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Original Research Paper

Morphological characterization of *Dendrobium* orchid species of East Siang district of Arunachal Pradesh

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ABSTRACT

Fifteen species of *Dendrobium* orchids collected from different regions of East Siang district of Arunachal Pradesh, India were evaluated for 12 vegetative and flowering characters. Significant differences were observed amongst the *Dendrobium* species for all the traits. The species *Dendrobium aphyllum* recorded maximum plant height (93.87 cm), number of internode (31) and leaves/plant (13.67), inflorescence/plant (25.67), flower longevity on plant (20.67 days), whereas, flower longevity was recorded minimum (4.33 days) in *Dendrobium jenkinsii*. Maximum internode diameter (1.36 cm) was recorded in *Dendrobium chrysotoxum*; maximum leaf width (6.33 cm), inflorescence length (17.70 cm) was recorded in *Dendrobium densiflorum.* Maximum leaf length (16 cm), flowers/inflorescence (32.67) was recorded in *Dendrobium thyrsiflorum*, however, *Dendrobium devonianum* recorded highest flower length (6.03 cm). On the basis of overall performance, species *Dendrobium aphyllum*, *Dendrobium densiflorum, Dendrobium thyrsiflorum* were found promising for hanging baskets and *Dendrobium nobile* var. *alba* and *D. nobile* for cut flower purpose. Based on hierarchical clusters of the morphological traits, the *Dendrobium* orchid genotypes were grouped into two which is confined to principal component analysis.

Keywords: Cluster, *Dendrobium*, evaluation, orchid, principal component analysis

INTRODUCTION

Orchidaceae is one of the diverse and largest plant families contributing nearly 10% to the flowering plant species of the world. It has been estimated by several workers that there are nearly 12,000-35,000 species of orchids in the world (Lokho, 2013). In India alone, nearly 1200-1500 species have been reported with the maximum diversity in North East India (Dressler, 1981). Orchids are valued amongst the horticulturist for its exquisite beauty, uniqueness in shape and form of flowers. North-East India hosts around 750 to 876 orchid species belonging to 151 genera, widely distributed across the region. Out of the 116 *Dendrobium* species reported in India, 70 are found in North-Eastern India, which lies within the Indo-Burma biodiversity hotspot, the second-largest in the world. The remaining species are mainly distributed in the Western Ghats (Deori et al., 2019).

Maximum diversity of *Dendrobium* occurs in South East Asia ranging from North-Eastern India to the Islands of New Guinea and Polynesia. In India, *Dendrobium* is naturalised in the Eastern Himalayas, Western Himalayas, Western Peninsular and Andaman and Nicobar Islands. Maximum species of *Dendrobium* have been reported in Arunachal Pradesh (49) and Manipur (48) followed by Assam (46), Meghalaya (42), Sikkim (41), Mizoram (40), Nagaland (30) and Tripura (5) (Lokho, 2013).

Morphological characterization in orchids helps in distinguishing the different plant groups. Characterization of *Dendrobium* orchid morphology is very important for the sustainability of conservation and increasing the usefulness of plant genetic resources. De et al. (2015) have analysed the grouping and genetic relationship of 30 species of *Dendrobium* found in India. In the recent times, the species is becoming endangered due to unscrupulous collection of plants from the wild which has resulted in the habitat loss and threat to its survival. The present study is an initial effort to collect native *Dendrobium* species of East Siang district of Arunachal Pradesh, India, to determine the diversity which may be present within or between the species collected. This will serve

Table 1: GPS co-ordinates of different locations of collected *Dendrobium* species

