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Correlation and Path Coefficient Analysis in Cut Flower Anthurium

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ABSTRACT

Genotypic and phenotypic correlation coefficients and path coefficient analysis were carried out in the anthurium using 14 cultivars for 22 characters. The estimate of genotypic correlation coefficient was higher than the corresponding phenotypic correlation coefficient both for vegetative and floral characters. Among the vegetative characters, total number of leaves per plant had high positive direct effect on the number of suckers per plant. Path-coefficient analysis at genotypic level revealed that total number of leaves per plant and leaf fresh weight had a high positive direct effect on sucker production. Among the floral characters, spadix length, spadix diameter, peduncle thickness, peduncle length, spathe length and spathe width had a positive association with number of flowers per plant. In path analysis, peduncle thickness, weeks taken for vegetative growth, days to flower opening and spathe width had positive direct effects on flower yield per plant. Hence, a selection index comprising the characters like total number of leaves per plant, leaf fresh weight, juvenile phase, plant spread on sucker yield and characters like peduncle thickness, weeks taken for vegetative growth, days to flower opening and spathe width on flower yield can be considered highly dependable and reliable characters for selection to improve yield in anthurium. The trait number of flowers per plant was significantly and negatively correlated with number of suckers per plant.

Key words : Anthurium, Genotypic correlation coefficient, Path- coefficient analysis, Phenotypic correlation coefficient.

Yield of crop is influenced by genotype and its interaction with environment in which the crop is grown. Anthuriums have distinctive features of morphologically diverse and taxonomically one (Croat,1980). The growing temperature had negative correlation with flower morphology, color, carbohydrate content of spathes of flowers (Derming, 2011). Direct selection for complex traits like sucker and flower yield in anthurium is often not very effective and indirect selection for some of the component traits associated with it may be rewarding. Hence, a desirable approach towards the improvement of yield is possible through selection of desirable yield components. The nature and degree of association between yield and its components claims distinct importance and will assist the breeder to ascertain the actual yield components and furnish an effective basis of phenotypic selection. Path- coefficient analysis provides the intrinsic nature of observed association between yield and its attributes and reveals the extent of contribution made by various traits in constructing yield. Path–analysis facilitates the partitioning of correlation coefficient into the direct and indirect effects on yield and other important characters. Hence, the present investigations were undertaken to find out the interrelationship among the components responsible for yield and the direct and indirect influences of each component characters towards the production of sucker and flower in anthurium.

MATERIAL AND METHODS

The research project on screening of Anthurium (*Anthurium andraeanum* Lind) genotypes of standard cut flower varieties for commercial cut flower production was conducted under Cost effective, Hi-Tech cultivation, open-ended hydroponic system under 75 per cent shade net house at College of Horticulture and Forestry, Central Agricultural University, pasighat East Siang District of Arunachal Pradesh during 2006 to 2009 in State –of – the art – Technology designed structure with hi tech irrigation systems i.e. Drip

Table 1. Genotypic and Phenotypic correlation coefficient for vegetative characters in anthurium

