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Gene effects on vegetative and floral characters of gerbera (*Gerbera jamesonii* L) Under Naturally ventilated polyhouse conditions

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Abstract
A polyhouse experiment was conducted for ten diverse genotypes of gerbera for twenty characters in Randomized Block Design with three replications at College of Horticulture, SKLTSHU, Hyderabad. Path analysis revealed that days to first-flower opening (1.976) exerted the highest positive direct effect on number of flowers per plant followed by, leaf area (0.8600), number of ray florets (0.6080) and length of the flower stalk (0.5841), number of leaves per plant (0.4315), fresh weight of flower (0.3884), number of suckers per plant (0.3381), chlorophyll content (0.2687), duration of flowering (0.2622), flower stalk diameter (0.1798) and field life (0.0514) at genotypic level indicating that the selection for these characters was likely to bring about an overall improvement in yield of gerbera cut flowers.

Keywords: Gerbera, gene effects, path analysis, floral characters, polyhouse

Introduction
Gerbera (*Gerbera jamesonii* L.) An evergreen and herbaceous blooming cut flower of family Asteraceae, is commonly known as Transvaal daisy, Barberton daisy or African daisy. Gerbera is an elegant flower of immense value in floriculture trade due to tremendous variability in flower colour, shape and sizes. It holds an esteemed position among the top ten cut flowers across the world and according to global trends in floriculture, it produces very attractive flowers, having single, semi double and double types of flowers. Gerbera is very fashionable and widely used as decorative garden flower or cut flowers (Kanwar *et al.*, 2008) [2]. These cut-flowers are widely used in bouquets and flower arrangement and highly suitable for growing beds, borders and pots. Gerberas are in great demand for presentation and interior decoration as its cut blooms remain fresh at least for a week. Plant breeder has done a wonderful job of creating outstanding flower shades, including red, white, rose, pink, and various bicolor forms and presented doubles and semi double blooming forms, adding to the beauty of this place.
Path coefficient analysis is a standardized regression coefficient and measures the direct influence of one variable upon the other. Direct selection for yield is not a reliable approach since it is influenced by the environment. Therefore, it is essential to identify the component characters through which yield can be improved. Keeping in view the importance of aforesaid aspects, the present investigation was planned.

Materials and Methods
The present investigation was carried out during the year 2015 -2016 at College of Horticulture, SKLTSHU, Hyderabad. Healthy tissue culture plants of ten genotypes of gerbera *viz*., Balance, Stanza, Savannah, Dana Ellen, Goliath, Prime rose, Helix, Liberty, Sabrina and Montenegro were planted in raised beds of 45 cm height, 75 cm base and 60 cm top at a spacing of 30 x 30 cm in two rows in randomized block design with three replications. The recommended package of practices were adopted besides providing necessary prophylactic plant protection measures to raise a good crop. Five randomly selected plants of each replication and observations were recorded from one month after transplanting up to 12 months. The traits studied on various parameters of vegetative growth, flowering, yield and quality as per genotypes.

The direct and indirect effects both at genotypic and phenotypic levels were estimated by taking number of flowers as dependent variable, using path coefficient analysis suggested by Wright (1921) [8] and Dewey and Lu (1959) [1].

Results and Discussion

These findings indicate that though there is a strong, inherent association between various characters, direct effect due to genotypes is higher than phenotypes for most of the characters under controlled conditions. In some cases, phenotypic and genotypic effects were very close, indicating less influence of environment.

The residual effect determines how best the causal factors account for the variability of the dependent factor. In the present investigation residual effects at phenotypic and genotypic levels are 0.1864 and 0.311 respectively suggesting that most of the characters contributing to variability were included in the study.