Species	Location	Latitude	Longitude	Elevation (m)
Dendrobium lituiflorum	Rengging	28°8’25" N	95°16’39" E	366.35
Dendrobium aphyllum	Pasighat	28°4’25" N	95°19’48" E	167.25
Dendrobium primulinum	Bodak	28°14’13" N	95°27’89" E	150
Dendrobium fimbriatum	Rengging	28°5’51" N	95°16’10" E	292.41
Dendrobium nobile	Rengging	28°8’25" N	95°16’41" E	372.48
Dendrobium chrysotoxum	Rengging	28°8’26" N	95°16’41" E	335.15
Dendrobium densiflorum	Rengging	28°8’21" N	95°15’28" E	582.6
Dendrobium nobile var. *alba*	Rengging	28°9’3" N	95°14’13" E	674.31
Dendrobium macraei	Pasighat	28°06’19" N	95°32’60" E	160
Dendrobium jenkinsii	Bodak	28°14’13" N	95°27’89" E	150
Dendrobium wardianum	Sirki	28°8’22" N	95°15’28" E	570
Dendrobium thyrsiflorum	Bodak	28°90’17" N	95°15’51" E	180
Dendrobium devonianum	Panging	28°10’9" N	95°13’35" E	320
Dendrobium chrysanthum	Rengging	28°8’22" N	95°15’29" E	498.05
Dendrobium eriiflorum	Rengging	28°7’21" N	95°16’25" E	279.82

as a basis to determine the crop diversification patterns and can be further possibly used as parents in breeding programmes. A genotype’s performance varies depending on the region, season and growing conditions (Punetha et al., 2011). As a result, genotype evaluation for quality and yield traits is required to understand their performance in a specific location.

MATERIALS AND METHODS

Field observation and botanical collection trips were carried out from 2020 to 2022 in different regions of East Siang district of Arunachal Pradesh, India. The specimens were collected as living collections and were grown under protected cultivation in the Floriculture Farm of the Department of Floriculture and Landscape Architecture, College of Horticulture and Forestry, Pasighat for *ex-situ* conservation, and identification was done once it flowered during 2021-22.

Fifteen species *viz.*, *Dendrobium lituiflorum*, *Dendrobium aphyllum, Dendrobium primulinum, Dendrobium fimbriatum, Dendrobium nobile, Dendrobium chrysotoxum, Dendrobium densiflorum, Dendrobium nobile* var. *alba, Dendrobium macraei, Dendrobium jenkinsii, Dendrobium wardianum, Dendrobium thyrsiflorum, Dendrobium devonianum, Dendrobium chrysanthum* and *Dendrobium eriiflorum* were collected from different locations of Arunachal Pradesh and evaluated for vegetative, flowering and longevity, in completely randomized design with three replications. Most of the *Dendrobium* species collected flowered during March to June except of one species *viz.*, *Dendrobium devonianum* which flowered in November. The GPS co-ordinates of the collected specimens have been presented in Table 1.

All the morphological characters were observed and recorded in protected condition. Five random plants were selected for recording various observations *viz*., plant height (cm), internode number, internode diameter (cm), number of leaves, leaf length (cm), leaf width (cm), inflorescence per plant, inflorescence length (cm), flowers per inflorescence, flower length (cm), flower width in front view (cm), flower longevity on plant (days). The experimental measurements were carried out in triplicates and the values were expressed as mean of three replication ± SD (standard deviation) described as per Gomez & Gomez (1984). To find the relations between the groups of species cluster analysis was carried out to distinguish possible groups among the population using ward method and principal component analysis (PCA) of the morphological data were performed using XL-STAT (Addinsoft, 2022).

RESULTS AND DISCUSSION

Vegetative traits

Data presented in Table 2 clearly indicated significant differences amongst the orchid species for all the vegetative characters. Maximum plant height was recorded in *Dendrobium aphyllum* (93.87 cm) followed by *Dendrobium fimbriatum* (77.13 cm); while the minimum plant height was recorded in *Dendrobium jenkinsii* (6.40 cm). The differences in plant height among the species are mainly due to genetic nature, habitat and environmental effect. De et al. (2015) also reported similar results in different *Dendrobium* species. The highest number of internode was recorded in *Dendrobium aphyllum* (31.0), followed by *Dendrobium fimbriatum* (28.67), while, the lowest internode number was recorded in *Dendrobium jenkinsii* (2.0). *Dendrobium chrysotoxum* registered the maximum internode diameter (1.36 cm) followed by *Dendrobium eriiflorum* (1.31 cm) and it recorded minimum in *Dendrobium devonianum* (0.42 cm). The variation in internode number and internode diameter may be attributed to the genetic makeup of the plant. Similar results on number of internode and internode diameter have been reported by De & Deb (2016) in *Dendrobium* orchids.