Character		Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf Area (cm^2)	Petiole length (cm)	Petiole thickness (mm)	No. of leaves / mother plant	Total no of leaves / plant	Leaf fresh weight (g)	Leaf dry weight (g)	Plant spread (cm)	No. of suckers/ plant
Plant height (cm)	G	**1.0000**	0.5265	0.5339	0.6514	0.7789	0.7059	0.1164	0.2329	0.7006	0.6686	0.5649	**0.0647**
	P	**1.0000**	0.5237***	0.5311***	0.6494***	0.7767***	0.7023	-0.0602	0.2299	0.6988***	0.6670***	0.5617***	**0.0597**
Leaf length (cm)	G		**1.0000**	0.8686	0.8592	0.6020	0.3557	0.0399	-0.1001	0.6114	0.6175	0.8945	**-0.2221**
	P		**1.0000**	0.8610***	0.8537***	0.5979***	0.3541*	-0.0288	-0.0981	0.6077***	0.6143***	0.8861***	**-0.2190**
Leaf width (cm)	G			**1.0000**	0.7302	0.6747	0.4536	-0.0628	-0.1689	0.6170	0.6049	0.8328	**-0.3083**
	P			**1.0000**	0.7285***	0.6724***	0.4541**	0.0542	-0.1686	0.6153***	0.6030***	0.8294***	**-0.3032**
Leaf Area (cm^2)	G				**1.0000**	0.6851	0.5131	-0.0615	-0.0275	0.8248	0.8119	0.7572	**-0.1548**
	P				**1.0000**	0.6848***	0.5123***	0.0247	-0.0273	0.8245***	0.8115***	0.7551***	**-0.1538**
Petiole length (cm)	G					**1.0000**	0.7592	0.0271	0.2104	0.6117	0.5903	0.6932	**0.0401**
	P					**1.0000**	0.7570***	-0.0126	0.2106	0.6115***	0.5900	0.6907	**0.0393**
Petiole thickness (mm)	G						**1.0000**	0.2403	0.4016	0.6159	0.6028	0.3155	**0.1841**
	P						**1.0000**	-0.0821	0.3990**	0.6143***	0.6013***	0.3159*	**0.1811**
No. of leaves / mother plant	G							**1.0000**	0.2109	-0.0245	-0.0270	-0.0355	**0.2324**
	P							**1.0000**	-0.0949	0.0021	0.0090	0.0113	**-0.0816**
Total no of leaves/plant	G								**1.0000**	-0.0577	-0.0306	0.0764	**0.9448**
	P								**1.0000**	-0.0573	-0.0308	0.0748	**0.9347**
Leaf fresh weight (g)	G									**1.0000**	0.9725	0.5832	**-0.2340**
	P									**1.0000**	0.9721***	0.5812***	**-0.2325**
Leaf dry weight (g)	G										**1.0000**	0.5817	**-0.2455**
	P										**1.0000**	0.5795***	**-0.2445**
Plant spread (cm)	G											**1.0000**	**-0.0345**
	P											**1.0000**	**-0.0371**
No. of suckers / plant	G												**1.0000**
	P												**1.0000**

irrigation system work based on gravitational force and misting system was operated twice daily to reduce temperature and maintain humidity in the growing environment. The observations were collected for the same genotypes from the amateur growers of Aizawl, Mizoram. The climatic conditions of north eastern hill region are highly congenial for large scale anthurium cultivation because of low to moderate temperature, very high rainfall of 540cm and its uniform distribution in about 8 – 10 months. Anthurium genotypes of sixty numbers (60) were collected from the growers, anthurium grower's cooperative societies, Aizawl, Mizoram and M/s. Zopar Agri exports Pvt. Ltd, Shillong, Meghalaya. The standard cut flower genotypes of 14varieties i.e., Esmeralda, Titicaca, Flame, Flymara, Akapana, Evita White, Evita Red, Daniella, Alexis, Isis, Ivory, Floriana, Yang and Elyze, which are micro-propagated, standard size plants (10-12cm), 8months old were collected from authorized supplier of Holland based Anthurium breeders. These varieties were grown in soilless open ended hydroponic system in three rows per bed, spaced at 30cm from plant to plant and row to row in a bed. The beds were lined with brick with width of 1.3 – 1.4m and length of 15-18m filled with lower layer of big stones, small stones, sand, coco-peat and perlite growing media of 20 - 25 cm thickness. The drippers and micro-sprinklers are laid in the flower beds, drippers are spaced at 30cm interval. The experiment was laid out in Completely Randomized Design (CRD) in three replications and 18 plants per replication. The anthurium plants were fed with water soluble nutrient formulations @200ppm per day in Tank A and Tank B on alternate days. The nutrients of Tank A (Nitrogen, phosphorus and potassium) fed to fertigation system on Monday, Wednesday and Friday and on the other days with Tank B nutrients which were predominantly micronutrients and Sunday was weekly off. The observations on vegetative growth and flower characters were recorded regularly at monthly intervals. The genotypic and phenotypic correlation coefficients were calculated as per methods given by Al-Jibouri *et al.*, 1958. The path-coefficients were obtained by following the methods of Dewey and Lu 1959.