The direct and indirect effects of the different characters on number of flowers per plant were presented on table 1 at the phenotypic and genotypic levels, respectively. The positive direct effects of independent characters *viz*. days to first-flower opening (1.976) had highest direct effect on number of flowers per plant followed by leaf area (0.8600), number of ray florets (0.6080) and length of the flower stalk (0.5841), number of leaves per plant (0.4315), fresh weight flower (0.3884), number of suckers per plant (0.3381), chlorophyll content (0.2687), duration of flowering (0.2622), flower stalk diameter (0.1798) and field life (0.0514) were derived from the genotypic path analysis. On the other hand, number of flowers per plant was directly and negatively affected 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 Hyderabad conditions.

Plant height recorded significantly negative direct genotypic effect and positive significant phenotypic effect with number of flowers per plant. Though direct effect is negative and low, positive correlation might have resulted due to weighing positive indirect effects. Number of leaves, leaf area, number of suckers recorded positive direct effect and significant correlation with number of flowers per plant at both levels while leaf area index had negative direct effect and positive significant correlation with number of flowers per plant at both level. Nair and Shiva (2003) [6], Maji and Dastidar (2005) [3] in gerbera and Misra *et al*. (2013) [5] in chrysanthemum also observed direct effect of number of leaves on yield of flowers per plant in positive direction but at both phenotypic and genotypic levels.

However, The vegetative characters like leaf area (0.8600) showed maximum direct effect on number of flowers per plant via plant height, leaf length and breadth, number of leaves, number of suckers, chlorophyll content, LAI followed by number of leaves per plant (0.4315), number of suckers per plant (0.3381) and chlorophyll content (0.2687). Similar results reported by Magar *et al.* (2010) [4] in gerbera where leaf area exhibited high direct effect on number of flowers per plant.

In case of floral characters days to first-flower opening, number of ray florets and length of the flower stalk and stalk diameter exhibited 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 direct effect and significant correlation with number of flowers per plant at both levels while disc diameter has recorded negative direct effect at genotypic level.

The days to 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). Number of ray florets (0.6080) had next direct effect on flower yield. This trait had the highest indirect effect via flower stalk diameter, flower diameter, disc diameter, duration of flowering, fresh weight and dry weight of flower. Under these circumstances, a 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 (bold) and indirect effects of different traits on yield of flowers per plant in Gerbera

variables		PH	LL	LB	NLP	LA	LAI	NSP	CH	DFO	FD	FSD	LFS	NRF	DD	DFF	DF	FL	FW	DW	NFP
PH	P	0.0925	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	-0.0408	-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**
LL	P	-0.0863	-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**
LB	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	0.1628	0.1911	0.1743	0.1480	0.1693	0.1697	0.0352	0.0706	-0.0767	0.0907	0.0441	0.1187	0.0035	0.0767	-0.0494	0.0734	0.0563	0.0789	0.0666	0.4412**
NLP	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**
LA	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**
NSP	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**
CH	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**
DFO	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**
FD	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**

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

Table 1: contd…

Variables		PH	LL	LB	NLP	LA	LAI	NSP	CH	DFO	FD	FSD	LFS	NRF	DD	DFF	DF	FL	FW	DW	NFP
FSD	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**
LFS	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**
NRF	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*
DD	P	0.0347	0.0347	0.0272	0.0404	0.0292	0.0294	0.0338	0.0273	-0.0371	0.0518	0.0354	0.0245	0.0133	0.0750	-0.0418	0.0390	0.0467	0.0408	0.0340	0.6182**
	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**
DFF	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**
DF	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**
FL	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**
FWF	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**
DWF	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**