Number of leaves was found to be highest in *Dendrobium aphyllum* (13.67), followed by *Dendrobium nobile* (9.0) and minimum (1.0) in *Dendrobium macraei*. Leaves are important for photosynthesis which greatly influences the growth and yield of the plants. The variation in number of leaves in each plant is strongly influenced by the genetic makeup of the variety. Hartati et al. (2021) stated that an increase in the number of leaves leads to a higher total leaf area, which in turn positively influences vegetative growth. The leaf characters are also used in determining the relationship between the plant species (Darmawati et al., 2018). *Dendrobium thyrsiflorum* recorded the maximum leaf length (16.0 cm), followed by *Dendrobium fimbriatum* (15.30 cm), while *Dendrobium jenkinsii* (3.40 cm) recorded minimum leaf length. Maximum leaf width was registered in *Dendrobium densiflorum* (6.33 cm) followed by *Dendrobium thyrsiflorum* (4.63 cm) and it was minimum in *Dendrobium jenkinsii* (1.57 cm). Akshata et al. (2018) stated that leaf length and leaf width influences the total photosynthetic activity and in turn the plant spread. However, Hartati et al. (2021) stated that length and width of the leaves does not influence the size of the flower and the number of flowers.

Flowering traits

Diversity in flower structure as a generative/ reproductive organ is one of the main characters used in the process of identifying a species (Kurniawan &

Table 2 : Vegetative traits of *Dendrobium* species collected from East Siang district of Arunachal Pradesh

Species	Plant height (cm)	No. of Internode	Internode diameter (cm)	No. leaves/plant	Leaf length (cm)	Leaf width (cm)
Dendrobium lituiflorum	69.20 ± 7.20	18.00 ± 2.65	0.73 ± 0.04	6.67 ± 1.15	9.77 ± 1.16	2.17 ± 0.12
Dendrobium aphyllum	93.87 ± 5.12	31.00 ± 2.00	0.48 ± 0.00	13.67 ± 1.53	9.53 ± 0.67	3.33 ± 0.29
Dendrobium primulinum	31.33 ± 3.82	13.33 ± 2.52	0.85 ± 0.06	3.67 ± 1.15	8.10 ± 0.56	2.47 ± 0.12
Dendrobium fimbriatum	77.13 ± 1.85	28.67 ± 3.06	0.69 ± 0.03	5.00 ± 1.00	15.30 ± 0.70	2.77 ± 0.31
Dendrobium nobile	54.67 ± 7.37	13.00 ± 2.00	1.18 ± 0.06	9.00 ± 1.00	12.70 ± 0.66	3.23 ± 0.59
Dendrobium chrysotoxum	15.90 ± 0.95	3.33 ± 0.58	1.36 ± 0.13	4.67 ± 0.58	13.27 ± 1.10	2.73 ± 0.25
Dendrobium densiflorum	41.27 ± 1.78	6.00 ± 1.00	1.10 ± 0.04	5.00 ± 0.00	14.47 ± 0.96	6.33 ± 0.25
Dendrobium nobile var *alba*	35.93 ± 1.30	8.67 ± 1.15	1.22 ± 0.01	4.00 ± 1.00	11.13 ± 0.95	3.03 ± 0.06
Dendrobium macraei	20.17 ± 2.08	5.33 ± 0.58	1.10 ± 0.16	1.00 ± 0.00	8.97 ± 0.25	1.60 ± 0.10
Dendrobium jenkinsii	6.40 ± 0.20	2.00 ± 0.00	1.16 ± 0.06	1.67 ± 0.58	3.40 ± 0.26	1.57 ± 0.15
Dendrobium wardianum	23.40 ± 1.20	6.00 ± 1.00	0.85 ± 0.06	5.33 ± 0.58	12.50 ± 0.70	2.83 ± 0.06
Dendrobium thyrsiflorum	43.33 ± 2.02	7.33 ± 0.58	1.06 ± 0.09	4.33 ± 0.58	16.00 ± 0.50	4.63 ± 0.40
Dendrobium devonianum	28.73 ± 1.37	5.67 ± 0.58	0.42 ± 0.02	6.33 ± 0.58	9.57 ± 0.60	2.40 ± 0.20
Dendrobium chrysanthum	36.57 ± 2.00	12.67 ± 1.53	0.64 ± 0.05	5.00 ± 1.00	10.90 ± 1.04	1.67 ± 0.21
Dendrobium eriiflorum	15.10 ± 0.89	2.67 ± 0.58	1.31 ± 0.15	5.33 ± 1.53	11.30 ± 0.56	1.93 ± 0.15
SE(m)±	1.959	0.919	0.045	0.537	0.440	0.148
CD (p=0.05)	5.686	2.667	0.132	1.560	1.276	0.429

