis studies in double type tuberose

■ **P. RANCHANA, M. KANNAN[1] AND M. JAWAHARLAL[1]**

Members of the Research Forum

Associated Authors:
[1]Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, COIMBATORE (T.N) INDIA

Author for correspondence :
P. RANCHANA
Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, COIMBATORE (T.N) INDIA
Email : ranchanahorti@gmail.com

ABSTRACT : Genetic variability studies in tuberose were carried out among 5 varieties for 12 characters at Botanical gardens, Tamil Nadu Agricultural University, Coimbatore during the year 2011-2013. In genotypic and phenotypic levels, weight of florets per spike exhibited positive relationship with yield of florets per plot (4 × 1 m) (0.965) and number of spikes per m^2 (0.534). Positive and significant association was also observed for number of spikes/ m^2 with yield of florets per plot (4 × 1 m) (0.565). The maximum positive direct effect on number of spikes per m^2 was contributed by weight of florets per spike (0.6378) followed by number of leaves per plant (0.5782), flowering duration (0.3756), rachis length (0.2779), days taken for sprouting of bulb (0.2580), length of the floret (0.2277) and days to spike emergence (0.0213). Hence, the characters *viz.*, weight of florets per spike, number of leaves per plant, flowering duration, rachis length, days taken for sprouting of bulb, length of the floret and days to spike emergence had significant positive correlation co-efficients and positive direct effects on yield which formed reliable indices for selection of genotypes for yield.

KEY WORDS : Tuberose, Double types, Correlation, Path analysis

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Tuberose (*Polianthes tuberosa* Linn.) belongs to the family Amaryllidaceae is one of the important bulbous flower crops of tropical and subtropical regions. Among the commercially grown flowers in India, tuberose occupies a prime position owing to its popularity as a cut flower, loose flower, for perfumery as well as its potential as source of secondary metabolites. Waxy white flowering spikes of single as well as double types of tuberose impregnate the atmosphere with their sweet fragrance and because of longer keeping quality of flower spikes (Sadhu and Bose, 1973; Benschop, 1993). Tuberose flowers have long been used in perfumery as a source of essential oils and aroma compounds. Its essential oil is exported at an attractive price to France, Italy and other countries (Sadhu and Bose, 1973), as long as there is no synthetic flavour to replace it's fragrance. It is also widely grown as specimen for exhibition and cut flower. It is cultivated on a large scale in Tamil Nadu, Karnataka, West Bengal and Maharastra. To a lesser extent it is also grown in Andhra Pradesh, Haryana, Delhi, Uttar Pradesh and Punjab. There is a tremendous scope for improvement especially with spike related traits through inter and intra specific hybridization programmes. A study on such traits will be essential for a successful breeding programme.

In tuberose, like any other plant species, the phenotypic expression of a character is mainly governed by the genetic make-up of the plant, the environment in which it is grown and the interaction between the genotype and environment. Further, the genotype of a plant is controlled by additive gene effect (heritable), non-additive gene effect or dominance (non-heritable) and epistasis (non-allelic interaction). Assigning of the phenotypic variability into its heritable and its non-heritable components with suitable genetic parameters such as genotypic and phenotypic co-efficient of variationis and path analysis is necessary (Murthy and Srinivas, 1997; Kannan *et al.*, 1998; Radhakrishna *et al.*, 2004; Vijayalaxmi *et al.*, 2012). Thus, the present study was taken upto know the genetic variability in tuberose which can be used in tuberose improvement programme.

RESEARCH METHODS

The experiment was carried out at Botanical gardens, Tamil Nadu Agricultural University, Coimbatore during the year 2011-2013. It is situated at 11° 02" N latitude, 76° 57" E longitude and 426.76 m above mean sea level. Experimental material consists of five double genotypes of tuberose *viz.,* Suvasini and Vaibhav. The experiment was laid out in Randomized Block Design (RBD) with three replications. The soil 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 t ha^{-1}. After levelling, raised beds of 1.5 × 1.5 m were formed and the medium sized bulbs of 3.0 - 3.5 cm diameter weighing about 25 grams were planted at a spacing of 45 × 30 m which accommodates 7 plants per m^2. Uniform cultural practices were followed throughout the experimentation. Observations were recorded from 10 randomly selected plants in each genotype for days taken for sprouting (days), plant height (cm), number of leaves per clump, days to spike emergence, flowering duration, spike length (cm), rachis length (cm), number of florets /spike, length of the floret, weight of the florets/spike, number of spikes/ m^2, yield of florets/ plot (4 × 1 m). Data were analysed and presented in tabular form. Data were put to statistical analysis as per Panse and Sukhatme (1967). Correlation analysis was carried out as per the formulae suggested by Fisher (1954). The significance of phenotypic and genotypic correlation co-efficients was tested against 'r' value given in Fisher and Yate's table (1963) at (n^{-2}) degrees of freedom. Path co-efficient analysis was estimated as suggested by Dewey and Lu (1959) to study the direct and indirect effects.

