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Mean Performance, Correlation Coefficient and Path Coefficient Analysis for Yield and Yield Attributing Characters in F1 Population of Tuberose (*Polianthes tuberosa L.*)

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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 mean performance, it could be inferred that three crosses Phule Rajani (P_1) $_x$ Mexican Single (P_7), Hyderabad Single (P_4) $_x$ Phule Rajani (P_1) and Hyderabad Single (P_4) $_x$ Variegated Single (P_2) recorded higher yield than the local check I (Nilakkottai Local) and commercial check II (Prajwal). An analysis of the association of various morphological traits through correlation showed that floret yield per plant was positive and significantly correlated with leaf length, rachis length, floret diameter, weight of single floret and number of florets per spike. Floret yield per plant imparted maximum positive direct effect on yield per m^2 followed by rachis length, leaf width, floret diameter and floret length. Leaf length imparted maximum negative direct effect on yield per m^2 followed by number of spikes per plant, weight of single floret, plant height, number of leaves and number of florets per spike.

Keywords: Tuberose, F_1 population, Mean performance, Correlation, Path analysis, Floret weight and yield

Rose, carnation, gladiolus, tuberose, chrysanthemum, orchids, anthurium*.,* are commonly and frequently demanded in both domestic and international markets. Among them, tuberose (*Polianthes tuberosa)* is 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 native to Mexico and belongs to the family Amaryllidaceae. It is a bulbous perennial plant with tuberous roots producing long spikes, bearing waxy white fragrant flowers, which impregnate the atmosphere with their sweet fragrance. 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), tube rose is in great demand for making floral arrangements and bouquets in major cities of India.

The study of interrelationship of various characters in the form of correlation is an important aspect in crop breeding. Knowledge of correlation studies helps the plant breeder to ascertain the real components of yield and provide an effective basis of selection. The characters contributing significantly to desirable traits can be identified and used as selection criteria in crop improvement programmes. 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.

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Materials 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 11^0 0' 02" N latitude, 76^0 0' 57" E longitude and 426.76 m above mean sea level. The F_1 population of eight different cross combinations (Phule Rajani x Hyderabad Single, Hyderabad Single x Variegated Single, Shringar x Variegated Single, Phule Rajani x Mexican Single, Variegated Single x Calcutta Single, Variegated Single x Pune Single, Shringar x Kahikuchi Single and Variegated Single x Phule Rajani) and three open pollinated seedlings of Shringar, Variegated Single, Phule Rajani and two checks namely, Prajwal (Commercial check) and Nilakottai Local (Local check) 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 plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm), number of spikes per plant, spike length (cm), rachis length (cm), floret length (cm), floret diameter (cm), weight of single floret (g), number of florets per spike, floret yield/plant (g) and yield/m^2 (kg). The mean data of

all the crosses for each character were tabulated and subjected to statistical analysis**.** The data were statistically analyzed and the correlation coefficient analysis for yield and yield components was done utilizing the formula suggested by Al-jibouri *et al.* (1958). Path co-efficient analysis was carried out using the phenotypic correlation coefficient as suggested by Wright (1921) and illustrated by Deway and Lu (1959).

Results and Discussion

The primary criterion to evaluate a hybrid is its mean performance. Kadambavanasundaram (1980) and Nadarajan (1986) reported that *per se* performance of hybrids appeared to be a useful index for judging the hybrids. In any breeding programme, the cross or family with the highest mean value was relatively effective in identifying the superior segregants (Finkner *et al*., 1973). Kumar *et al.* (1979) also emphasized that for desirable plant selection or for elimination of undesirable traits, the mean performance served as a preliminary criterion. The mean performance of the eight parents, eight hybrid combinations and three open pollinated seedlings for quantitative and qualitative characters is presented below and the data are tabulated in Tables 1 and 2.

Plant height (cm)

Plant height ranged from 31.67 cm (P_6) to 47.67 cm (P_4) for the parents and from 30.67 cm (P_8 x P_2) to 48 cm (P_4 x P_1) for the hybrids. In open pollinated seedlings, Variegated Single recorded 41.33 cm and Phule Rajani (39.33 cm). The mean plant height for the parents, hybrids and OPS was 41.18, 38.46 and 40.00 cm, respectively.