Semiarti, 2021). Significant differences were observed in flowering of different *Dendrobium* species (Table 3). The species *Dendrobium primulinum, Dendrobium nobile, Dendrobium nobile* var. *alba* flowered during March; *Dendrobium fimbriatum, Dendrobium lituiflorum, Dendrobium densiflorum, Dendrobium nobile, Dendrobium chrysotoxum, Dendrobium jenkinskii, Dendrobium wardianum, Dendrobium thyrsiflorum, Dendrobium macrei* flowered in April; *Dendrobium aphyllum* in May; *Dendrobium eriifolium* and *Dendrobium chrysanthum* in June; while, *Dendrobium devonianum* flowered in November. Highest number of inflorescences was recorded in *Dendrobium aphyllum* (25.67) followed by *Dendrobium lituiflorum* (8.67), while, lowest number were recorded in *Dendrobium macraei* (1.0). Maximum inflorescence length was registered in *Dendrobium densiflorum* (17.70 cm), followed by *Dendrobium thyrsiflorum* (17.40 cm), while, it was minimum in *Dendrobium aphyllum* (0.40 cm). Variation for inflorescence number and inflorescence length of a species seems to be genetically controlled and have also been reported by Lokho et al. (2012). Highest number of flowers per inflorescence was recorded in *Dendrobium thyrsiflorum* (32.67) followed by *Dendrobium densiflorum* (29.67), while, lowest was recorded in *Dendrobium macraei* (1.0) and *Dendrobium primulinum* (1.0). The number of flowers produced per plant may be directly related to the increase in plant height, internode number, number of leaves per plant which accumulates more photosynthates and thereby leading to more number of flowers per inflorescence. Similar results were observed by Lokho et al. (2012) in *Dendrobium* species.

Large variation was observed in flower length of different species under study. *Dendrobium devonianum* (6.03 cm) recorded longest flower length followed by *Dendrobium wardianum* (5.77 cm), while, smallest flower length was recorded in *Dendrobium eriiflorum* (1.13 cm). Maximum flower width was recorded in *Dendrobium nobile* var. *alba* (7.17 cm) followed by *Dendrobium nobile* (6.73 cm), while minimum flower width was recorded in *Dendrobium macraei* (0.67 cm). Highest flower longevity was recorded in *Dendrobium nobile* (17.33 days) followed by *Dendrobium nobile* var. *alba* (15.67 days), while, lowest was recorded in *Dendrobium jenkinsii* (4.33 days). Flowering duration is an important trait for selection in crop improvement programmes. Maximum duration (18.33 days) of flowering was recorded in *Dendrobium primulinum* followed by

Table 3 : Flowering traits of *Dendrobium* species collected from East Siang district of Arunachal Pradesh