RESEARCH FINDINGS AND DISCUSSION

The phenotypic and genotypic correlation co-efficients were computed in all possible combinations for twelve characters and are presented in Tables 1 and 2. Correlation co-efficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection is based for genetic improvement for a particular character (Robinson *et al.,* 1949). A positive correlation between desirable characters is favourable to the plant breeder because it helps in simultaneous improvement of both the characters. In the present study, genotypic correlation co-efficients were found to be higher than phenotypic correlation co-efficients for most of the characters, indicating a strong inherent association between various characters and were masked by environmental component with regard to phenotypic expression. Similar results were obtained by Singh (2011) in antirrhinum.

Table 1 : Phenotypic correlation co-efficient among different characters in tuberose

Sr. No.	1	2	3	4	5	6	7	8	9	10	11	12
1.	1.000	-0.772	-0.637	1.036*	-0.830	-0.792	-0.646	-0.690	-0.477	-0.623	-0.852	-0.698
2.		1.000	0.939**	-0.347	0.940**	0.999**	0.639**	0.955**	0.581**	0.900**	0.685**	0.971**
3.			1.000	-0.157	0.914**	0.928**	0.413**	0.897**	0.608**	0.946**	0.649**	0.931**
4.				1.000	-0.445**	-0.389**	-0.411**	-0.416**	-0.125**	-0.364**	-0.427**	-0.401**
5.					1.000	0.940*	0.683*	0.854*	0.806*	0.868*	0.859*	0.896*
6.						1.000	0.639**	0.961**	0.595**	0.899**	0.685**	0.974**
7.							1.000	0.470*	0.544*	0.320*	0.734*	0.500*
8.								1.000	0.456**	0.946**	0.490**	0.993**
9.									1.000	0.621**	0.812**	0.554**
10.										1.000	0.516*	0.963*
11.											1.000	0.550*
12.												1.000

1. Days taken for sprouting of bulb, 2. Plant height, 3. Number of leaves per plant, 4. Days to spike emergence, 5. Flowering duration, 6. Spike length, 7. Rachis length 8. Number of florets/ spike, 9. Length of the floret, 10. Weight of florets per spike, 11. Number of spikes/m^2 , 12. Yield of florets/ plot (4 x 1 m)

* and ** indicates significance of values at P=0.05 and 0.01, respectively

The study showed a highly significant and positive correlation between days taken for sprouting of bulb with days to spike emergence (0.671). This trait however, showed negative correlation with flowering duration (-0.978), number of leaves per plant (-0.954), number of spikes per m^2 (-0.952), plant height (-0.939), spike length (-0.927), weight of florets per spike (-0.874), yield of florets per plot (4 × 1 m) (-0.803), rachis length (-0.802), length of the floret (-0.761) and number of florets per spike (-0.736).

Highly significant and positive correlations for plant height was observed with spike length (1.001), yield of florets per plot (4 × 1 m) (0.975), number of florets per spike (0.971), number of leaves per plant (0.958), flowering duration (0.944), weight of florets per spike (0.904), number of spikes per m^2 (0.695), rachis length (0.652) and length of the floret (0.623). The trait however, showed negative correlation with days to spike emergence (-1.574). Kumar *et al.* (2011) did similar studies and reported significant and positive association of plant height with spike length in gladiolus. Further, the number of leaves per plant had highly significant relationship with weight of the florets per spike (0.994), yield of florets per plot (4 × 1 m) (0.987), number of florets per spike (0.981), spike length (0.965), flowering duration (0.941), length of the floret (0.730), number of spikes per m^2 (0.665) and rachis length (0.438). The trait however, showed negative correlation with days to spike emergence (-1.759). Similar findings were also reported by Vetrivel (2010) and Kumar *et al*. (2011) in gladiolus.

Days to spike emergence showed highly significant but negative correlation with flowering duration (-1.706), spike length (-1.518), yield of florets per plot (4 x 1 m) (-1.430), number of spikes per m^2 (-1.418), weight of florets per spike (-1.406), rachis length (-1.384), length of the floret (-2.136) and number of florets per spike (-1.276). This is line with the findings of Kumar *et al*. (2011) in gladiolus for spike length and weight of florets per spike.