Table 1. Mean performance of parents, F_1 hybrids and open pollinated seedlings for vegetative growth and flower yield parameters

Parents and Cross Characters	Plant height (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)	No. of spikes per plant	Weight of single floret (g)	No. of florets per spike	Weight of florets/ plant (g)
P_1 (Phule Rajani)	44.08	192.20	35.00	0.94	3.30	0.72	64.30	158.52
P_2 (Variegated Single)	41.00	134.33	34.17	0.60	5.50	0.70	41.17	158.58
P_3 (Shringar)	41.67	148.00	36.63	0.68	4.17	0.65	60.50	163.98
P_4 (Hyderabad Single)	47.67	109.67	45.08	1.08	8.83	1.05	62.83	549.54
P_5 (Kahikuchi Single)	44.00	148.33	34.33	0.83	3.00	0.70	55.00	115.50
P_6 (Calcutta Single)	31.67	134.83	29.00	1.00	6.00	0.93	49.50	276.21
P_7 (Mexican Single)	35.00	163.33	32.42	0.77	4.83	0.72	55.00	191.26
P_8 (Pune Single)	44.40	156.00	35.60	0.94	2.00	0.94	53.60	101.36
P_1 x P_2	40.67	134.33	34.00	1.27	2.00	1.20	44.00	105.60
P_2 x P_3	34.67	107.75	29.18	1.15	3.61	0.99	28.00	100.80
P_4 x P_2	37.67	124.76	30.42	1.01	8.80	1.00	30.00	264.00
P_3 x P_5	34.00	101.00	26.00	1.07	2.33	1.00	42.33	68.63
P_6 x P_2	36.67	112.79	35.49	1.02	3.99	1.00	50.50	201.50
P_8 x P_2	30.67	89.67	24.67	1.20	2.67	1.03	46.00	126.50
P_4 x P_1	48.00	201.86	41.05	1.06	9.06	1.03	48.44	450.54
P_1 x P_7	45.33	109.92	37.60	1.11	3.58	1.75	145.05	1012.59
Variegated Single OPS	41.33	112.59	34.48	1.00	3.74	1.07	44.78	179.20
Shringar OPS	39.33	100.83	33.27	1.00	3.66	0.96	48.06	168.80
Phule Rajani OPS	39.30	129.67	32.00	1.17	2.33	1.07	51.33	127.97
Check I (Local type Nilakkottai local)	45.00	215.22	30.49	1.16	3.48	1.45	38.00	202.14
Check II (Commercial variety Prajwal)	55.00	260.00	49.00	1.72	5.50	1.56	48.00	398.13
Parents mean	41.18	148.34	35.28	0.86	4.70	0.80	55.24	214.37
Hybrids mean	38.46	122.76	32.30	1.11	4.51	1.15	54.29	291.27
OPS mean	40.00	114.36	33.25	1.06	3.24	1.03	48.06	158.66
Grand mean	40.81	142.24	34.28	1.04	4.40	1.03	52.69	243.87
C.V	6.07	0.61	3.00	5.55	0.99	0.72	0.88	1.76
S. E.	1.43	0.50	0.59	0.03	0.03	0.00	0.27	2.48
C. D. 5 %	4.09	1.43	1.70	0.09	0.07	0.01	0.76	7.09
C. D. 1 %	5.47	1.92	2.27	0.13	0.10	0.02	1.02	9.49

Number of leaves

The number of leaves among the parents ranged from 109.67 (P_4) to 192.20 (P_1). Among the eight hybrids, P_8 x P_2 recorded the lowest value (89.67), while the highest value was registered in the hybrid P_4 x P_1 (201.86) followed by P_1 x P_2 (134.33) and P_4 x P_2 (124.76). Phule Rajani (open pollinated seedlings) recorded the highest number of leaves (129.67 nos). The mean values for parents, hybrids and open pollinated seedlings were 148.34, 122.76 and 114.36, respectively.

