ASSESSMENT OF GENETIC DIVERSITY AMONG ORCHIDS USING MORPHOLOGICAL CHARACTERS

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Abstract

The present study was conducted to study the nature and magnitude of genetic diversity among twenty five orchids collected from different places of Mymensingh, Bangladesh. Based on genetic analysis phenotypic coefficients of variation was slightly higher than genotypic coefficients of variation. A wide range of variation was observed for the ten characters studied. Non -hierarchical clustering of twenty five orchids indicated five main groups or classes where orchids were placed according to their morphological traits resemblance. Group 3 had maximum number of orchids (9) followed by Group 2 (7). Clustering pattern revealed that geographical diversity was not associated with genetic diversity i.e., orchids collected from same location were grouped into different clusters or groups. The intra-group

distance was highest in the group 2 and the minimum intra-group distance was observed in the group 3, which included nine orchids. The inter-group (D^2) values varied from 3.579 to 18.724 indicating wide diversity among orchids. The maximum inter-group distance was observed between groups 4 x 1 and that of minimum in between the groups 4 x 2. Considering cluster mean values the orchids of group 3 and 4 could be selected for yield and flower contributing characters.

Keywords: Non -hierarchical clustering, D^2 analysis, genetic diversity, orchids.

Introduction

The Orchidaceae is the most numerous and the second largest group of flowering plants in the plant kingdom. There are about 788 genera and 25,000 to 30,000 known species of orchids around the world (Mabberley, 1997). Orchids attracting botanists, naturalists, and ecologists since the time immemorial due to their incredible range of diversity in shape, size, and colour of flowers. This highly advanced family of monocots is comprised mostly of herbaceous plants characterized by distinct floral morphology, pollination mechanism and minute seeds (Pridgeon *et al.*, 1999). In 2011, imports of orchids for bouquets and ornamental purposes have increased 13.06 per cent, from US$944,370 in 2010 to US$1.07 million imports of orchid plants, including roots, cuttings & slips were also expanded by 18.46 per cent in 2011 to US$1.32 million from US$1.12 million recorded in 2010. The worldwide suppliers in 2011 were the Netherlands (87.2 per cent), Taiwan (7.97 per cent), China (3.00 per cent), Thailand (1.23 per cent) and the United States (0.60 per cent), (SAGARPA, 2012). Among many reasons, the lack of high yielding is one of the reasons for less export of this flower. In crop improvement program, genetic diversity has been considered as an important factor for obtaining varieties with important desirable characters like disease resistant, earliness or quality of a particular character (Chowdhury, 1975). The present study was undertaken with the objective to estimate genetic variation, its components especially heritability, GCV (%), PCV (%), GA and GA (%) for selection the best characters for future breeding program in orchids.Using the morphological characters, genetic diversity among the collected orchids were carried out through univariate and multivariate analyses techniques. Genetic parameters such as genotypic coefficient of variation, phenotypic coefficient of variation, heritability in broad sense, genetic advance were calculated. For multivariate analyses, non-hierarchical clustering and intra and inter cluster distance were done. Moniruzzaman *et al*. (2012) observed that out of 15 quantitative characters studied in orchids, spike length, rachis length, plant height, floret number and flower durability exhibited high heritability. The characters exhibiting high hb^2 with high genetic advance were spike length (94.00% and 98.29), rachis length (95.34% and 93.85) and flower durability (94.00% and 89.00). The characters exhibited high hb^2 along with low genetic advance in orchid were plant height (87.00 and 40.99%) and pod size (74.00and 48.51%). High broad sense heritability with high genetic advance was observed in spike length (94.00% and 98.29), rachis length (95.34% and 93.85), flower durability (94.00% and 89.00) and floret number (70.50% and 65.47) indicating additive gene action, suggesting the possibility of improvement of these traits through selection. Other characters exhibited moderate broad sense heritability with low genetic advance. Hybridization and geographic distribution can be involved in the differentiation of the species and lineages in this complex (Fabio and Barros, 2009). According to Roychowdhury and Tah (2011), genetic improvement of any crop largely depends on the magnitude of several genetic parameters like analysis of variance of each mean value, phenotypic and genotypic variance, phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability (H2) and genetic advance (GA) on which the breeding methods are formulated for its further improvement.

Materials and Methods

Available twenty five orchids were collected from different places of Bangladesh including commercial orchid farm (Dipta Orchids (District Mymensingh) and BAU Campus. The genotypic, phenotypic coefficient of variation and genetic advance (GCV, PCV and GA) were computed on morphological data on the 10 most important quantitative characters according to the method advocated by Singh and Chaudhary (1985). Broad-sense heritability (h^2) was calculated as the ratio of the genotypic variance to the phenotypic variance using the formula according to Allard (1960). Cluster analysis as performed by D^2 analysis (Rao, 1952), which divides the orchids based on the data set into more or less homogenous groups. D^2 is the sum of squares of differences between any two populations for each of the uncorrelated variables (obtained by transforming correlated variables through pivotal condensation method). Clustering was done using non-hierarchical and hierarchical classification. (Rao, 1952). The procedure for calculating inter-group distance between group II and I, between group III and I, and between IV and I and so on. The groups were taken one by one and their distances from other groups were calculated.