Positive and significant association for flowering duration was observed for spike length (0.944), yield of florets per plot (4 × 1 m) (0.899), weight of florets per spike (0.875), number of spikes per m^2 (0.862), number of florets per spike (0.859), length of the floret (0.851) and rachis length (0.695). This is in line with the findings of Kumar *et al.* (2012) in snapdragon. The spike length showed highly significant and positive correlation with yield of florets per plot (4 × 1 m) (0.974), number of florets per spike (0.967), weight of florets per spike (0.905), number of spikes per m^2 (0.696), rachis length (0.653) and length of the floret (0.604). This is in consonance with the findings of Kumar *et al.* (2012) in snapdragon. There exists a positive and highly significant relationship of rachis length with number of spikes per m^2 (0.742), length of the floret (0.566), yield of florets per plot (4 × 1 m), number of florets per spike (0.481) and weight of florets per spike (0.347). Similar such findings were reported by Kumar *et al.* (2012) in snapdragon. Positive and significant association was observed for number of florets/ spike with yield of florets per plot (4 × 1 m) (0.996), weight of florets per spike

Table 2 : Genotypic correlation co-efficient among different characters in tuberose

Sr. No.	1	2	3	4	5	6	7	8	9	10	11	12
1.	1.000	-0.939	-0.954	0.671**	-0.978	-0.927	-0.803	-0.736	-0.761	-0.874	-0.952	-0.803
2.		1.000	0.958**	-1.574	0.944**	1.001**	0.652**	0.971**	0.623**	0.904**	0.695**	0.975**
3.			1.000	-1.759	0.941**	0.965**	0.438**	0.981**	0.730**	0.994**	0.665**	0.987**
4.				1.000	-1.706	-1.518	-1.384	-1.276	-2.136	-1.406	-1.418	-1.430
5.					1.000	0.944*	0.695*	0.859*	0.851*	0.875*	0.862*	0.899*
6.						1.000	0.653**	0.967**	0.604**	0.905**	0.696**	0.974**
7.							1.000	0.481*	0.566*	0.347*	0.742*	0.517*
8.								1.000	0.489**	0.950**	0.500**	0.996**
9.									1.000	0.630**	0.918**	0.561**
10.										1.000	0.534*	0.965*
11.											1.000	0.565*
12.												1.000

1. Days taken for sprouting of bulb; 2. Plant height; 3. Number of leaves per plant; 4. Days to spike emergence; 5. Flowering duration; 6. Spike length; 7. Rachis length; 8. Number of florets/ spike; 9. Length of the floret; 10. Weight of florets per spike; 11. Number of spikes/m^2; 12. Yield of florets/ plot (4x1m)

* and ** indicate significance of values at P=0.05 and P=0.01, respectively

(0.950), number of spikes per m^2 (0.500) and length of the floret (0.489). These results are in conformity with the findings of Kumar *et al*. (2011) in gladiolus. Length of the floret exhibited positive and significant association with number of spikes per m^2 (0.918), weight of florets per spike (0.630) and yield of florets per plot (4 × 1 m) (0.561). In genotypic and phenotypic levels, weight of florets per spike exhibited positive relationship with yield of florets per plot (4 × 1 m) (0.965) and number of spikes per m^2 (0.534). Positive and significant association was also observed for number of spikes/ m^2 with yield of florets per plot (4 × 1 m) (0.565). This is in consonance with the findings of Kumar *et al*. (2011) in gladiolus for number of spikes/ m^2.

Table 3 showed the maximum positive direct effect on number of spikes per m^2 was contributed by weight of florets per spike (0.6378) followed by number of leaves per plant (0.5782), flowering duration (0.3756), rachis length (0.2779), days taken for sprouting of bulb (0.2580), length of the floret (0.2277) and days to spike emergence (0.0213). Yield of florets/ plot (4 × 1 m) (-0.0518), spike length (-0.3784), plant height (-0.3291), number of florets per spike (-0.2078) showed negative direct effect on yield and similar observations were also made by Saravanakumar (2000) in tuberose for spike length and plant height.

Days taken for sprouting of bulb recorded strong positive indirect effect through days to spike emergence (0.1838) and weight of florets per spike (0.0088). Whereas, the other characters exerted a negative indirect effect. The contribution of indirect effect of plant height through days to spike emergence (0.1785) and weight of the florets per spike (0.0312) was positive while its influence through other characters was negative. The number of leaves per plant recorded a strong positive indirect effect through number of florets per spike (0.5627), plant height (0.5242), rachis length (0.4984), number of spikes per m^2 (0.3592), spike length (0.3272) and flowering duration (0.2998) whereas, other characters exerted negative indirect effect. Days to spike emergence recorded strong positive indirect effect through days to sprouting of bulb (0.0152), whereas, the other characters exerted a negative indirect effect. The contribution of indirect effect of duration of flowering through number of florets per spike (0.2629), plant height (0.2608), spike length (0.2467), rachis length (0.2123), number of leaves per plant (0.1941), length of the floret (0.1055), weight of the florets per spike (0.0349) and number of spikes per m^2 (0.0119) was positive while its influence through other characters was negative. This is in consonance with the findings of Saravanakumar (2000) in tuberose.