Leaf length

The parent P_4 recorded the highest leaf length of 45.08 cm, while the lowest leaf length was registered in P_6 (29.00 cm). For the hybrids, leaf length ranged from 41.05 in P_4 x P_1 to 24.67 in P_8 x P_2. The open pollinated seedlings registered 32.00, 33.27 and 34.48 cm in Phule Rajani OPS, Shringar OPS and Variegated Single OPS respectively. The mean values for parents, hybrids and open pollinated seedlings were 35.28, 32.30 and 33.25, respectively.

Table 2. Mean performance of parents, F_1 hybrids and open pollinated seedlings for flower quality parameters

Parents and Cross Characters	Floret length (cm)	Floret diameter (cm)	Spike length (cm)	Rachis length (cm)	Yield/m^2 kg
P_1 (Phule Rajani)	5.70	3.48	81.70	24.80	1.39
P_2 (Variegated Single)	5.92	3.35	91.33	23.67	1.40
P_3 (Shringar)	5.78	3.17	78.33	31.00	1.44
P_4 (Hyderabad Single)	5.40	3.55	71.25	24.95	4.80
P_5 (Kahikuchi Single)	5.00	3.00	77.00	25.33	1.01
P_6 (Calcutta Single)	5.25	3.62	72.67	26.03	2.43
P_7 (Mexican Single)	5.88	2.97	71.83	25.17	1.68
P_8 (Pune Single)	6.00	3.50	63.20	24.00	0.89
P_1 x P_2	5.00	3.20	91.00	21.00	0.93
P_2 x P_3	5.97	3.42	124.18	17.90	0.89
P_4 x P_2	5.56	3.21	84.06	23.26	2.30
P_3 x P_5	4.80	3.03	93.67	27.67	0.87
P_6 x P_2	5.74	3.51	120.77	25.03	1.77
P_8 x P_2	4.50	2.93	110.00	23.33	1.11
P_4 x P_1	5.32	3.46	118.96	25.96	3.90
P_1 x P_7	6.21	3.48	124.95	65.50	8.91
Variegated Single OPS	5.98	3.42	80.71	20.64	1.57
Shringar OPS	6.02	3.42	79.71	15.08	1.48
Phule Rajani OPS	5.07	2.93	112.70	26.67	1.12
Check I (Local type Nilakkottai local)	5.50	4.50	95.92	22.14	1.78
Check II (Commercial variety Prajwal)	5.59	5.00	99.10	29.32	3.50
Parents mean	5.62	3.33	75.91	25.62	1.88
Hybrids mean	5.41	3.28	108.45	28.71	2.59
OPS mean	5.69	3.26	91.04	20.80	1.39
Grand mean	5.54	3.43	92.53	26.12	2.15
C.V	0.18	0.30	0.42	0.74	1.77
S. E.	0.01	0.01	0.22	0.11	0.02
C. D. 5 %	0.02	0.02	0.64	0.32	0.06
C. D. 1 %	0.02	0.02	0.85	0.43	0.08

Leaf width

The parent P_2 recorded the lowest leaf width (0.60 cm), whereas P_4 recorded the highest leaf width (1.08). In hybrids, it ranged from 1.01 in P_4 x P_2 to 1.27 in P_1 x P_2. The open pollinated seedlings recorded the lowest leaf width of 1.00 cm in Variegated Single OPS and the highest (1.17 cm) in Phule Rajani OPS. The mean values of OPS was 1.06 cm; for hybrids 1.11 cm and for parents, it was 0.86 cm.

