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Path coefficient analysis for flower quality traits of gerbera (*Gerbera jamesonii* L.) genotypes

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Abstract
Path coefficient analysis were studied in ten diverse genotypes of gerbera for twenty characters under naturally ventilated polyhouse conditions during 2015-2016, Horticulture University, Hyderabad. Path analysis showed that days taken for first-flower opening showed the maximum direct effect and positive impact on number of flowers per plant followed by leaf area, number of ray florets, flower stalk length, leaves produced per plant, fresh ness of fresh weight of flower, number of suckers per plant, chlorophyll content, flowering duration, flower stalk diameter and longevity of cut flower come out as salient features of gerbera cut glower yield in the current study. The residual effects appeared to be quite low magnitude which indicated that the characters included in this trail explained almost all variability towards flower yield.

Keywords: Path coefficient, gerbera, cut flower yield

Introduction
African daisy (*Gerbera jamesonii* L) is an important cut flower, suitable for both export and domestic purposes. It occupies fifth rank in the world for cut flower production, they come behind roses, carnations, chrysanthemums, and tulips. Gerbera produces gorgeous flowers known as capitulum or head. The plants are tender perennial herbs and an ornamental plant. Leaves are tongue-shaped, 10-inch-long leaves cluster around the tall flower stalks that each bear a single daisy. The foliage has a coarse texture and is deeply lobed or wavy on the edges and arranged in a rosette fashion at the base. Gerbera is stunning flower of enormous value in cut flower industry due to tremendous variability and wide range of colours red, yellow, terracotta, yellow, maroon, orange, salmon peach, cream, scarlet, white, brick red, pink and different other intermediate shades. Gerbera is very trendy and extensively used as cut flowers or decorative garden flower. Gerbera blossoms can be a focal point or add mass to a floral design. These cut-flowers are highly used in display bouquets and arrangement of flowers and mostly apt for borders, growing beds and pot culture. Gerberas are in huge demand for interior decoration as its cut blooms are remain fresh usually 10-15 days.
Path coefficient analysis is employed to measure the direct and indirect effect of variables on yield. Yield is dependent variable not only by the interrelationship of associated characters but also changes in any trait could affect the whole cause and effect relationship.
Gerbera is a major flower crop but very bit information is available on its genetic potential for yield and yield contributing characters. Therefore, the present efforts were made investigate and to know interrelationship and association of twenty characters and to understand the nature of direct and indirect effect of these characters on yield.

Material and Methods
Ten genotypes were collected from KF bio plants. The experiment was undertaken in Randomized Block Design replicated thrice during 2015-2016 at Horticulture University, Hyderabad. Each genotype was represented by two rows on the either side of the bed with 45 cm height, 75 cm base at a spacing of 30 cm. The crop was raised carefully till the final harvest as per the recommended package of practices. The parameters were noted at various crop growth stages from randomly selected five plants from each genotype for height of plants, leaves produced per plant, leaf length, leaf breadth, leaf area, leaf area index, number of suckers plants, chlorophyll content, days to first flowering, days taken for 50% flowering, flowering duration, flower size (diameter), flower stalk diameter, flower stalk length, ray florets, disc diameter, longevity of spike (field life), number of flowers per plant, fresh ness of fresh weight and dry weight of flower.

Path coefficient analysis expressed direct and indirect effect of all studied character on cut flower yield. The dependent and independent variables was worked out by the calculation of direct effect, indirect effect and calculation of residual effects. These effects were calculating by employing the method suggested by Wright (1921) [8] and as elaborated by Dewey and Lu (1959) [1]

Results and Discussion

Yield is a complex character and selection for yield and yield components deserves considerable attention.

A crop breeding programme, aimed at increasing the plant productivity requires consideration not only of yield but also of its components that have direct or indirect bearing on yield.

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The results indicated that direct effects on genotypes is higher than phenotypes for most of the characters because of strong, inherent association between various characters under naturally ventilated polyhouse conditions. In few cases, phenotypic and genotypic effects were very close, showing slight influence of environment.

