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Genetic variability and character association analysis of various quantitative traits of orchids (*Dendrobium* spp.) from the East Siang District of Arunachal Pradesh

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Abstract

To assess the genetic variability, heritability, and association of 21 key quantitative variables in 15 distinct *Dendrobium* species, efforts were made to study the germplasm of *Dendrobium* orchids in different parts of Arunachal Pradesh between 2020 and 2022. Significant variance was found in every attribute in the study, indicating that there is sufficient genetic diversity to support breeding efforts. The most significant values of PCV and GCV were recorded for the number of flowers per inflorescence (136.13% and 135.35%, respectively) and the number of inflorescences per plant (136.18% and 133.94%, respectively). High heritability coupled with high genetic advance was observed for inflorescence length (99.74%), the number of flowers per inflorescence (99.68%), flower width in the front view (99.41%), and flower length (99.25%). Selection based on these characteristics would be more effective for improving interspecific hybrids. Other characters exhibited moderate broad-sense heritability with low genetic advance. Plant height, internode number, number of leaves, and flower longevity showed positive and highly significant associations with the number of flowers per inflorescence and the number of inflorescences per plant at both the genotypic and phenotypic levels. However, correlation study revealed that selecting parents based on plant height, internode number, number of leaves, and flower longevity in plants would be helpful in breeding programs.

Key words: Genetic variability, *Dendrobium* species, heritability, genetic advance, correlation

Introduction

The order *Orchidaceae* represents the most highly evolved family among monocotyledons, comprising 30,000-35,000 species within 800 genera, of which 1300 species are found in India (Medhi *et al.*, 2012). Almost 950 species (nearly 69%) have been documented from all of Northeast India (De and Singh, 2015). With regard to the species diversity distribution in the region, Arunachal Pradesh has the highest population of orchids, with 577 orchid species belonging to 147 genera. Sikkim ranks second in terms of species richness, with 561 species from 144 genera, followed by Nagaland (380 species), Meghalaya (380 species), Manipur (314 species), Mizoram (253 species), Assam (231 species), and Tripura, with only 39 species (Kataki *et al.*, 1984).

Dendrobium is the second-largest genus in the *Orchidaceae* family and is highly valued for commercial cut flower production. When grown under protected structures, good quality flowers and year-round production are possible due to better control over environmental factors. In the entire northeastern region, 82 *Dendrobium* species have been reported. Arunachal Pradesh has the highest number of occurrences, with 49 species, and Tripura has the lowest number, with 5 species (Lokho, 2013). Northeast India has drawn attention due to its rich biodiversity and the urgent need for conservation by international agencies. The native ornamental plant species that exist in India offer a large amount of genetic diversity for bioprospecting. The degree of variability that is available and the following skillful management of that variability towards the selection of acceptable types determine whether genetic improvement in any crop is successful. The availability of genetic variability in a particular species is a major determinant of the sources of any breeding program for creating appropriate variations. The selection of criteria for the improvement of the existing germplasm is aided by the correlation between distinct features, which helps determine the degree of association among various traits (Kumar and Sharma, 2013).

In orchid breeding, particularly in species such as *Dendrobium* and *Spathoglottis*, the vast variability in plant and floral characteristics offers immense opportunities for genetic improvement. However, both environmental and genetic variables influence how distinct plant traits are expressed. Determining the ratio of environmental and heritable variation is

frequently difficult. The degree, kind, and interplay of genotypic and environmental differences in plant characteristics impact the breeding process. Of the three types of variability in genetic improvement—*i.e.*, phenotypic, environmental, and genotypic variability—genotypic variability is the most important. Traits with high genetic variability exhibit high genetic inheritance from one generation to the next (Seeja *et al.*, 2019). Therefore, the present study aimed to investigate the genetic variability and character associations of several important species of the genus *Dendrobium*, which assists in identifying the traits that are heritable over generations in crop breeding. In order to create new orchid varieties, this information might be helpful in choosing plants with desired characteristics.

Materials and methods

A total of 15 different species belonging to the genus *Dendrobium* were collected from different locations in Arunachal Pradesh (Table 1). The experiment was performed in a completely randomized design (CRD) with three replications during 2020-2022 at a polyhouse in the Department of Floriculture and Landscaping, College of Horticulture and Forestry, Central Agricultural University, Pasighat. Data were collected from five randomly selected plants per species, following the prescribed procedures. Twenty-one characteristics were observed, namely: plant height, internode number, internode diameter, number of leaves, leaf length, leaf width, inflorescence length, peduncle length, number of flowers per inflorescence, flower length, flower width in front view, dorsal sepal length, dorsal sepal width, petal length, petal width, lip length, lip width, column width across stigma, spur length, flower longevity on plant, and number of inflorescences per plant. Mean values were taken for analysis of variance as per Panse and Sukhatme (1967). Using formulas proposed by Burton and Devane (1953), the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed. Genetic advance (GA) and heritability were determined as proposed by Hanson *et al.* (1956). As recommended by Al-Jibouri *et al.* (1958), the Pearson's correlation coefficient was calculated using analysis of variance and covariance for each variable.