Species	No. of inflorescence/ plant	Inflorescence length (cm)	No. of flowers/ inflorescence	Flower length (cm)	Flower width in front view (cm)	Flower longevity on plant (days)	Flowering duration (days)
Dendrobium lituiflorum	8.67 ± 2.08	0.90 ± 0.06	2.33 ± 0.58	4.53 ± 0.06	4.97 ± 0.06	14.33 ± 0.58	6.33 ± 0.58
Dendrobium aphyllum	25.67 ± 2.52	0.40 ± 0.10	2.00 ± 0.00	2.00 ± 0.10	3.97 ± 0.06	20.67 ± 0.58	6.33 ± 0.58
Dendrobium primulinum	7.33 ± 1.53	0.90 ± 0.06	1.00 ± 0.00	3.13 ± 0.15	5.03 ± 0.25	6.33 ± 1.15	18.33 ± 0.58
Dendrobium fimbriatum	1.33 ± 0.58	10.10 ± 1.03	9.67 ± 1.15	4.03 ± 0.42	4.13 ± 0.12	9.33 ± 0.58	8.00 ± 1.00
Dendrobium nobile	4.33 ± 0.58	3.60 ± 0.15	3.00 ± 0.00	4.97 ± 0.06	6.73 ± 0.45	17.33 ± 0.58	14.67 ± 0.58
Dendrobium chrysotoxum	1.33 ± 0.58	16.30 ± 0.20	8.00 ± 1.00	3.37 ± 0.06	3.80 ± 0.26	14.33 ± 0.58	13.33 ± 0.58
Dendrobium densiflorum	1.67 ± 0.58	17.70 ± 0.12	29.67 ± 0.58	3.53 ± 0.06	2.93 ± 0.06	9.67 ± 1.15	12.33 ± 0.58
Dendrobium nobile var *alba*	3.33 ± 0.58	3.90 ± 0.06	3.67 ± 0.58	4.93 ± 0.06	7.17 ± 0.06	15.67 ± 1.53	14.67 ± 0.58
Dendrobium macraei	1.00 ± 0.00	0.70 ± 0.06	1.00 ± 0.00	1.23 ± 0.06	0.67 ± 0.06	4.67 ± 0.58	13.33 ± 0.58
Dendrobium jenkinsii	2.67 ± 0.58	0.50 ± 0.12	2.33 ± 0.58	1.63 ± 0.12	1.97 ± 0.06	4.33 ± 0.58	5.33 ± 0.58
Dendrobium wardianum	2.33 ± 1.53	1.10 ± 0.06	2.67 ± 0.58	5.77 ± 0.12	7.10 ± 0.10	12.33 ± 1.15	7.67 ± 1.15
Dendrobium thyrsiflorum	3.67 ± 0.58	17.40 ± 0.60	32.67 ± 0.58	2.63 ± 0.06	2.17 ± 0.06	8.33 ± 0.58	12.33 ± 0.58
Dendrobium devonianum	1.67 ± 1.15	0.70 ± 0.12	3.00 ± 0.00	6.03 ± 0.06	6.03 ± 0.15	9.00 ± 1.00	5.33 ± 0.58
Dendrobium chrysanthum	2.33 ± 1.15	0.90 ± 0.00	3.33 ± 0.58	2.17 ± 0.12	3.00 ± 0.10	8.67 ± 0.58	8.00 ± 1.00
Dendrobium eriiflorum	2.00 ± 0.00	8.70 ± 0.30	5.67 ± 0.58	1.13 ± 0.06	0.93 ± 0.06	5.67 ± 0.58	6.33 ± 0.58
SE(m) ±	0.672	0.191	0.333	0.078	0.097	0.487	0.362
CD (p=0.05)	1.951	0.553	0.967	0.228	0.280	1.413	1.049