Number of spikes per plant

The number of spikes per plant for the parents

Table 3. Simple correlation coefficient between yield and yield contributing traits in F_1 population

Characters	Plant height (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)	No. of spikes per plant	Spike length (cm)	Rachis length (cm)	Floret length (cm)	Floret diameter (cm)	Weight of single floret (g)	No. of florets per spike	Floret yield / plant (g)	Yield/m^2 (kg)
Plant height(cm)	1.000	-0.180	0.013	0.383	-0.051	0.499*	0.359	0.096	-0.010	0.493*	0.225	0.325	0.327
No. of leaves		1.000	0.378	-0.357	0.290	0.280	-0.028	0.046	0.128	-0.397	0.003	-0.013	-0.026
Leaf length (cm)			1.000	-0.160	0.495*	0.215	0.238	0.363	0.558*	0.125	0.390	0.552*	0.540*
Leaf width (cm)				1.000	-0.153	-0.164	0.009	-0.372	-0.051	0.572*	-0.004	0.134	0.138
No. of spikes per plant					1.000	-0.077	-0.050	0.156	0.478*	-0.116	-0.104	0.386	0.375
Spike length (cm)						1.000	0.560*	-0.116	0.013	0.138	0.498*	0.347	0.347
Rachis length (cm)							1.000	0.303	0.129	0.719*	0.929**	0.820**	0.826**
Floret length (cm)								1.000	0.548*	0.233**	0.381	0.406	0.403
Floret diameter (cm)									1.000	0.193	0.238**	0.486*	0.480*
Weight of single floret (g)										1.000	0.687**	0.736**	0.743**
No. of florets per spike											1.000	0.836**	0.839**
Floret yield /plant (g)												1.000	0.999**
Yield/m^2 (kg)													1.000

*, ** Significant at 5 % and 1 % level, respectively

Table 4. Path coefficient of yield and yield attributing parameters in F_1 population

Characters	Plant height (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)	No. of spike per plant	Spike length (cm)	Rachis length (cm)	Floret length (cm)	Floret diameter (cm)	Weight of single floret (g)	No. of florets per spike	Floret yield/ plant (g)	Yield/m^2 (kg)
Plant height(cm)	**-0.011**	0.002	0.000	0.002	0.002	0.000	0.019	0.000	0.000	-0.015	-0.019	0.346	0.327
No. of leaves	0.002	**-0.010**	0.000	-0.002	-0.013	0.000	-0.001	0.000	0.000	0.012	0.000	-0.014	-0.026
Leaf length (cm)	0.000	-0.004	**-0.001**	-0.001	-0.022	0.000	0.013	0.001	0.002	-0.004	-0.033	0.589	0.540*
Leaf width (cm)	-0.004	0.004	0.000	**0.006**	0.007	0.000	0.001	-0.001	0.000	-0.017	0.000	0.143	0.138
No. of spike per plant	0.001	-0.003	0.000	-0.001	**-0.044**	0.000	-0.003	0.000	0.001	0.003	0.009	0.412	0.375
Spike length (cm)	-0.006	-0.003	0.000	-0.001	0.003	**0.000**	0.030	0.000	0.000	-0.004	-0.042	0.370	0.347
Rachis length (cm)	-0.004	0.000	0.000	0.000	0.002	0.000	**0.053**	0.001	0.000	-0.021	-0.079	0.874	0.826**
Floret length (cm)	-0.001	0.000	0.000	-0.002	-0.007	0.000	0.016	**0.002**	0.002	-0.007	-0.032	0.433	0.403
Floret diameter (cm)	0.000	-0.001	-0.001	0.000	-0.021	0.000	0.007	0.001	**0.003**	-0.006	-0.020	0.518	0.480*
Weight of single floret (g)	-0.006	0.004	0.000	0.003	0.005	0.000	0.038	0.000	0.001	**-0.029**	-0.058	0.785	0.743**
No. of florets per spike	-0.003	0.000	0.000	0.000	0.005	0.000	0.049	0.001	0.001	-0.020	**-0.085**	0.892	0.839**
Floret yield /plant (g)	-0.004	0.000	-0.001	0.001	-0.017	0.000	0.043	0.001	0.001	-0.022	-0.071	**1.066**	0.999**

Residual effect= 0.031

ranged from 2.00 (P_8) to 8.83 (P_4). Among the eight hybrids, P_1 x P_2 recorded the lowest value (2.00) and the highest value was registered in the hybrids P_4 x P_1 (9.06) followed by P_4 x P_2 (8.80). The Variegated Single open pollinated seedlings recorded the highest number of spikes per plant (3.74 nos). The mean value for the parents, hybrids and OPS were 4.70, 4.51 and 3.24, respectively.