Table 1. List of species collected from various locations along with geographical coordinates

No.	Species	Location	Latitude	Longitude	Elevation
1	*Dendrobium lituiflorum*	Rengging	28°8'25" N	95°16'39" E	366.35 m
2	*Dendrobium aphyllum*	Pasighat	28°4'25" N	95°19'48" E	167.25 m
3	*Dendrobium primulinum*	Bodak	28°14'13" N	95°27'89" E	150.00 m
4	*Dendrobium fimbriatum*	Rengging	28°5'51" N	95°16'10" E	292.41 m
5	*Dendrobium nobile*	Rengging	28°8'25" N	95°16'41" E	372.48 m
6	*Dendrobium chrysotoxum*	Rengging	28°8'26" N	95°16'41" E	335.15 m
7	*Dendrobium densiflorum*	Rengging	28°8'21" N	95°15'28" E	582.6 m
8	*Dendrobium nobile* var. *alba*	Rengging	28°9'3" N	95°14'13" E	674.31m
9	*Dendrobium macraei*	Pasighat	28°06'19" N	95°32'60" E	160 m
10	*Dendrobium jenkinsii*	Bodak	28°14'13" N	95°27'89" E	150 m
11	*Dendrobium wardianum*	Sirki	28°8'22" N	95°15'28" E	570 m
12	*Dendrobium thyrsiflorum*	Bodak	28°90'17" N	95°15'51" E	180 m
13	*Dendrobium devonianum*	Panging	28°10'9" N	95°13'35" E	320 m
14	*Dendrobium chrysanthum*	Rengging	28°8'22" N	95°15'29" E	498.05 m
15	*Dendrobium eriiflorum*	Rengging	28°7'21" N	95°16'25" E	279.82 m

Results and discussion

Genetic variability, heritability and genetic advance: Knowledge of the range of genetic variation in the species for different characters is essential for any programme of crop improvement. Quantitative indices of phenotypic variation like mean, range, coefficient of phenotypic (PCV) and genotypic variation (GCV), broad-sense heritability (H), genetic advance (GA) and genetic advance as per cent of mean partitioned the variability accessible in the species into heritable and non heritable component. The data used for the variability analysis of different *Dendrobium* orchid species are presented in Table 2.

The range of variation was greatest for plant height (6.20–99.50), followed by the number of flowers per inflorescence (1–33), internode number (2–33), and number of inflorescences per plant (1–28). The lowest variation was recorded for column width across the stigma (0.11–0.40), followed by internode diameter (0.40–1.46) and spur length (0.20–1.50). Because orchids are cross-pollinated crops, there is significant variation, and the current findings are consistent with those reported earlier by Moniruzzaman *et al.* (2012) for orchid species.

The maximum genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) of 136.13% and 135.35%, respectively, were recorded for the number of flowers per inflorescence. This was followed by the number of inflorescences per plant (GCV = 133.94% and PCV = 136.18%), inflorescence length (GCV = 119.45% and PCV = 119.61%), and peduncle length (GCV = 82.35% and PCV = 82.79%). For all the traits studied, the phenotypic coefficient of variation estimates were greater than the genotypic coefficient of variation estimates, indicating an additive effect of the environment on trait expression. Similar findings were reported by Dewanti *et al.* (2019), Kumar and Sharma (2013), and Moniruzzaman *et al.* (2012) in orchid species.

Heritability of characteristics helps breeders base their selection on the plant's phenotypic performance by determining the extent to which the phenotype serves as a reference to the genotype (Kumar *et al.*, 2012). Considerable variation in the heritability (broad-sense) of different quantitative traits of *Dendrobium* species has been recorded. The greatest heritability (broad-sense) was recorded for inflorescence length (99.74%), followed by the number of flowers per inflorescence (99.68%), flower width in the front view (99.41%), and flower length (99.25%). High heritability may be an effective method based on phenotypic expression. Inflorescence length and the number of flowers per inflorescence are potential characteristics for selection in *Dendrobium* species. These findings are consistent with the results of Miano *et al.* (2016) in orchids and Misra and Gupta (2003) in carnations.