Dendrobium nobile and *Dendrobium nobile* var. *alba* (14.67 days) while minimum was noted in species like *Dendrobium jenkinskii* and *Dendrobium devonianum* lasted only for 5 days. The variation in flower longevity of different species may be due to the difference in senescencing behavior of individual species. In a similar study by Hartati et al. (2021), it was reported that the flowering duration in *Dendrobium* species of Indonesia ranged from 9 days (*Dendrobium anosmum*) to 60 days *(Dendrobium mirbelianum).* It is evident from the above findings that species like *Dendobium aphyllum*, *Dendrobium densiflorum*, *Dendrobium thyrsiflorum* performed well with respect to plant height, number of internode, leaves and inflorescences, inflorescence length and number of flowers per infloresence. Further, these species have naturally cascading growth habit making it ideal for growing in hanging pots and creating a visually appealing display. For cut flower purpose, species like *Dendrobium nobile alba* and *D. nobile* were found to be suitable owing to its flower longevity, attractive flower colour and visual appeal along with its long and sturdy stems suitable for flower arrangements and display.

Diversity analysis

The agglomerative hierarchical clustering (AHC) divided 15 species into two major groups based on the correlation existing between the morphological traits among the species. The dendrogram for morphological traits of *Dendrobium* species is shown in Fig. 1. In the present study group 1 comprised of 5 species, which is further divided into two subgroups group 1a contains 3 species and 1b contains 2 species. Ten species were classified into group 2, which is again subdivided into three subgroups group 2a contains five species and group 2b and group 2c containing 4 and 1 species, respectively. The clusters exhibiting greater genetic similarity include *Dendrobium jenkinsii* and *Dendrobium macraei; Dendrobium thyrsiflorum* and *Dendrobium densiflorum; Dendrobium chrysanthum* and *Dendrobium primulinum; Dendrobium wardianum* and *Dendrobium nobile* var. *alba.* These