RESULTS AND DISCUSSION

In general, the estimate of genotypic correlation coefficient was higher than the corresponding phenotypic correlation coefficient (Table1). This indicates a strong inherent association between different traits under study but phenotypic value is very slightly lessened by the significant influence of environment, thereby suggesting the usefulness of genotypic estimates. Similar findings were reported by Binodh *et al.,* (2004) and Siva and Nair (2008). Among the vegetative characters, number of suckers per plant exhibited significant positive correlation with total number of leaves per plant and also positively correlated with petiole thickness, petiole length and plant height. Binodh *et al.*, (2004) reported a positive significant association between suckering ability and leaf area in anthurium where as Siva and Nair (2008) found positive significant association of suckering with number of leaves per plant, leaf fresh weight and leaf area. The number of leaves on mother plant had positive genotypic correlation coefficient of 0.232 whereas the negative phenotypic correlation coefficient of 0.082 with suckers. The results revealed that these characters could be considered as major contributing traits towards number of suckers per plant in anthurium. Hence, for increasing sucker production, selection should be focussed on these associated characters viz, total number of leaves per plant, number of leaves on mother plant and petiole thickness. However, number of suckers per plant had negative correlation with leaf size i.e., leaf width and leaf length, leaf area, leaf fresh weight and plant spread indicating the independent nature of these characters. Highly significant and positive association was observed between other important traits, i.e., plant height with petiole length, petiole thickness, leaf fresh weight, leaf dry weight, leaf area, leaf size and plant spread; leaf length with leaf width, leaf area, plant spread, petiole length, leaf dry weight, and leaf fresh weight; leaf width with plant spread, leaf area, petiole length, leaf fresh and dry weight; leaf area with leaf fresh weight, leaf dry weight, plant spread, petiole length and petiole thickness; petiole length with petiole thickness, plant spread, leaf fresh weight and leaf

Table 2. Direct and Indirect effects for vegetative characters in anthurium

Character	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf Area (cm^2)	Petiole length (cm)	Petiole thickness (mm)	No. of leaves / mother plant	Total no of leaves / plant	Leaf fresh weight (g)	Leaf dry weight (g)	Plant spread (cm)	No. of suckers/ plant
Plant height (cm)	**-0.0334**	-0.0176	-0.0178	-0.0217	-0.0260	-0.0236	-0.0039	-0.0078	-0.0234	-0.0223	-0.0189	**0.0647**
Leaf length (cm)	-0.1780	**-0.3382**	-0.2937	-0.2906	-0.2036	-0.1203	-0.0135	0.0338	-0.2068	-0.2088	-0.3025	**-0.2221**
Leaf width (cm)	0.0629	0.1024	**0.1179**	0.0861	0.0795	0.0535	-0.0074	-0.0199	0.0727	0.0713	0.0982	**-0.3083**
Leaf Area (cm^2)	0.2445	0.3224	0.2741	**0.3753**	0.2571	0.1926	-0.0231	-0.0103	0.3095	0.3047	0.2842	**-0.1548**
Petiole length (cm)	-0.0248	-0.0191	-0.0215	-0.0218	**-0.0318**	-0.0241	-0.0009	-0.0067	-0.0195	-0.0188	-0.0220	**0.0401**
Petiole thickness (mm)	-0.1611	-0.0812	-0.1035	-0.1171	-0.1732	**-0.2282**	-0.0548	-0.0916	-0.1405	-0.1375	-0.0720	**0.1841**
No. of leaves / mother plant	0.0132	0.0045	-0.0071	-0.0070	0.0031	0.0273	**0.1138**	0.0240	-0.0028	-0.0031	-0.0040	**0.2324**
Total no of leaves/plant	0.2394	-0.1029	-0.1737	-0.0283	0.2163	0.4128	0.2168	**1.0279**	-0.0594	-0.0314	0.0785	**0.9448**
Leaf fresh weight (g)	0.3777	0.3297	0.3327	0.4447	0.3298	0.3321	-0.0132	-0.0311	**0.5392**	0.5243	0.3144	**-0.2340**
Leaf dry weight (g)	-0.5020	-0.4637	-0.4542	-0.6096	-0.4432	-0.4526	0.0203	0.0229	-0.7302	**-0.7508**	-0.4368	**-0.2455**
Plant spread (cm)	0.0262	0.0415	0.0386	0.0351	0.0322	0.0146	-0.0016	0.0035	0.0271	0.0270	**0.0464**	**-0.0345**
Partial R^2	-0.0022	0.0751	-0.0363	-0.0581	-0.0013	-0.0420	0.0264	0.9712	-0.1261	0.1843	-0.0016	

R SQUARE = 0.9894 RESIDUAL EFFECT = 0.1027

dry weight; Petiole thickness with leaf fresh weight, leaf dry weight; total number of leaves with number of suckers; leaf fresh weight with plant spread and leaf dry weight; leaf dry weight with plant spread. These results suggest strong inter-relationship among characters and there by aids in crop improvement.