The greatest genetic advance was recorded for plant height (50.44%), followed by the number of flowers per inflorescence (20.53%), internode number (17.97%), and inflorescence length (13.68%). High heritability with moderate to low genetic advance in the number of flowers per inflorescence, internode number, and inflorescence length may be due to dominant

Table 2. Genetic parameters for 21 morphological traits amongst 15 *Dendrobium* species

Sl. No.	Traits	Mean	Range		Variability		Heritability (%)	Genetic advance	Genetic advance as percent of mean
			Min	Max	GCV (%)	PCV (%)			
1	Plant height (cm)	39.53	6.2	99.5	62.47	63.00	98.31	50.44	127.59
2	Internode number	10.91	2.0	33.0	81.23	82.56	96.81	17.97	164.65
3	Internode diameter (cm)	0.94	0.4	1.4	31.25	32.39	93.08	0.59	62.10
4	Number of leaves	5.38	1.0	15.0	54.44	57.22	90.51	5.74	106.70
5	Leaf length (cm)	11.13	3.1	16.5	28.33	29.11	94.70	6.32	56.79
6	Leaf width (cm)	2.85	1.4	6.6	43.74	44.66	95.94	2.51	88.26
7	Inflorescence length (cm)	5.56	0.3	18.0	119.45	119.61	99.74	13.68	245.75
8	Peduncle length (cm)	1.95	0.3	5.7	82.35	82.79	98.96	3.29	168.76
9	Flower number per inflorescence	7.33	1.0	33.0	136.13	136.35	99.68	20.53	279.97
10	Flower length (cm)	3.41	1.1	6.1	47.10	47.28	99.25	3.29	96.66
11	Flower width in front view (cm)	4.04	0.6	7.2	52.63	52.79	99.41	4.37	108.11
12	Dorsal sepal length (cm)	2.43	0.9	4.1	44.19	44.49	98.64	2.19	90.40
13	Dorsal sepal width (cm)	0.96	0.3	1.7	40.66	41.27	97.06	0.80	82.52
14	Petal length (cm)	2.49	0.9	4.4	44.76	45.08	98.58	2.28	91.54
15	Petal width (cm)	1.49	0.2	2.8	48.83	49.95	95.56	1.47	98.32
16	Lip length (cm)	2.45	0.3	3.9	37.56	38.02	97.57	1.87	76.42
17	Lip width (cm)	2.19	0.4	3.6	38.55	38.75	98.98	1.73	79.00
18	Column width across stigma (cm)	0.28	0.1	0.4	21.67	22.4	93.59	0.12	43.18
19	Spur length (cm)	0.76	0.2	1.5	44.74	45.59	96.31	0.69	90.44
20	Flower longevity on plant (days)	10.71	4.0	21.0	45.41	45.97	97.59	9.90	92.42
21	Inflorescence number per plant	4.62	1.0	28.0	133.94	136.18	96.75	12.55	271.40