Spike length

The mean spike length ranged from 63.20 to 91.33 cm among the eight parents. The longest spike was in P_2 and the shortest in P_8. The range for spike length among the hybrids was 124.95 (P_1 x P_7) to 84.06 cm (P_4 x P_2). The hybrid P_1 x P_7 registered the highest spike length of 124.95 cm followed by P_2 x P_3 (124.18 cm) and P_6 x P_2 (120.77 cm). Shringar open pollinated seedlings recorded spike length of 79.71 cm. The mean value for the parents, hybrids and OPS were 75.91, 108.45 and 91.04 cm, respectively.

Rachis length

The parent P_3 recorded the highest rachis length of 31.00 cm, while the lowest rachis length was registered with P_2 (23.67 cm). Among the hybrids, it ranged from 65.50 in P_1 x P_7 to 17.90 in P_2 x P_3. Open pollinated seedlings registered 26.67, 15.08 and 20.64 cm in Phule Rajani OPS, Shringar OPS and Variegated Single OPS, respectively. The mean values for parents, hybrids and open pollinated seedlings were 25.62, 28.71 and 20.80, respectively.

Floret length

The parent P_8 recorded the highest leaf length of 6.00 cm, while the lowest leaf length was registered in P_5 (5.00 cm). Among the hybrids, it ranged from 4.50 in P_8 x P_2 to 6.21 in P_1 x P_7 and open pollinated seedlings registered 5.07, 6.02 and 5.98 cm in Phule Rajani OPS, Shringar OPS and Variegated Single OPS, respectively. The mean values for parents, hybrids and open pollinated seedlings were 5.62, 5.41 and 5.69, respectively.

Floret diameter

The parent P_7 recorded the lowest floret diameter (2.97 cm), whereas P_6 recorded the highest floret diameter (3.62 cm). In hybrids, it ranged from 2.93 in P_8 x P_2 to 3.51 in P_6 x P_2 and open pollinated seedlings produced the lowest floret diameter 2.93 cm in Phule Rajani OPS and the highest (3.42 cm) in rest of other two OPS. The mean performance of OPS was 3.26cm, hybrids 3.28 cm and for parents it was 3.33 cm, respectively.

Weight of single floret

Among the parents, P_4 recorded the highest single floret weight of 1.05 g, while P_3 showed the lowest weight of 0.65 g. The range among the hybrids was 0.99 to 1.75 g. The hybrids P_1 x P_7 (1.75 g) exhibited the highest single floret weight followed by P_1 x P_2 (1.20) and P_8 x P_2 (1.03 g), while the lowest weight was recorded in P_2 x P_3 (0.99 g). Whereas, open pollinated seedlings of Variegated Single and Phule Rajani registered same as 1.07 g. The mean weight of single floret of parents, hybrids and OPS were 0.80, 1.15 and 1.03 g, respectively.

No. of florets per spike

The number of florets per spike among the parents ranged from 49.50 (P_6) to 62.83 (P_4). Among the eight hybrids, P_1 x P_2 recorded the lowest value (44.00) and the highest value was registered in the hybrids P_1 x P_7 (145.05) followed by P_6 x P_2 (50.50). Phule Rajani open pollinated seedlings recorded the highest number of florets per spike (51.33 nos). The mean values for parents, hybrids and OPS were 55.24, 54.29 and 48.06 nos., respectively.

Weight of florets/plant

Among the parents, P_4 recorded the highest weight of florets per plant 549.54 g, while P_8 showed the lowest weight of 101.36 g. The range among the hybrids was 68.63 to 1012.59 g. The hybrids P_1 x P_7 (1012.59 g) exhibited the highest weight of florets per plant followed by P_4 x P_1 (450.54) and P_4 x P_2 (264.00 g), while the lowest weight was recorded in P_3 x P_5 (68.63 g). Open pollinated seedlings of Variegated Single and Phule Rajani registered 179.20 and 127.97 g, respectively. The mean weight of florets per plant for parents, hybrids and OPS were 214.37, 291.27 and 158.66 g, respectively.