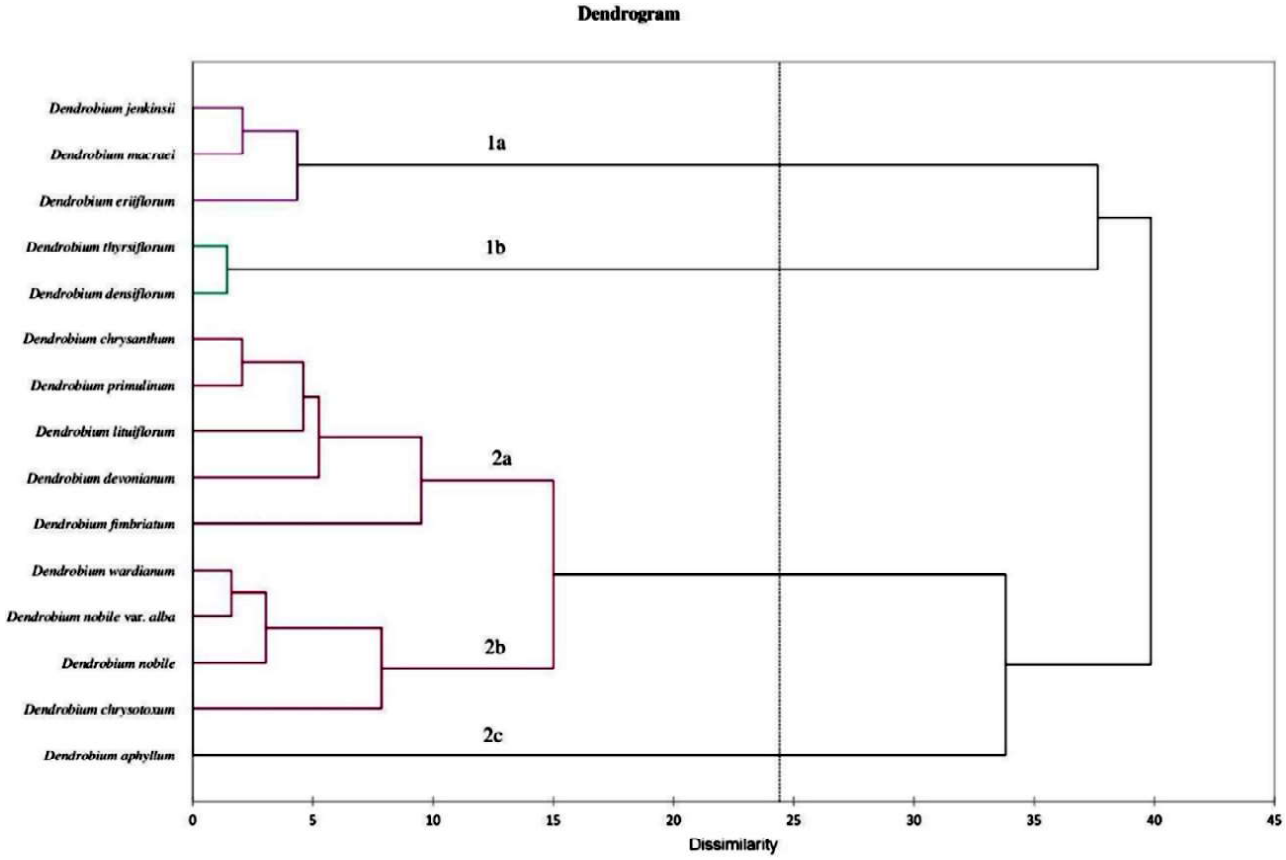

Fig. 1 : Dendrogram for morphological traits of *Dendrobium* species

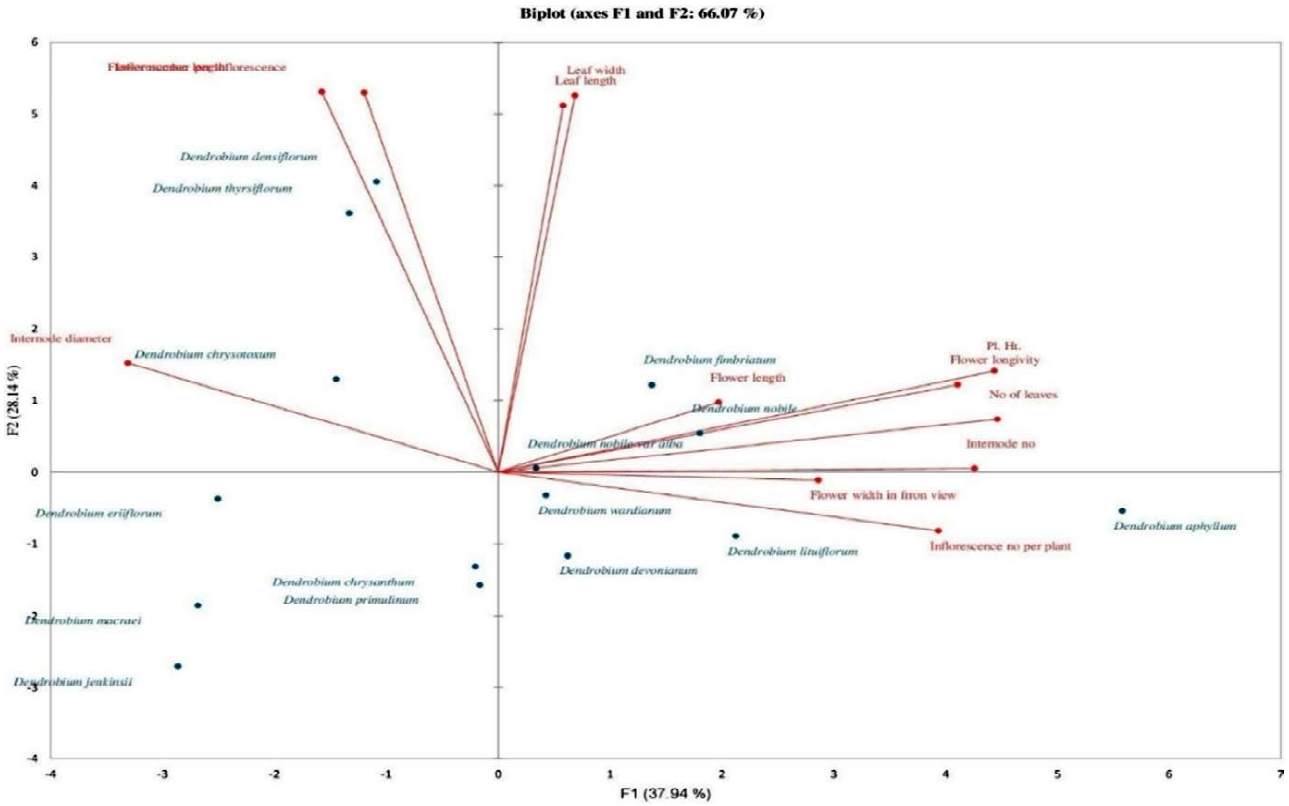

Fig. 2 : Scatter plot of *Dendrobium* species based on first two principal components

species demonstrate a higher likelihood of successful hybridization due to their genetic closeness. These findings are consistent with the results reported by Moudi & Go (2017) and Hartati et al. (2021) in *Dendrobium* species. Based on their genetic similarity, these closely related species pairs have been identified as suitable parental combinations with enhanced potential for successful crossing.

Table 4 : Principal component analysis of twelve quantitative traits of *Dendrobium* species

Variable	F1	F2	F3	F4	F5
Plant height	0.872	0.239	-0.275	-0.176	-0.154
Internode number	0.837	0.008	-0.329	-0.252	-0.269
Internode diameter	-0.65	0.257	0.07	0.628	-0.237
Number of leaves	0.877	0.125	-0.142	0.247	0.07
Leaf length	0.114	0.865	0.137	-0.154	-0.355
Leaf width	0.135	0.89	-0.004	0.049	0.375
Inflorescence number per plant	0.774	-0.139	-0.469	0.272	0.23
Inflorescence length	-0.31	0.898	-0.122	0.054	-0.12
Flower number per inflorescence	-0.235	0.896	-0.193	-0.152	0.238
Flower length	0.387	0.165	0.877	-0.169	0.076
Flower width in front view	0.563	-0.019	0.8	0.052	0.047
Flower longevity	0.807	0.207	0.199	0.464	-0.1
Eigenvalue	4.553	3.376	1.948	0.924	0.566
Variability (%)	37.938	28.136	16.236	7.699	4.717
Cumulative %	37.938	66.074	82.31	90.01	94.726

Principal component analysis (PCA)

