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CORRELATION AND PATH COEFFICIENT ANALYSIS OF GROWTH AND FLOWERING TRAITS ASSOCIATED WITH FLOWERING PERFORMANCE IN ADENIUM (*Adenium obesum* Forssk. Roem. & Schult.)

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ABSTRACT

An experiment to estimate correlation and path coefficient among traits were carried out in eleven varieties and genotypes of adenium (*Adenium obesum* (Forssk.) Roem. & Schult.) to assess the nature and magnitude of association among growth and flowering traits and to identify the most important characters contributing to synchronized flowering. Correlation analysis revealed that number of flowers open at a time per plant exhibited positive and significant association with number of branches per plant, *in-situ* longevity of flower, number of flower clusters per plant and number of flower buds and flowers per cluster at both genotypic and phenotypic levels. Path coefficient analysis indicated that flower diameter, number of flower clusters per plant, number of flower buds and flowers per cluster exerted positive direct effects on number of flowers open at a time per plant. These characters were identified as major contributors and may be effectively exploited in selection programmes for improving flowering performance in adenium.
***Keywords* :** Adenium, correlation, path analysis, flowering traits.

Introduction

Adenium (*Adenium obesum* (Forssk.) Roem. & Schult.) is a popular ornamental flowering plant valued for its attractive caudex, vibrant flowers and extended blooming period. Flowering behaviour and synchronization in adenium are complex traits governed by several interrelated morphological and physiological characters. Since such traits are polygenic in nature, improvement through direct selection alone may not be effective (Falconer, 1981).

Correlation analysis provides information on the degree and direction of association among characters, whereas path coefficient analysis partitions these associations into direct and indirect effects, thereby identifying the most influential traits for effective selection (Wright, 1921; Dewey and Lu, 1959). Such approaches have been successfully applied in ornamental crops including adenium, dahlia and tuberose (Chavan *et al*., 2018b; Gogoi *et al*., 2020; Ratna *et al*., 2020). Therefore, the present investigation was undertaken to study correlation and path coefficient analysis among growth and flowering traits in adenium with special emphasis on synchronized flower opening.

Materials and Methods

The present investigation was carried out during the year during 2022-23 and 2023-24 at the experimental farm of the Department of Floriculture and Landscape Architecture, College of Horticulture, Junagadh Agricultural University, Junagadh, Gujarat. The experimental material comprised eleven varieties and genotypes (ADWB-78, Sunny Bunny, ADWB-1, Dancing Santa, Beauty Queen, ADWB-22, Dragon Blood, ADWB-4B, Butterfly Dream, ADWB-50, and Local) of adenium. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. All the recommended cultural and plant protection practices were followed to raise a healthy crop. Observations were recorded on randomly selected plants for twelve quantitative characters, namely plant height, caudex girth, number of branches per plant, number of leaves per plant, leaf area, leaf area index, flower diameter, weight of flower, in-situ longevity of flower, number of flower clusters per plant, number of flower buds and flowers per cluster and number of flowers open at a time per plant.

The recorded data were subjected to statistical analysis to estimate genotypic and phenotypic correlation coefficients following the method suggested by Al-Jibouri *et al.* (1958). Path coefficient analysis was carried out as per the procedure outlined by Dewey and Lu (1959), taking number of flowers open at a time per plant as the dependent variable.

Results and Discussion

Correlation Analysis

In general, genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients, indicating that the associations among traits were largely governed by genetic factors with limited environmental influence (Al-Jibouri *et al.*, 1958).

Association of dependent character (Number of flowers open at a time per plant)

Number of flowers open at a time per plant showed significant and positive association with *in-situ* longevity of flower **(rg = 0.9023**, rp = 0.8999**), number of flower clusters per plant (rg = 0.8515, rp = 0.8493**) and number of flower buds and flowers per cluster (rg = 0.8966, rp = 0.8947**) at both genotypic and phenotypic levels. These strong positive associations clearly indicate that plants having longer flower longevity, more flower clusters, and higher bud number per cluster tend to produce a greater number of simultaneously open flowers. Therefore, improvement in these traits would directly enhance floral display and market value in Adenium. Similar associations among flowering traits have also been reported earlier in adenium and other ornamental crops (Chavan *et al*., 2018b; Zala *et al*., 2023b).