The best causal factors accounted to variability of dependent factor which determined by the residual effect. In the present experiment residual effects are 0.1864 and 0.311 at phenotypic and genotypic levels respectively recommending that most of the characters contributing to variability were included in the study.

The direct effects of the different characters on number of flowers per plant were presented on table 1 at the phenotypic and genotypic levels, respectively.

At genotypic path analysis, showed direct effect which were positive on days to first flowering (1.976) on number of flowers per plant followed by leaf area (0.8600), number of ray florets (0.6080), flower stalk length (0.5841), leaves per plant (0.4315), fresh weight flower (0.3884), suckers per plant (0.3381), chlorophyll content (0.2687), flowering duration (0.2622), flower stalk diameter (0.1798) and field life (0.0514). The other direct effect which was negatively impacted with leaf area index (-0.9090) followed by duration of 50% flowering (-0.6413), dry weight of flower (-0.0983) and flower diameter (-0.0324), at both levels under this trial.

Plant height showed positive direct effect at phenotypic and significantly negative direct effect at genotypic on number of flowers. If direct effect is low and negative, positive correlation might have resulted due to indirect positive effects. Leaves per plant, leaf area, suckers per plant registered positive direct effect and significant correlation with number of flowers per plant at both levels whereas leaf area index showed negative direct effect and significantly positive with number of flowers per plant at both levels. Similar kind of results was obtained by Maji and Dastidar (2005) and Nair and Shiva (2003) [3, 6] in gerbera and Misra *et al*. (2013) [5] in chrysanthemum.

Among vegetative traits like leaf area (0.8600) exerted maximum direct effect on number of flower yield via plant height, leaf length and breadth, leaves per plant, number of suckers, chlorophyll content, LAI followed by leaves per plant (0.4315), suckers per plant (0.3381) and chlorophyll content (0.2687). The same results were reported by Magar *et al.* (2010) in gerbera where leaf area had highest direct effect on number of flowers per plant.

Similarly, flower traits like days required to first-flower opening, flower stalk length, number of ray florets and stalk diameter showed positive direct effect and positive significant correlation with flower yield per plant at both the levels while flower diameter, days to 50% flowering and dry weight of flower exhibited negative impact and significant correlation with number of flowers per plant at both levels while disc diameter expressed negative direct effect at genotypic level.

The days required for first flower opening (1.1976) had positive direct effect on number of flowers per plant with positive indirect effect to days to 50% flowering (1.1813). The following direct effect on flower yield impacted by number of ray florets (0.6080). The trait had the highest indirect effect via flower stalk diameter, flower diameter, disc diameter, duration of flowering, fresh weight and dry weight of flower. As a result of restricted simultaneous selection model is to be followed *i.e.,* restrictions are to be imposed to nullify the undesirable indirect effects in order to make use of the direct effect (Singh and Chaudhary, 1977) [7].

Table 1: Direct and indirect effects of various flowering traits on flowers yield in ten genotypes of Gerbera

Characters		PH	LL	LB	LP	LA	LAI	SP	CH	DFO	FD	FSD	LFS	NRF	DD	DFF	DF	FL	FW	DW	NFP
Plant height	P	0.0930	0.0691	0.0550	0.0540	0.0596	0.0597	0.0410	0.0323	-0.0517	0.0583	0.0332	0.0446	0.0244	0.0428	-0.0365	0.0605	0.0351	0.0472	0.0470	0.6337**
	G	-0.0414	-0.0385	-0.0381	-0.0285	-0.0334	-0.0335	-0.0245	-0.0175	0.0312	-0.0407	-0.0300	-0.0287	-0.0145	-0.0344	0.0272	-0.0288	-0.0300	-0.0269	-0.0232	0.7756**
Leaf length	P	-0.0854	-0.1156	-0.0745	-0.0762	-0.0970	-0.0971	-0.0583	-0.0470	0.0670	-0.0583	-0.0377	-0.0682	-0.0070	-0.0534	0.0499	-0.0677	-0.0550	-0.0672	-0.0577	0.6004**
	G	-0.0214	-0.0227	-0.0248	-0.0194	-0.0224	-0.0225	-0.0072	-0.0085	0.0166	-0.0170	-0.0102	-0.0207	-0.0011	-0.0154	0.0135	-0.0170	-0.0132	-0.0177	-0.0162	0.6849**
Leaf breadth	P	0.0133	0.0144	0.0224	0.0121	0.0145	0.0145	0.0001	0.0036	-0.0083	0.0091	0.0026	0.0102	0.0003	0.0081	-0.0051	0.0076	0.0050	0.0084	0.0050	0.3019*
	G	0.162	0.191	0.174	0.148	0.169	0.169	0.035	0.070	-0.0767	0.09	0.044	0.118	0.003	0.076	-0.0494	0.07	0.056	0.078	0.066	0.4412*