Yield

The parent P_4 recorded the highest yield / m^2 of 4.80 kg, while the lowest yield / m^2 was registered in P_8 (0.89 kg). Among the hybrids, it ranged from 0.89 kg in P_2 x P_3 to 8.91 g in P_1 x P_7 followed by P_4 x P_1 (3.90 kg) and P_4 x P_2 (2.30 kg), whereas, in open pollinated seedlings of Variegated Single recorded 1.57 kg. The mean values for parents, hybrids and open pollinated seedlings were 1.88, 2.59 and 1.39 kg, respectively. Two cross combinations exhibited higher yield / m^2 than the hybrids mean.

Based on the mean performance, it is inferred that three crosses (P_1 x P_7, P_4 x P_1 and P_4 x P_2) recorded higher yield than the check I and II. Similar results were observed in intervarietal hybridization of tuberose by Shen *et al*. (1987) and Srinivas *et al.* (1995). The heterozygous nature of the F_1 population paves the way for single plant selection on the basis of yield for further advancement.

Correlation is an important tool in crop improvement programmes and it assesses the degree of association between characters. Correlation between characters may be due to either pleiotropy or genetic linkage. There is a possibility for breaking of association due to genetic linkage through genetic manipulations, while it is not possible for association due to pleiotropy. Knowledge of association of various characters among themselves and also with economic characters provides necessary information on selection of plants for improvement of economic characters. The relationship could be obtained from simple correlation coefficients, which will aid in determining direction and number of characters

to be considered in improving economic characters (Kavitha and Anburani, 2010).

In the present study, simple correlation was computed between character pairs for thirteen characters of F_1 population. The results of correlation analysis are furnished in Table 3.

The results showed that the association between yield per m^2 and floret yield per plant was generally positive and highly significant. Yield per m^2 had positive and significant correlation with leaf length (0.540), rachis length (0.826), floret diameter (0.480), weight of single floret (0.743), number of florets per spike (0.839) and floret yield/plant (0.999). The parameters, plant height (0.327), leaf width (0.138), number of spikes per plant (0.375), spike length (0.347), floret length (0.403) had positive and non significant association with yield per m^2. However, the number of leaves per plant (-0.026) had negative correlation with yield per m^2. The results are in line with the findings of Radhakrishna *et al.* (2004) in tuberose and Balaram and Janakiram (2009) in gladiolus.

Leaf length (0.552), rachis length (0.820), floret diameter (0.486), weight of single floret (0.736) and number of florets per spike (0.836) had positive and significant association with floret yield/plant. Non significant but positive correlation was noticed for plant height (0.325), leaf length (0.134), number of spike per plant (0.386), spike length (0.347) and floret length (0.406) with floret yield/plant. Preferable negative correlation coefficient value was recorded for number of leaves (-0.013) without significance. The results are in accordance with the observations of Prabhat *et al.* (2011) in gladiolus.

The number of florets per spike had positive and significant correlation with spike length (0.498), rachis length (0.929), floret diameter (0.238) and weight of single floret (0.687). Plant height (0.225), number of leaves (0.003), leaf length (0.390) and floret length (0.381) had positive and non significant correlation with number of florets per spike. However, it had negative correlation coefficient with leaf width (-0.004) and number of spikes per plant (-0.104). These observations collaborate with the observations of Nair and Shiva (2003) in gerbera and Kannan *et al.* (1998) and Ranchana *et al.* (2015) in tuberose.

Significant and positive correlation was observed between morphological and floral parameters *viz.,* plant height (0.493), leaf width (0.572), rachis length (0.719), floret length (0.233) with weight of single floret. Non significant and positive correlation was recorded for leaf length (0.125), spike length (0.138) and floret diameter (0.193) with weight of single floret. However, it had negative correlation coefficient with number of leaves (-0.397), number of spikes per plant (-0.116). Similar findings were also reported by Vetrivel, 2010 and Prabhat *et al.* (2011) in gladiolus.