Role of flowering traits

Number of flower clusters per plant showed a highly significant positive correlation with number of buds and flowers per cluster (rg = 0.6350, rp = 0.6322**) and in-situ longevity (rg = 0.6730, rp = 0.6711**). This suggests that flower productivity in Adenium is a collective outcome of both floral abundance and persistence, rather than a single trait. Similarly, number of buds and flowers per cluster recorded a strong and positive correlation with *in-situ* longevity, further emphasizing that genotypes capable of retaining flowers for longer duration also support higher floral load.

Influence of vegetative traits

Among vegetative traits, leaf area and leaf area index exhibited significant positive correlations with each other (rg = 0.7869**, rp = 0.7851**) and also showed positive associations with caudex girth and flower diameter. This indicates that vigorous vegetative growth enhances assimilate production, which in turn supports better flowering performance. Caudex girth had significant positive correlations with leaf area, leaf area index, and flower diameter, highlighting its importance as a storage and support organ contributing to floral development in Adenium.

Negative associations

Plant height exhibited a negative association with number of flowers open at a time per plant, suggesting that compact growth habit favours synchronized flowering. Comparable results have been reported earlier in adenium and tuberose (Gogoi *et al*., 2020; Ratna *et al*., 2020). Caudex girth showed positive association with leaf area, leaf area index and flower diameter, indicating that a well-developed caudex supports enhanced vegetative growth and floral development. Flower diameter exhibited positive association with weight of flower, suggesting that larger flowers contribute positively to floral traits, as also observed by Chavan *et al*. (2018b).

Genotypic *vs* phenotypic correlations

In almost all cases, genotypic correlation coefficients were slightly higher than phenotypic correlations, indicating that environmental factors reduced the expression of inherent genetic relationships. This confirms that selection based on phenotypic performance would still be effective, but greater genetic gain could be achieved through genotype-based selection.

The correlation analysis revealed that flower yield and display in Adenium is a complex trait governed by multiple interrelated vegetative and reproductive characters. The predominance of strong positive genotypic correlations among key flowering traits indicates ample scope for genetic improvement through indirect selection, making these traits reliable selection indices in Adenium breeding programmes.

Path Coefficient Analysis

Direct effects of different characters

Among all the traits studied, number of flower buds and flowers per cluster exerted the highest positive direct effect (0.4157) on number of flowers open at a time per plant. This clearly indicates that this trait is a primary determinant of flowering intensity in Adenium and should receive maximum emphasis during selection. These traits also exhibited strong positive correlations with the dependent character, indicating their true contribution towards synchronized flowering. Similar observations have been reported in adenium and dahlia (Chavan *et al*., 2018b; Zala *et al.*, 2023b).

In-situ longevity of flower showed a strong positive correlation with number of flowers open at a time per plant; however, its direct effect was negative, suggesting that its influence was mainly through indirect effects via other flowering components. Such indirect contributions of longevity-related traits have also been reported in tuberose (Gogoi *et al*., 2020; Ratna *et al*., 2020). In addition to this, plant height (-0.4356), leaf area index (-0.2492), weight of flower (-0.8790), in-situ longevity (-0.2079) and number of leaves per plant (-0.1573) showed negative direct effects, suggesting that direct selection for these traits alone may not improve the number of flowers open simultaneously. The low magnitude of residual effect indicated that the characters included in the study adequately explained the variation in number of flowers open at a time per plant.

Indirect effects through other characters

Despite having a negative direct effect, several traits exhibited strong positive indirect effects, which resulted in their overall positive and significant correlation with the dependent trait.

In-situ longevity showed a highly significant positive correlation (0.8999**), mainly due to its strong positive indirect effects via number of flower buds and flowers per cluster (0.3738) and number of flower clusters per plant (0.2395). This indicates that flower longevity contributes to higher flower numbers indirectly by sustaining floral availability.