		8	1	3	0	3	7	2	6		07	1	7	5	7		34	3	9	6	*
Leaves/ plant	P	0.0672	0.0759	0.0621	0.1151	0.0780	0.0783	0.0308	0.0411	-0.0460	0.0285	0.0051	0.0533	-0.0163	0.0620	-0.0395	0.0467	0.0253	0.0447	0.0438	0.4040**
	G	0.3012	0.3695	0.3664	0.4315	0.3114	0.3128	0.1600	0.2315	-0.1848	0.1625	0.0241	0.2325	-0.0599	0.3519	-0.1774	0.1713	0.2157	0.1887	0.1843	0.4767**
Leaf Area	P	0.5953	0.7868	0.8133	0.5548	0.7432	0.2954	0.3837	0.3878	-0.3079	0.1556	0.7570	-0.2139	0.2639	0.4767	-0.4557	0.5463	0.4826	0.5953	0.7868	0.6481**
	G	0.8854	0.9156	0.9982	0.9609	0.8600	0.5846	0.6182	0.6879	-0.6640	0.5292	0.3157	0.7864	-0.3820	0.4666	-0.7022	0.8489	0.7249	0.8698	0.7570	0.6800**
LAI	P	-0.5137	-0.7213	-0.6265	-0.5824	-0.8600	-0.8706	-0.3249	-0.4274	0.3455	-0.2901	-0.1556	-0.6677	0.2288	-0.2909	0.3803	-0.4426	-0.4021	-0.4689	-0.4082	0.6470**
	G	-0.7518	-0.9589	-0.9697	-0.8291	-0.9892	-0.9090	-0.5864	-0.6154	0.6848	-0.5845	-0.4543	-0.8761	0.4587	-0.3012	-0.5248	-0.6112	-0.5498	-0.6854	-0.6845	0.6803**
Suckers/ plant	P	0.0676	0.0769	0.0008	0.0408	0.0757	0.0756	0.1524	0.0924	-0.1082	0.0636	0.0772	0.0632	0.0087	0.0687	-0.1110	0.1045	0.1075	0.0930	0.0927	0.7537**
	G	0.2033	0.1081	0.0683	0.1254	0.1871	0.1868	0.3381	0.2606	-0.3128	0.2469	0.2658	0.2344	0.0108	0.2548	-0.3553	0.3382	0.3691	0.3060	0.3426	0.9899**
Chlorophyll	P	0.0740	0.0862	0.0342	0.0756	0.1083	0.1085	0.1286	0.2120	-0.1269	0.0449	0.0428	0.0862	-0.0246	0.0773	-0.1320	0.1059	0.1357	0.0905	0.0986	0.6203**
	G	0.1151	0.1012	0.1088	0.1441	0.1515	0.1521	0.2071	0.2687	-0.2318	0.0864	0.1503	0.1402	-0.0382	0.1549	-0.2631	0.1764	0.2286	0.1887	0.1880	0.7113**
First flowering	P	-0.2239	-0.2322	-0.1479	-0.1602	-0.2671	-0.2669	-0.2844	-0.2398	0.4006	-0.2639	-0.2663	-0.2555	-0.0816	-0.1983	0.3656	-0.3507	-0.2962	-0.3403	-0.2936	-0.8568**
	G	-0.9154	-0.8790	-0.5269	-0.5130	-0.8604	-0.8591	-1.1077	-1.0331	1.1976	-0.9147	-0.9787	-0.8602	-0.2368	-0.7786	1.1813	-1.1697	-1.1912	-1.0878	-1.1400	-0.9761**
Flower diameter	P	-0.1230	-0.0984	-0.0795	-0.0483	-0.0862	-0.0865	-0.0815	-0.0414	0.1286	-0.1952	-0.1355	-0.0779	-0.0980	-0.1349	0.1095	-0.1259	-0.1149	-0.1210	-0.1046	0.6550**
	G	-0.0323	-0.0244	-0.0169	-0.0122	-0.0179	-0.0179	-0.0237	-0.0104	0.0247	-0.0324	-0.0318	-0.0153	-0.0198	-0.0243	0.0198	-0.0289	-0.0220	-0.0253	-0.0254	0.8649**