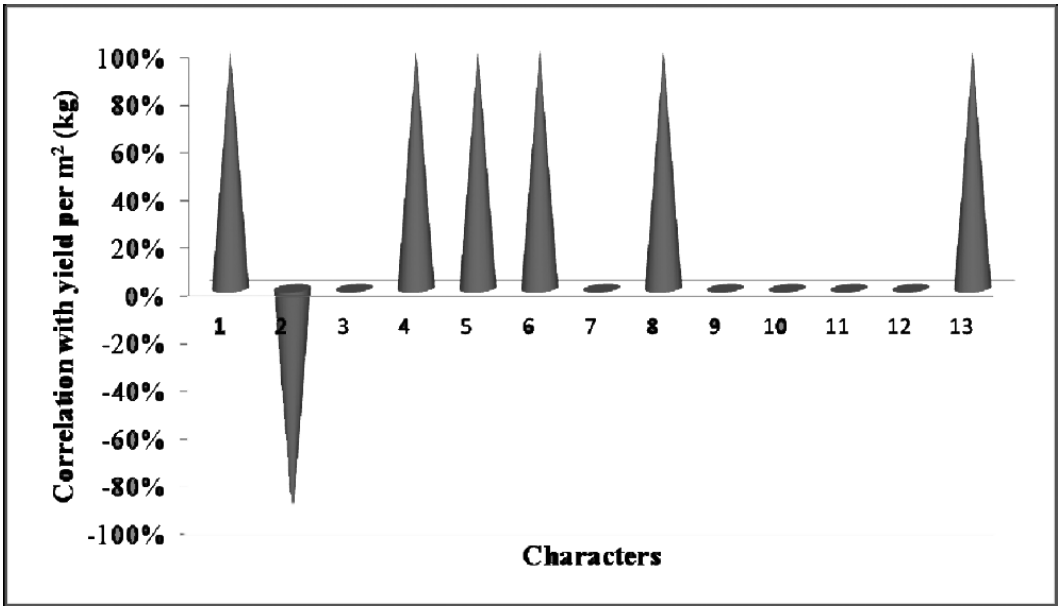

Fig. 1. Correlation coefficient for yield and related characters in F_1 population of tuberose

Floret diameter was found to be significant and it positively correlated with leaf length (0.558), number of spikes per plant (0.478), floret length (0.548). Non significant and positive correlation was observed for number of leaves (0.128), spike length (0.013) and rachis length (0.129) with floret diameter. Similar observation was reported in gladiolus by Prabhat *et al.* 2011. However, it had negative correlation coefficient for plant height (-0.010) and leaf width (-0.051). Positive and non significant correlation was observed for plant height (0.096), number of leaves (0.046), leaf length (0.363), number of spikes per plant (0.156),

rachis length (0.303) with floret length as reported by Rakesh *et al.* (2012) in snapdragon. However, negative correlation coefficients were recorded for leaf width (-0.372) and spike length (-0.116).

Rachis length exhibited a positive and significant association with spike length (0.560). Plant height (0.359), leaf length (0.238) and leaf width (0.009) had positive and non significant correlation with rachis length. Negative correlation was observed for number of leaves (-0.028), number of spikes per plant (-0.050) with rachis length. Spike length showed positive and highly significant association with plant height (0.499) while it had negative correlation with leaf width (-0.164) and number of spikes per plant (-0.077). Positive and non significant correlation was observed for number of leaves (0.280) and leaf length (0.215) with spike length. Similar findings were also reported by Kannan *et al*. (1998), Vijayalakhsmi *et al*. (2012) and Vanlalruati *et al.* (2013) in tuberose.

Number of spikes per plant was found to have positive and significant association with leaf length (0.495) and positive and non significant with number of leaves (0.290). Negative correlation was observed for plant height (-0.051) and leaf width (-0.153). Plant height (0.383) had positive and non significant with leaf width. Similarly, negative correlation coefficient was observed for number of leaves (-0.357) and leaf length (-0.160) with leaf width. Positive and non significant correlation was found for plant height (0.013) and number of leaves (0.378) with leaf length. Negative correlation coefficient was observed for plant height (-0.180) with number of leaves. This is in consonance with the findings of Singh, 2011 in snapdragon.