Number of flower clusters per plant, though having a moderate direct effect, expressed strong positive indirect contributions through number of buds and flowers per cluster (0.2256) and in-situ longevity (0.2395), explaining its high positive correlation (0.8493**) with the dependent trait.

Number of branches per plant showed a modest direct effect (0.1644) but contributed substantially through indirect effects via flower clusters (0.1454) and *in-situ* longevity (0.0806), resulting in a significant positive association with the dependent character.

Traits with negative contribution

Plant height recorded a significant negative correlation (-0.4622**) with number of flowers open at a time per plant, mainly due to its high negative direct effect and unfavorable indirect effects through leaf-related traits and flower clusters. This suggests that excessive vegetative elongation adversely affects reproductive efficiency in Adenium.

Similarly, weight of flower exhibited a strong negative direct effect (-0.8790) and negligible positive indirect effects, resulting in an overall non-significant correlation. This implies that heavier flowers do not necessarily contribute to higher flowering intensity.

Agreement between correlation and path analysis

Traits such as number of flower buds and flowers per cluster, number of flower clusters per plant, and in-situ longevity exhibited both high positive correlation and substantial positive direct or indirect effects, confirming their true and reliable association with the dependent trait. Hence, these traits can be effectively used as selection indices.

The path coefficient analysis revealed that number of flower buds and flowers per cluster is the most important yield-contributing trait, followed by number of flower clusters per plant and flower diameter, in determining the number of flowers open at a time per plant in Adenium.

Conclusion

Improvement in number of flowers open at a time per plant in Adenium can be most effectively achieved through simultaneous selection for higher number of flower clusters per plant, greater number of buds and flowers per cluster, and longer in-situ flower longevity, rather than selection based on vegetative traits alone. These characters may therefore be considered as reliable selection indices for breeding and varietal improvement programmes aimed at enhancing the ornamental value of Adenium. Emphasis on these traits would be effective for genetic improvement of flowering performance in adenium.

Table 1 : Genotypic (r_g) and phenotypic (r_p) correlation coefficients among 12 characters in adenium

Character		1	2	3	4	5	6	7	8	9	10	11	12
1	r_g	**1.000**	0.5032**	-0.8451**	-0.5551**	0.4261*	0.3557*	0.3023	-0.1073	-0.4195*	-0.6670**	-0.3349	-0.4653**
	r_p	**1.000**	0.5057**	-0.8358**	-0.5496**	0.4234*	0.3519*	0.2987	-0.1037	-0.4145*	-0.6589**	-0.3337	-0.4622**
2	r_g		**1.000**	-0.3396	-0.2969	0.6894**	0.7303**	0.5681**	0.0282	0.2448	-0.1005	0.4061*	0.2486
	r_p		**1.000**	-0.3361	-0.2888	0.6818**	0.7199**	0.5587**	0.0296	0.2407	-0.1020	0.4014*	0.2448
3	r_g			**1.000**	0.6970**	-0.5103**	-0.2533	-0.1320	0.0796	0.4926**	0.8914**	0.4177*	0.6821**
	r_p			**1.000**	0.6911**	-0.5076**	-0.2516	-0.1317	0.0786	0.4904**	0.8843**	0.4141*	0.6789**
4	r_g				**1.000**	-0.4525**	0.0319	-0.3243	-0.2763	0.1715	0.4701**	0.0536	0.2971
	r_p				**1.000**	-0.4510**	0.0313	-0.3226	-0.2748	0.1692	0.4659**	0.0542	0.2967
5	r_g					**1.000**	0.7869**	0.6078**	0.2345	-0.0936	-0.5149**	0.1788	-0.1416
	r_p					**1.000**	0.7851**	0.6052**	0.2337	-0.0926	-0.5127**	0.1788	-0.1417
6	r_g						**1.000**	0.3761*	-0.2046	0.1166	-0.2986	0.2540	0.0793
	r_p						**1.000**	0.3758*	-0.2024	0.1152	-0.2971	0.2525	0.0790
7	r_g							**1.000**	0.7148**	0.1516	-0.0397	0.3967*	0.2133
	r_p							**1.000**	0.7136**	0.1504	-0.0397	0.3937*	0.2126
8	r_g								**1.000**	-0.1153	0.0781	0.1186	-0.0191
	r_p								**1.000**	-0.1147	0.0782	0.1169	-0.0187
9	r_g									**1.000**	0.6730**	0.9039**	0.9023**
	r_p									**1.000**	0.6711**	0.8992**	0.8999**
10	r_g										**1.000**	0.6350**	0.8515**
	r_p										**1.000**	0.6322**	0.8493**
11	r_g											**1.000**	0.8966**
	r_p											**1.000**	0.8947**