PH = Plant height (cm)
LL = Leaf length (cm)
LB = Leaf breadth (cm)
LP = Leaves per plant
LA = Leaf area (cm^2)
LAI = Leaf area index
NSP = Suckers per plant
CH = Chlorophyll content
DFO = Days taken to first-flower opening
FD = Flower diameter (cm)
FSD = Flower stalk diameter (mm)
LFS = Flower stalk length (cm)
NRF = Number of ray florets
DD = Disc diameter (cm)
DFF = Days to 50% flowering (Days)
FS = Flowering duration (Days)
FL = Field life (Days)
FWP = Fresh weight of flower (g)
DWP = Dry weight of flower (g)
NFP =Number of flowers per plant

Table 1: contd…

Characters		PH	LL	LB	NLP	LA	LAI	NSP	CH	DFO	FD	FSD	LFS	NRF	DD	DFF	DF	FL	FW	DW	NFP
Stalk Diameter	P	0.0521	0.0473	0.0170	0.0064	0.0456	0.0457	0.0735	0.0293	-0.0965	0.1007	0.1451	0.0263	0.0835	0.0685	-0.0951	0.0947	0.0730	0.0957	0.0813	0.7129**
	G	0.1324	0.0812	0.0455	0.0100	0.0670	0.0669	0.1413	0.1006	-0.1469	0.1766	0.1798	0.0561	0.1298	0.1177	-0.1349	0.1683	0.1323	0.1552	0.1656	0.9334**
Stalk Length	P	0.0969	0.1186	0.0917	0.0931	0.1650	0.1648	0.0834	0.0817	-0.1282	0.0802	0.0365	0.2010	-0.0714	0.0657	-0.1097	0.1234	0.1287	0.1229	0.0991	0.5511**
	G	0.4113	0.5335	0.3975	0.3148	0.5264	0.5255	0.4048	0.3048	-0.4195	0.2763	0.1824	0.5841	-0.2211	0.2262	-0.3644	0.4176	0.4717	0.4317	0.4408	0.5945**
Ray Florets	P	0.1088	0.0252	0.0062	-0.0584	-0.0749	-0.0743	0.0236	-0.0479	-0.0842	0.2075	0.2376	-0.1468	0.4132	0.0735	-0.0575	0.0857	-0.0280	0.0585	0.0494	0.3087**
	G	0.2156	0.0305	0.0123	-0.0844	-0.1140	-0.1131	0.0194	-0.0865	-0.1202	0.3713	0.4392	-0.2302	0.6080	0.1662	-0.0828	0.1503	-0.0717	0.0988	0.0848	0.3527*
Disc Diameter	P	0.0347	0.0347	0.0272	0.0404	0.0292	0.0294	0.0338	0.0273	-0.037	0.0518	0.0354	0.0245	0.0133	0.0750	-0.041	0.0390	0.0467	0.0408	0.0340	0.6182**