Information on correlation alone is often misleading as the correlation observed may not be always true. The correlation of two characters shows only correlation because these characters are associated with a third common trait (Jaiswal and Gupta, 1967). It is necessary to estimate the causal relationship between the variables in addition to the degree of relationship. For this path analysis is the most reliable method, which provide direct and indirect association among the characters. A highly significant and positive association was observed between number of suckers per plant and total number of leaves per plant (Table 2). It is evident from the path analysis at genotypic level that total number of leaves, leaf fresh weight had the maximum and positive direct contribution towards number of suckers per plant and leaf area, there by suggesting their reliability in improving sucker production and indicated their importance in deciding the selection criteria. However, Leaf dry weight, leaf length and petiole thickness exhibited high and negative direct contribution towards number of suckers per plant followed by petiole length and plant height. The traits like total number of leaves on the plant, leaf width, leaf fresh weight, leaf area, number of leaves on mother plant and plant spread showed very high indirect effects on sucker production via leaf width and leaf fresh weight. Similarly, leaf dry weight, leaf length, leaf fresh weight, plant height and plant spread exhibited high indirect contribution towards sucker yield per plant through leaf area indicating the importance of these characters in breeding programme for improving the sucker yield.

Higher magnitude of genotypic correlation coefficient was noticed than the corresponding phenotypic correlation

Table 3. Genotypic and Phenotypic correlation coefficient for floral characters in anthurium.

Character		Spathe length (cm)	Spathe width (cm)	Spadix length (cm)	Spadix diameter (mm)	Peduncle (Stalk) length (cm)	Peduncle (Stalk) thickness (mm)	Flower opening from flower bud Initiation (Days)	Juvenile Phase (No of Standard weeks)	Shelf-life of flowers on the plant (days)	No of flowers/ plant
Spathe length (cm)	G	**1.0000**	0.9010	0.2374	0.5838	0.4077	0.4541	0.3714	-0.6689	-0.2008	**0.1906**
	P	**1.0000**	0.9004***	0.2364	0.5702***	0.4065**	0.4530**	0.3562*	-0.6646***	-0.1983	**0.1906**
Spathe width (cm)	G		**1.0000**	0.0748	0.5814	0.4979	0.6329	0.1596	-0.5928	-0.0360	**0.0726**
	P		**1.0000**	0.0753	0.5683***	0.4968***	0.6306***	0.1532	-0.5905***	-0.0344	**0.0722**
Spadix length (cm)	G			**1.0000**	0.6135	0.6331	0.1588	0.5271	-0.5594	-0.0162	**0.3233**
	P			**1.0000**	0.6037***	0.6292***	0.1562	0.4948*	-0.5559***	-0.0100	**0.3192**
Spadix diameter	G				**1.0000**	0.7391	0.7651	0.2718	-0.5547	0.1264	**0.2489**
(mm)	P				**1.0000**	0.7201***	0.7466***	0.2428	-0.5414***	0.1230	**0.2372**
Peduncle (Stalk)	G					**1.0000**	0.5521	0.4514	-0.4432	0.1315	**0.2042**
length (cm)	P					**1.0000**	0.5476***	0.4220***	-0.4399***	0.1318	**0.2036**
Peduncle (Stalk)	G						**1.0000**	-0.2726	-0.3432	0.3517	**0.2234**
thickness (mm)	P						**1.0000**	-0.2524	-0.3388*	0.3462*	**0.2225**
Flower opening	G							**1.0000**	-0.5321	-0.5646	**0.0612**
from flower bud	P							**1.0000**	-0.4926***	-0.5249***	**0.0615**
Initiation (Days)											
Juvenile Phase (No.	G								**1.0000**	0.3740	**-0.1841**
of Standard weeks)	P								**1.0000**	0.3689*	**-0.1824**
Shelf-life of flowers	G									**1.0000**	**-0.1892**
on the plant (days)	P									**1.0000**	**-0.1875**
No. of flowers/	G										**1.0000**
plant	P										**1.0000**

Table 4. Direct and Indirect effects for floral characters in anthurium.