Simple correlation coefficient analysis thus showed that all the traits influenced flower yield per plant and were found to have significant and positive correlation. The traits leaf length, rachis length, floret diameter, weight of single floret, number of florets per spike and floret yield/plant were found to play a major role as selection criteria for flower yield in tuberose. (Fig.1)

The direct and indirect effects of the different characters on yield per m^2 are presented on Table 4. From the path analysis, positive direct effects of independent characters *viz.,* leaf width, weight of florets/plant, rachis length, floret length and floret diameter were observed whereas number of florets per spike (-0.085), number of spikes per plant (-0.044), weight of single floret (-0.029), plant height (-0.011), number of leaves (-0.010) and leaf length (-0.001) incurred highest negative effects towards yield per m^2. Weight of florets per plant imparted maximum positive direct effect (1.066) on yield per m^2 followed by rachis length (0.053), leaf width (0.006), floret diameter (0.003) and floret length (0.002). These findings are in accordance with the observations of Balaram *et al.* (2009) in gladiolus and Kannan *et al.* (1998) and Ranchana *et al.* (2015) in tuberose.

The highest indirect and positive effect of plant height on yield per m^2 was through weight of florets per plant (0.346), rachis length (0.019), number of leaves (0.002), leaf length (0.002), leaf width (0.002) whereas number of leaves influenced yield per m^2 indirectly and positively through weight of single floret (0.012). These findings are in agreement with the observations of Kavitha and Anburani (2010) in marigold.

Leaf length influenced yield per m^2 indirectly and positively through weight of florets per plant (0.589), rachis length (0.013), floret diameter (0.002) and floret length (0.001). Leaf width influenced yield per m^2 indirectly and positively through weight of florets per plant (0.143), number of spikes per plant (0.007), number of leaves (0.004) and rachis length (0.001). These observations collaborate with those of Prabhat *et al.* (2003) in gerbera.

Number of spikes per plant influenced yield per m^2 indirectly and positively through weight of florets per plant (0.412), number of florets per spike (0.009), weight of single floret (0.003), floret diameter (0.001) and plant height (0.001). Spike length influenced yield per m^2 indirectly and positively through weight of florets per plant (0.370), rachis length (0.030) and number of spike per plant (0.003). These findings are in accordance with the observations of Vanlalruati and Pradhan (2013) in tuberose.

Rachis length influenced yield per m^2 indirectly and positively through weight of florets per plant (0.874), number of spikes per plant (0.002) and floret length (0.001). Floret length influenced yield per m^2 indirectly and positively through weight of florets per plant (0.433), rachis length (0.016) and floret diameter (0.002). These findings are in concurrence with those of Ranchana *et al.* (2015) in tuberose.

Floret diameter influenced yield per m^2 indirectly and positively through weight of florets per plant (0.518), rachis length (0.007) and floret length (0.001), while, weight of single floret influenced yield per m^2 indirectly and positively through weight of florets per plant (0.785), rachis length (0.038), number of spike per plant (0.005), number of leaves (0.004), leaf width (0.003) and floret diameter (0.001). Similar findings were also reported by Vetrivel (2010) and Prabhat *et al.* (2011) in gladiolus.

Number of florets per spike influenced yield per m^2 indirectly and positively through weight of florets per plant (0.892), rachis length (0.049), number of spike per plant (0.005), floret length (0.001) and floret diameter (0.001), whereas it influenced yield per m^2 indirectly and positively through rachis length (0.043), leaf width (0.001), floret length (0.001) and floret diameter (0.001). These results are in accordance with those of Prabhat *et al.,* (2011) in gladiolus. In the present study, the residual effect 0.031 in F_1 progenies indicates that the chosen characters for the path analysis are appropriate.

Yield per m^2 was also positively correlated with leaf width, weight of florets/plant, rachis length, floret length and floret diameter. On the basis of path analysis, weight of florets per plant had the highest positive direct effect on yield.

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