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	G	-0.1921	-0.1543	-0.1002	-0.1857	-0.1261	-0.1269	-0.1716	-0.1312	0.1480	-0.1708	-0.1491	-0.0882	-0.0622	0.2277	0.1289	-0.1747	-0.1547	-0.1685	-0.1987	0.7606**
50% Flowering	P	0.0690	0.0755	0.0395	0.0599	0.0990	0.0990	0.1274	0.1088	-0.1596	0.0981	0.1146	0.0954	0.0243	0.0973	-0.1748	0.1414	0.1337	0.1349	0.1244	-0.8382**
	G	0.4272	0.3809	0.1819	0.2637	0.4163	0.4154	0.6739	0.6280	-0.6326	0.3927	0.4812	0.4001	0.0874	0.3631	-0.6413	0.6177	0.6280	0.5742	0.6174	-0.9931**
Flowering Duration	P	0.1818	0.1628	0.0948	0.1127	0.1864	0.1860	0.1906	0.1390	-0.2435	0.1794	0.1814	0.1708	0.0577	0.1446	-0.2249	0.2782	0.1844	0.2425	0.2380	0.8967**
	G	0.1854	0.1962	0.1105	0.1041	0.1934	0.1931	0.2623	0.1722	-0.2561	0.2336	0.2455	0.1875	0.0648	0.2012	-0.2526	0.2622	0.2726	0.2669	0.2689	1.0005**
Field life	P	0.0742	0.0931	0.0434	0.0429	0.1057	0.1057	0.1380	0.1252	-0.1447	0.1151	0.0984	0.1253	-0.0133	0.1217	-0.1496	0.1297	0.1957	0.1285	0.1038	0.7474**
	G	0.0379	0.0301	0.0166	0.0257	0.0379	0.0379	0.0561	0.0437	-0.0511	0.0350	0.0378	0.0415	-0.0061	0.0349	-0.0503	0.0534	0.0514	0.0500	0.0571	0.9023**
Fresh Weight	P	0.1321	0.1506	0.0972	0.1006	0.1728	0.1726	0.1580	0.1106	-0.2201	0.1606	0.1709	0.1584	0.0367	0.1410	-0.2000	0.2259	0.1702	0.2591	0.2163	0.8316**
	G	0.2566	0.3034	0.1758	0.1699	0.3093	0.3089	0.3515	0.2728	-0.3528	0.3030	0.3353	0.2871	0.0631	0.2875	-0.3478	0.3953	0.3779	0.3884	0.4227	0.9620**
Dry Weight	P	-0.0452	-0.0445	-0.0197	-0.0339	-0.0530	-0.0529	-0.0542	-0.0414	0.0653	-0.0477	-0.0499	-0.0439	-0.0106	-0.0403	0.0634	-0.0762	-0.0473	-0.0743	-0.0891	0.7409**
	G	-0.0560	-0.0702	-0.0376	-0.0420	-0.0732	-0.0730	-0.0996	-0.0688	0.0936	-0.0772	-0.0906	-0.0742	-0.0137	-0.0858	0.0946	-0.1008	-0.1092	-0.1070	-0.0983	1.0355**

Residual effect: 0.311 (G) and 0.1864 (P)

Conclusion

Path coefficient analysis revealed that yield characters like leaves per plant, leaf area, chlorophyll content, suckers per plant, days to first flower opening, duration of flowering, number of ray florets, length of flower stalk, flower stalk diameter, field life and fresh weight of flower are contributing directly to number of flowers per plant and selection based on these characters would help in getting enhanced flower yield.

Finally, it can be understood from the path analysis of the flower yield that number of suckers per plant, chlorophyll content, days to first flower opening, flower stalk length, stalk diameter and field life have indirectly contributed for flower yield in gerbera genotypes. Hence selection for these traits will be helpful in increasing cut flower yield in gerbera genotypes.

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Conflict of Interest Statement

The authors declare that they don't have conflict of interest.

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