Spike length recorded strong positive indirect effect through days taken for sprouting of bulb (0.3429), days to spike emergence (0.3320) and number of leaves per plant (0.2143). The contribution of indirect effect of duration of rachis length through number of florets per spike (0.2823), number of leaves per plant (0.2388), plant height (0.1994), spike length (0.1932), number of spikes per m^2 (0.0725), length of the floret (0.0249) and weight of the florets per spike (0.0187) was positive while its influence through other characters was negative. The

Table 3 : Path analysis

Sr. No.	1	2	3	4	5	6	7	8	9	10	11	12
1.	0.2580	-0.2408	-0.1951	0.1838	-0.1423	-0.2272	-0.1626	-0.1999	-0.1175	0.0088	-0.1143	-0.4385
2.	0.3998	-0.3291	-0.2834	0.1785	-0.2143	-0.2289	-0.2289	-0.2786	-0.0754	0.0312	-0.1806	0.4213
3.	-0.4865	0.5242	0.5782	-0.2052	0.2998	0.3272	0.4984	0.5627	-0.0259	-0.0752	0.3592	0.4742
4.	0.0152	-0.0117	-0.0072	0.0213	-0.0127	-0.0179	-0.0089	-0.0113	-0.0167	-0.0086	-0.0062	-0.6491
5.	-0.2183	0.2608	0.1941	-0.2143	0.3756	0.2467	0.2123	0.2629	0.1055	0.0349	0.0119	0.4485
6.	0.3429	-0.2805	0.2143	0.3320	-0.2481	-0.3784	-0.2637	-0.2747	-0.2388	-0.0830	-0.2051	0.5967
7.	-0.1812	0.1994	0.2388	-0.1351	-0.1576	0.1932	0.2779	0.2823	0.0249	0.0187	0.0725	0.6203
8.	0.1676	-0.1906	-0.2021	0.1149	-0.1443	-0.1534	-0.2109	-0.2078	-0.0334	0.0014	-0.1300	0.6723
9.	-0.1078	0.0538	-0.0127	-0.1993	0.0632	0.1457	0.0212	0.0344	0.2297	0.1377	-0.1389	0.5915
10.	0.0243	-0.0602	-0.0836	-0.2575	0.0693	0.1399	0.0437	-0.0046	0.3851	0.6378	0.3615	0.9232
11.	0.1056	-0.0774	-0.0713	-0.0875	-0.0592	0.0943	-0.0793	-0.0767	-0.0625	-0.0335	-0.0518	0.5756
12.	-0.0253	0.1348	0.0353	-0.0182	0.0019	0.0317	0.0158	0.0355	0.0345	0.0332	0.0573	0.9929

Residual effect = 0.182

1. Days taken for sprouting of bulb
2. Plant height
3. Number of leaves per plant
4. Days to spike emergence
5. Flowering duration
6. Spike length
7. Rachis length
8. Number of florets/ spike
9. Length of the floret
10. Weight of florets per spike
11. Number of spikes/m^2
12. Yield of florets/ plot (4 x 1m)

number of florets per spike recorded strong positive indirect effect through days taken for sprouting of bulb (0.1676), days to spike emergence (0.1149) and weight of the florets per spike (0.0014). The contribution of indirect effect of floret length through spike length (0.1457), weight of florets per spike (0.1377), flowering duration (0.0632), plant height (0.0538), number of florets per spike (0.0344) and rachis length (0.0212) was positive, while its influence through other characters was negative. The weight of florets per spike recorded strong positive indirect effect through flowering duration (0.0693), rachis length (0.0437), length of the floret (0.3851), number of spikes per m^2 (0.3615), days taken for sprouting of bulb (0.0243) and spike length (0.1399). Whereas, the other characters exerted a negative indirect effect and similar observations were also made by Saravanakumar (2000) in tuberose.

It could be inferred from the results of genotypic correlation co-efficient and path analysis *viz.*, weight of florets per spike, number of leaves per plant, flowering duration, rachis length, days taken for sprouting of bulb, length of the floret and days to spike emergence had significant positive correlation co-efficients and positive direct effects on yield which formed reliable indices for selection of genotypes for yield.

In the present study, residual effect made a marked contribution (0.182) in determining the flower yield indicating some characters other than those included in present path co-efficient study might also play an important role in determing the total yield. Similar results of residual path value were reported by Saravanakumar (2000) in tuberose.

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