Character	Spathe length (cm)	Spathe width (cm)	Spadix length (cm)	Spadix diameter (mm)	Peduncle (Stalk) length (cm)	Peduncle (Stalk) thickness (mm)	Flower opening from flower bud Initiation (Days)	Juvenile Phase (No of Standard weeks)	Shelf-life of flowers on the plant (days)	No of flowers/ plant
Spathe length (cm)	**-0.2452**	-0.2209	-0.0582	-0.1431	-0.0999	-0.1113	-0.0910	0.1640	0.0492	**0.1906**
Spathe width (cm)	0.7884	**0.8750**	0.0655	0.5088	0.4357	0.5538	0.1397	-0.5187	-0.0315	**0.0726**
Spadix length (cm)	0.5095	0.1606	**2.1459**	1.3164	1.3585	0.3408	1.1311	-1.2005	-0.0349	**0.3233**
Spadix diameter (mm)	-1.1940	-1.1892	-1.2546	**-2.0452**	-1.5116	-1.5647	-0.5558	1.1344	-0.2585	**0.2489**
Peduncle (Stalk) length (cm)	-0.6170	-0.7537	-0.9582	-1.1186	**-1.5135**	-0.8357	-0.6831	0.6708	-0.1990	**0.2042**
Peduncle (Stalk) thickness (mm)	1.3366	1.8629	0.4674	2.2518	1.6251	**2.9433**	-0.8024	-1.0102	1.0350	**0.2234**
Flower opening from flower bud Initiation (Days)	0.5418	0.2329	0.7690	0.3965	0.6585	-0.3977	**1.4589**	-0.7763	-0.8238	**0.0612**
Juvenile Phase (No. of Standard weeks)	-1.0303	-0.9131	-0.8616	-0.8543	-0.6826	-0.5286	-0.8195	**1.5402**	0.5760	**-0.1841**
Shelf-life of flowers on the plant (days)	0.1008	0.0181	0.0082	-0.0634	-0.0660	-0.1765	0.2834	-0.1877	**-0.5019**	**-0.1892**
Partial R^2	-0.0467	0.0635	0.6937	-0.5091	-0.3091	0.6575	0.0892	-0.2835	0.0949	

R SQUARE = 0.4506 RESIDUAL EFFECT = 0.7412 Bold figures in main diagonal indicate direct effects

coefficient for floral characters also (Table 3) as reported by Binodh *et al.*, (2004) and Siva & Nair (2008). Both at genotypic and phenotypic levels, the correlation between number of flowers per plant with spadix length and spadix diameter was positive. Similarly, a significant and positive association of number of flowers with peduncle length, peduncle thickness and spathe length was observed indicating that these characters are major yield contributing components in anthurium. In contrast Siva and Nair (2008) observed positive direct effect of spathe size, shelf life of flower on plant on number of flowers per plant. However, number of flowers per plant, juvenile phase (number of standard weeks), shelf life of flowers on the plant and suckers per plant was significantly and negatively correlated, which implies the independent association of these characters. Thus, flower yield of anthurium is observed to be influenced by characters such as spathe length, peduncle length etc and emphasizes their importance in the selection programme. Highly significant and positive association was also recorded among other floral characters, viz., spathe width with spathe length; spadix length with spathe width; Spadix diameter with spadix length, spathe length and spathe width; peduncle (stalk) length with spadix diameter spadix length, spathe width and spathe length; peduncle (stalk) thickness with spadix diameter, spathe width, peduncle length and spathe length; days to flower opening from flower bud initiation with spadix length, peduncle length and spathe length; shelf life of flowers on the plant with peduncle thickness and juvenile phase. Significant and negative association was recorded among floral characters viz., shelf life of flowers on the plant

with flower opening from flower bud initiation; Juvenile phase (number of standard weeks) with spathe length, spathe width, spadix length, spadix diameter, days to flower opening from flower bud initiation, peduncle length and peduncle thickness. Binodh *et al.,* (2004) observed negative association of peduncle length with juvenile period.

The path coefficient analysis (Table 4) revealed that among the various yield components, the genotypic correlation between number of flowers per plant and peduncle thickness, spadix length, days to flower opening, juvenile phase and spathe width was found to be significant and positive. However, peduncle thickness had a highly significant and positive association with spathe width, spadix length, but its direct influence was positive. The characters such as spadix length, peduncle length, spadix diameter, spathe length and spathe width showed positive indirect effects on number of flowers. On the other hand, shelf life of flowers on plant followed by number of standard weeks required to flowering (Juvenile period) had negative indirect effects on flower yield. Among the various floral characters, number of suckers per plant exhibited highest negative direct influence on number of flowers per plant. From the foregoing discussion on pre pages, it is emphasized that sucker production is very important trait for selection and all the characters contributing directly or indirectly for sucker number could be considered for selection programme. But, it is inferred that number of suckers had high negative association with flower yield (Fig-1). Number of suckers per plant had negative correlation with leaf size which indicate the independent nature of these traits. The residual effect at genotypic level was low which indicated the inclusion of adequate variables in the present investigation. Thus it can be concluded that total number of leaves per plant, leaf size, leaf fresh weight, plant spread, petiole length, petiole thickness, spathe width, peduncle length, peduncle thickness, number of flowers per plant are the major yield contributing traits and hence, the selection for these characters would enhance the yield in anthurium.

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