*, ** significant at 5 and 1 % levels, respectively

Where,

1) Plant height (cm), **2)** Caudex girth (cm), **3)** Number of branches per plant, **4)** Number of leaves per plant, **5)** Leaf area (cm^2), **6)** Leaf area index, **7)** Flower diameter (cm), **8)** Weight of flower (g), **9)** *In-situ* longevity (days), **10)** Number of flower clusters per plant, **11)** Number of flower buds and flowers per cluster **12)** Number of flowers open at time per plant (Dependent character)

Table 2 : Direct and indirect effects of different characters on number of flowers open at time per plant in 11 varieties and genotypes of adenium

Characters	**Plant height (cm)**	**Caudex girth (cm)**	**Number of branches per plant**	**Number of leaves per plant**	**Leaf area (cm^2)**	**Leaf area index**	**Flower diameter (cm)**	**Weight of flower (g)**	***In-situ* longevity (days)**	**Number of flower clusters per plant**	**Number of flower buds and flowers per cluster**
Plant height (cm)	**-0.4356**	-0.2203	0.3641	0.2394	-0.1844	-0.1533	-0.1301	0.0452	0.1806	0.2870	0.1454
Caudex girth (cm)	0.0936	**0.1850**	-0.0622	-0.0534	0.1262	0.1332	0.1034	0.0055	0.0445	-0.0189	0.0743
Number of branches per plant	-0.1374	-0.0553	**0.1644**	0.1136	-0.0835	-0.0414	-0.0217	0.0129	0.0806	0.1454	0.0681
Number of leaves per plant	0.0864	0.0454	-0.1087	**-0.1573**	0.0709	-0.0049	0.0507	0.0432	-0.0266	-0.0733	-0.0085
Leaf area (cm^2)	-0.0484	-0.0780	0.0580	0.0516	**-0.1144**	-0.0898	-0.0692	-0.0267	0.0106	0.0586	-0.0204
Leaf area index	-0.0877	-0.1794	0.0627	-0.0078	-0.1956	**-0.2492**	-0.0936	0.0504	-0.0287	0.0740	-0.0629
Flower diameter (cm)	0.2635	0.4929	-0.1162	-0.2846	0.5339	0.3315	**0.8821**	0.6294	0.1327	-0.0351	0.3473
Weight of flower (g)	0.0912	-0.0261	-0.0691	0.2416	-0.2054	0.1779	-0.6272	**-0.8790**	0.1008	-0.0687	-0.1028
In-situ longevity (days)	0.0862	-0.0500	-0.1020	-0.0352	0.0193	-0.0239	-0.0313	0.0238	**-0.2079**	-0.1395	-0.1869
Number of flower clusters per plant	-0.2351	-0.0364	0.3156	0.1663	-0.1830	-0.1060	-0.0142	0.0279	0.2395	**0.3569**	0.2256
Number of flower buds and flowers per cluster	-0.1387	0.1669	0.1721	0.0225	0.0743	0.1050	0.1637	0.0486	0.3738	0.2628	**0.4157**
correlation of number of flowers open at a time per plant with other traits	-0.4622**	0.2448	0.6789**	0.2967	-0.1417	0.0790	0.2126	-0.0187	0.8999**	0.8493**	0.8947**

*, ** significant at 5 and 1 % levels, respectively

Residual effect = 0.00

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