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

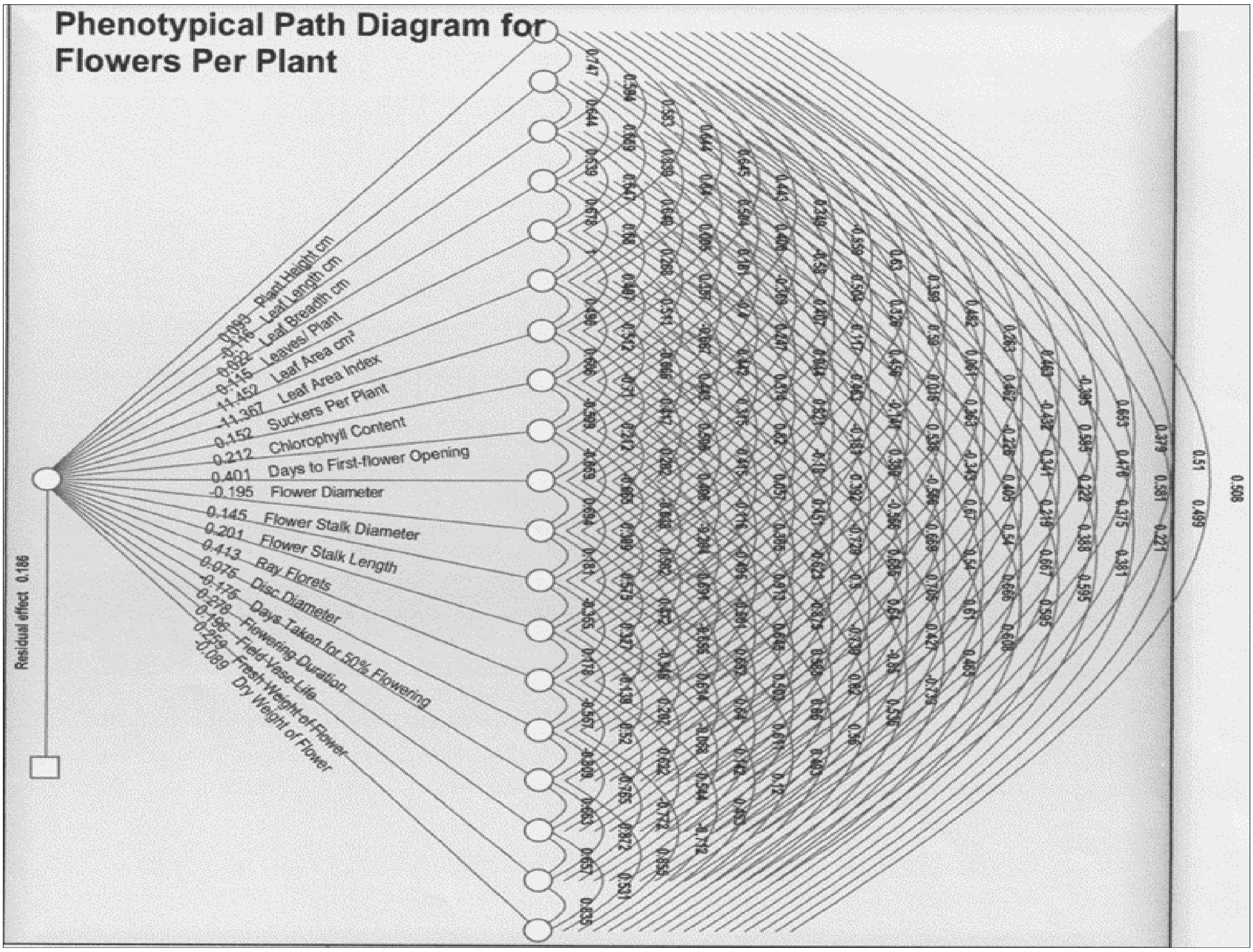

Fig 1: Phenotypical path diagram for flowers per plant

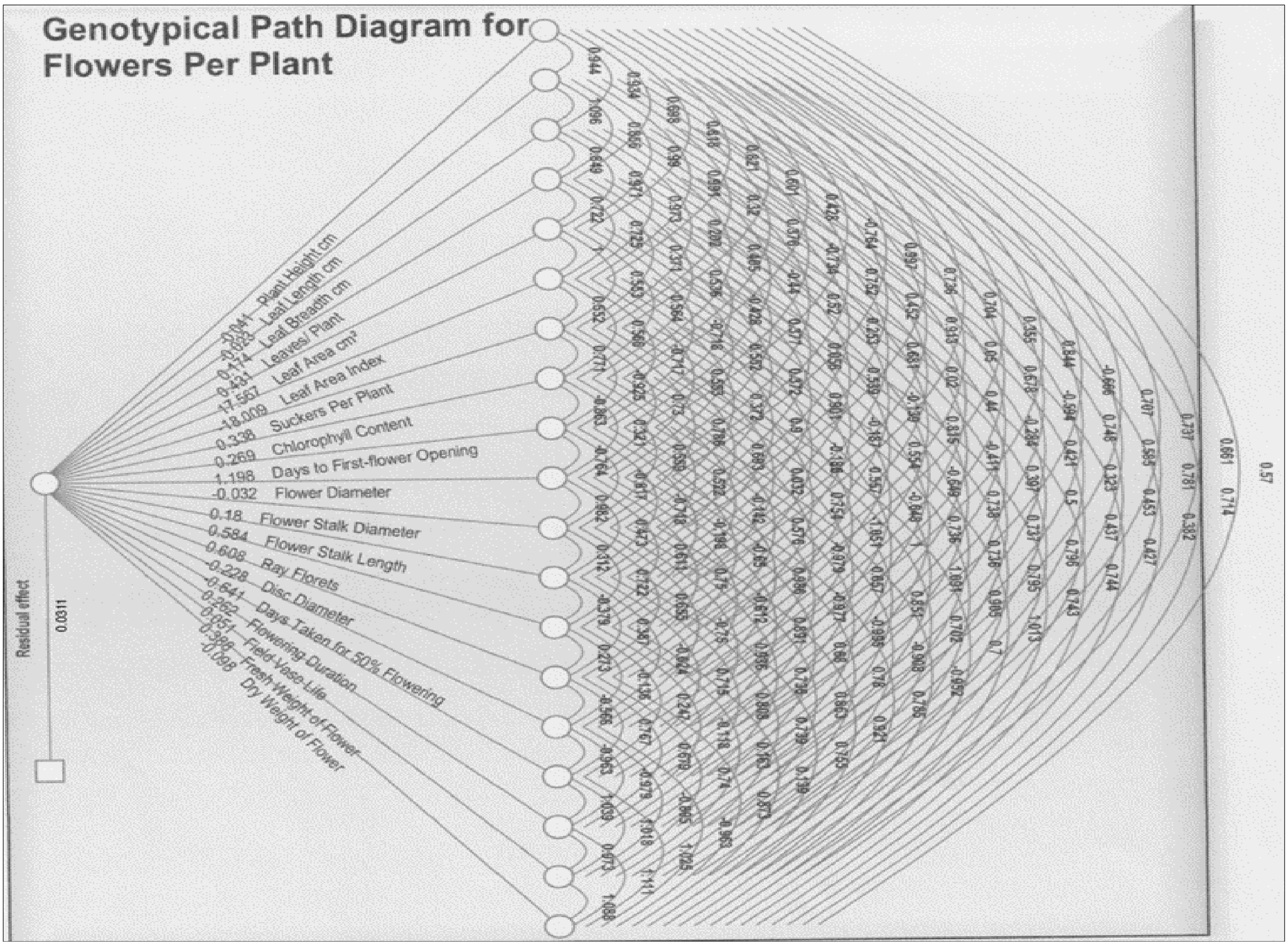

Fig 2: Genotypiccal path diagram for flowers per plant

Conclusion

From the path analysis studies it is evident that the characters leaf area, number of ray florets**,** days to first flower opening**,** duration of flowering, fresh weight of flower**,** chlorophyll content**,** length of flower stalk**,** field life**,** number of suckers per plant, flower stalk diameter and number of leaves per plant are directly contributing to number of flowers per plant and selection based on these traits would help in getting increased flower yield.

In general, It can be understood from the results of 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 enhancing cut flower yield in gerbera genotypes.

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