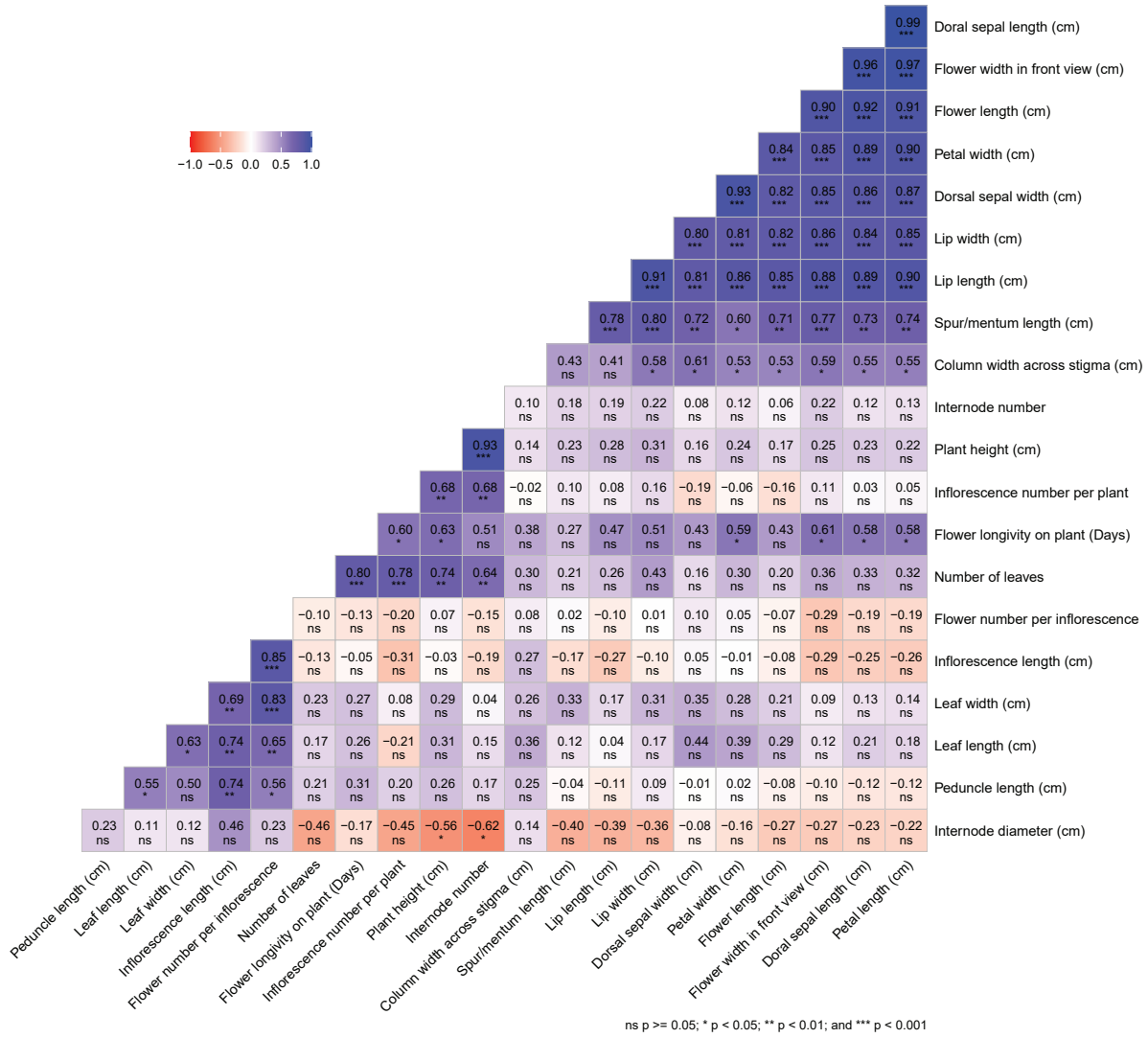

Fig. 1. Genotypic correlation coefficients of different traits in *Dendrobium* species.

and epistatic gene action, and simple selection may not be effective. Hybridization could be used to improve these traits. Similar findings have also been reported by Seeja *et al.* (2019) for *Spathoglottis*; Vanlalruati *et al.* (2016) for orchids; and Kumar and Sharma (2013) for *Dendrobium* hybrids.

The number of flowers per inflorescence exhibited the greatest genetic advancement (279.97%), followed by the number of inflorescences per plant (271.40%), inflorescence length (245.75%), and peduncle length (168.76%). The low heritability and low genetic advance as a percentage of the mean for column width across the stigma and leaf length indicated the contribution of nonadditive gene effects, and adequate progeny testing could be performed to improve these traits. These findings are in agreement with those of Dewanti *et al.* (2019) in Vanda; Miano *et al.* (2016); and Vanlalruati *et al.* (2016) in orchids.

Correlation: Analyzing the character association between floral and flower-producing features showed that all of the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients. The environment, by lowering the phenotypic coefficients, altered the phenotypic expression of these traits, indicating a suppressive influence. The correlation coefficients between the genotype and phenotype of many variables were examined for every possible combination (Fig. 1).

Plant height (0.679), internode number (0.680), number of leaves (0.809), and flower longevity on plants (0.606) exhibited positive and significant genotypic associations with the number of inflorescences per plant. However, negative and significant correlations were detected between internode diameter (−0.462) and inflorescence length (−0.311). Similarly, plant height (0.673), internode number (0.675), number of leaves (0.730), and flower longevity (0.590) exhibited positive and significant phenotypic associations with this trait. Negative and significant phenotypic correlations were also detected between internode diameter (−0.440) and inflorescence length (−0.305).

Selection programs benefit greatly from knowledge of the correlation between key economic traits, as it ensures the simultaneous improvement of one or more traits. A negative correlation emphasizes the necessity of striking a balance between desired traits. The correlation between traits may be due to either pleiotropy or genetic linkage (Pridgeon *et al.*, 1999; Lekharani, 2002). The observed positive correlation between the flowers per inflorescence and inflorescences per plant is likely species-specific in orchids. On the other hand, the negative correlation of flower number and flower width in the front view indicates a genetic trade-off in orchids between flower width and number with species with larger flower widths producing fewer flowers per inflorescence.Similar observations were noted by Vanlalruati *et al.* (2016); Miano *et al.* (2015); and Moniruzzaman *et al.* (2012) in different orchid species. Based on these findings, selecting parents based on plant height, internode number, number of leaves, and flower longevity in plants would be beneficial in a breeding program.

The study suggests that species should be selected based on the number of flowers per inflorescence, number of inflorescences per plant, inflorescence length, and peduncle length because these characteristics exhibit the most variation between species. The correlation coefficients highlighted the importance of plant height, flower longevity, internode number, and leaf number as selection factors for the production of interspecific hybrids.

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