Results

Genetic variability among orchids

The analysis of variance revealed significant differences among twenty five orchids for all the characters indicating the prevalence of genetic variability. The mean, coefficient of phenotypic and genotypic variations, heritability estimates and expected genetic advance in percent of mean are given in Table 1. A wide range of variation was observed for the ten characters studied. The phenotypic variation was higher than genotypic variation in all the characters indicating environmental influence. Average mean values for different characters showed wide variations among the characters (Table 1). Mean values were minimum (2.00) for spikes per plant and maximum (67.96) for plant height. The GCV value was maximum for plant height (67.77%) followed by leaf area (65.61), average flower weight (49.03) and average number of flowers per plant (47.59). Similarly PCV value was maximum for plant height (68.42%) followed by leaf area (64.36), average flower weight (48.86) and average number of flowers per plant (46.30), low values of GCV and PCV were recorded for spike length. Very little variations were observed between GCV and PCV values among all the characters. Broad sense heritability estimates were high (100.00) for horizontal and vertical spread of flower, flower weight (99.29), plant height (98.13), leaf area (96.21), roots per plant (96.05), root length (95.76), spike length (95.43) and flowers per plant (94.64). However it was moderate for spikes per plant (88.09). Significant variations occurred among all the characters under GA, maximum GA (93.98) was observed for plant height and minimum for spikes per plant (1.16).

Non-hierarchical clustering

Results on non -hierarchical clustering of twenty five orchid germplasm indicated five main groups or classes where orchids were placed according to their morphological traits resemblance. Group one had the orchids with maximum mean value for leaf area (160.42), plant height (158.87), aerial roots per plant (57.84) and vertical spread of flower (38.42), group two had orchids with maximum mean value for leaf area (49.45), plant height (49.21), vertical spread of flower (42.87) and flowers per plant (15.52), group three had orchids with maximum mean value for plant height (86.26), leaf area (52.99) and vertical spread of flower (38.07), group four had orchids with maximum mean value for vertical spread of flower (46.03), leaf area (34.04) and flowers per plant (21.69), group five had maximum values for leaf area (86.32), vertical spread of flower (45.33) (Table 2). According to their mean value for characters **Group 1** had Mokara Orange, Mokara Yellow Annie, Mokara Robin Red, **Group 2** had D. Earsakul, D. Miss Singapore, D. Kultana Blue, D. Violate White, D. Sacula Pink, D. Sonia, D.Qasim Gold, **Group 3** had Mokara Aranda Blue, Dendrobium White 5N, Mokara Carol Pink, Mokara Nora Blue, Mokara Dieheard Red, Dendrobium Chaingama pink, Ascosands, Mokara Chalk Guar Pink, Mokara Jitti, **Group 4** had Dendrobium Satu

Pink, Dendrobium Red Bull, Ascocentrum, Vanda, Oncidium and **Group 5** had only cattleya (Table 3). These groups were formed according to the mean values for morphological characters. Therefore orchids were grouped accordingly.

Intra and inter-group distance

The intra-group distance was highest in the group 2 followed by the group 4 (Table 4). The minimum intra-group distance was observed in the group 3, which included nine orchids. The inter-group (D^2) values varied from 3.579 to 18.724 indicating wide diversity among orchids. The inter- group distance was the highest between group 4 x 1 followed by the distance between group 2 x 1, 5 x 1, 3 x 1 and 5 x 3. The orchids grouped in group 4 x 1 showed maximum inter-group distance are expected to show wide variability in genetic make-up. The lowest inter-group distance observed in group 4 x 2 suggests that orchids of this group had closeness among themselves (Table 4).

Discussion

In the present study results showed that phenotypic coefficients of variations were slightly higher than the genotypic coefficients of variation for all the traits studied. This indicated the presence of environmental influence to some degree in the phenotypic expression of the characters. Sultana (2003) observed similar findings. Similarly Faroque (2003) and Roychowdhury *et al.* (2011), found environmental influence on genetic variability for these traits in orchids. High to medium broad sense heritability estimates observed for horizontal and vertical spread of flower, flower weight, plant height, leaf area, roots per plant, root length, flowers per plant and spike length. It suggests high component of heritable portion of variation, it is the portion which is exploited by breeders (Moniruzzaman *et al*., 2012). Different geographical conditions might have possesed a slight difference because of variations in environmental influenced characters like, leaf length, plant height and spike length. Therefore, diversity of morphological-based markers for genetic diversity of varieties and interaction of environment are expected to be quite high as reported by Trapnell *et al*. (2004), Pellegrino *et al*. (2005) and Jacquemyn *et al*. (2007). Non-hierarchical clustering and Intra and inter-group distance analysis avoided possible distortions produced by a specific method (Everitt, 1978), relationship of these methods is very clear from the results, which maximized the variance between characters by choosing axes that were linear combinations of biological variables.