To determine the most significant characteristics of the data set, the same set (15 species and 12 morphological characters) were used for cluster analysis, subjected to PCA. The analysis also helped to understand the contribution of morphological characters across the species used for grouping. The first principal component (F1) explained 37.93% of the total variation and the F2 explained 28.13% of total variation. The scatterplot of the first two principal components, accounting for 66.07% of cumulative variance supported the result of the cluster analysis (Fig. 2). In the first principal component of the five considered, number of leaves (+0.877) and internode number (+0.872) were the most important traits to contribute to the total phenotypic variation and internode diameter had a negative loading of -0.650 (Table 4).

For the second principal component, the most important traits were inflorescence length (+0.898), number of flowers per inflorescence (+0.896) and inflorescence number per plant had a negative loading of -0.139. The result of PCA is consistent with that of the cluster analysis. A similar pattern was also observed for hips traits in *Rosa* sp. (Verma et al., 2013) and in pea (Esposito et al., 2007).

CONCLUSION

Traits such as flower longevity, attractive flower colour and visual appeal along with its long and sturdy stems in species like *Dendrobium nobile alba* and *Dendrobium nobile* makes it suitable for cut flower and display purposes. Additionally, species such as *Dendrobium aphyllum*, *Dendrobium densiflorum*, *and Dendrobium thyrsiflorum* were also observed to have naturally cascading growth habit, making it ideal for growing in hanging pots and creating a visually appealing display. The clustering analysis revealed close genetic relationships among certain species within the population, indicating their usefulness in breeding programs aimed at developing novel flower colours, shapes, and forms through interspecific hybridization.

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