Conclusion

Genetic variability among orchids was analyzed on the basis of morphological data which also showed variations among characters studied. analysis of the study revealed that the plant height, number of flowers per plant, leaf area, flower spread and the number of spikes per plant were the most important characters. Therefore, the results concluded that these characters are contributing traits and selection based on these traits would be most effective for plant breeders in developing new orchid varieties.

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Table 1: Mean, heritability, genotypic and phenotypic coefficients of variation, genetic advance and genetic advance in percent of mean for ten characters among orchids

Characters	Mean	Hb^2 (%)	GCV (%)	PCV (%)	GA	GA (%)
Plant height	67.96	98.13	67.77	68.42	93.98	138.28
Leaf area	62.43	96.21	64.36	65.61	81.17	130.01
Spikes/Plant	2.00	88.09	30.41	32.40	1.16	58.00
Spike length	41.34	95.43	24.51	25.09	20.38	49.29
Flower weight	2.43	99.29	48.86	49.03	2.43	100.00
Roots/Plant	6.90	96.05	40.47	41.29	5.61	81.30
Root length	40.09	95.76	37.19	38.01	30.04	74.93
Horiz. Flower	7.01	100.00	25.15	25.15	3.62	51.64
Verti. Flower	6.94	100.00	35.90	35.90	5.12	73.77
Flowers/Plant	16.59	94.64	46.30	47.59	15.38	92.70

Hb^2 = Heritability in broad sense (%), **GCV%=** Genotypic coefficients of variation (%), **PCV%** = Phenotypic coefficients of variation (%),**GA=** Genetic advance, **GA%=** Genetic advance in percent of mean.

Table 2: Non-hierarchical clustering analysis showing class mean values in five groups of orchids

Characters	I	II	III	IV	V
1	158.87	49.21	86.26	19.42	4.49
2	160.42	49.45	52.99	34.04	86.32
3	1.86	1.95	2.02	2.01	2.57
4	3.08	2.14	2.60	1.93	3.43
5	9.31	0.00	6.18	0.95	1.33
6	57.84	0.00	33.48	4.52	23.73
7	7.12	6.64	7.67	5.76	9.67
8	7.29	5.94	7.63	5.79	12.47
9	38.42	42.87	38.07	46.03	45.33
10	17.18	15.52	13.96	21.69	20.53

Table 3: Groups containing class order (orchids) according to their similarities among characters

Groups	Orchids
Group 1	Mokara Orange, Mokara Yellow Annie, Mokara Robin red
Group 2	Dendrobium Earsakul , Dendrobium Miss Singapore, Dendrobium Kultana Blue, Dendrobium Violate White, Dendrobium Sacula Pink, Dendrobium Sonia, Dendrobium Qasim Gold
Group 3	Mokara Aranda Blue, Dendrobium White 5N, Mokara Carol Pink, Mokara Nora Blue, Mokara Dieheard Red, Dendrobium Chaingama pink, Ascosands, Mokara Chalk Guar Pink, Mokara Jitti
Group 4	Dendrobium Satu Pink, Dendrobium Red Bull, Ascocentrum, Vanda, Oncidium
Group 5	Cattleya

Table 4: Intra and inter-group distances (D^2)

Groups	1	2	3	4	5
1	0.000				
2	**16.159**	0.000			
3	13.997	**5.560**	0.000		
4	18.724	3.579	**7.194**	0.000	
5	16.061	9.814	11.267	**9.476**	0.000

Figure 1. Orchid flowers with variation in colors

Mokara Orange

Mokara Yellow Annie

Mokara Robin Red

Mokara Aranda Blue

Dendrobium White 5N

Dendrobium Earsakul

Dendrobium Miss Singapore

Dendrobium Kultana Blue

Dendrobium Violate White

Mokara Carol Pink

Dendrobium Satu Pink

Dendrobium Red Bull

Dendrobium Chaingama pink

Dendrobium Sacula Pink

Dendrobium Sonia

Ascocentrum garayi (E.)

Vanda coerulea (G.)

Ascosanda sp

Cattleya percivaliana (R.)

Oncidium crista (R.)

Mokara Chalk Guar Pink

Mokara Jitti

Dendrobium Qasim Gold

Mokara Nora Blue

Mokra Dieheard Red