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Genetic variability, character association and path coefficient analysis in orchids (*Orchid* spp) of Mizoram, Sikkim and Darjeeling District of West Bengal for various quantitative traits

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ABSTRACT

Efforts were made on augmentation of orchids germplasm in different parts of Mizoram, Pakyong (Sikkim) and Pedong (Darjeeling hills of West Bengal) during 2011-2013 to estimate the genetic variability, heritability, genetic advance, correlation and path coefficient in seventy nine diverse genotypes of orchids on 14 important quantitative traits. Germplasms were evaluated for various vegetative, floral and spike quality related traits. Flower quality characters like length of spike, length of internode of the spike, length of pedicel were found to be high in the species like *Arundina graminifolia* and *Cymbidium aloifolium*. However, the number of florets/spike was more in *Oberonia orbicularis* and *Oberonbia iridifolia* and *Phaius tankervillae* recorded biggest floret size. Spike longevity was found to be high in *Dendrobium formosum* and *Vanda parishii*. Spike yield was maximum in *Dendrobium chrysanthum* and *Dendrobium eriaeflorum*. The study revealed wide variation for all the characters indicating sufficient genetic variability to be exploited in breeding programme. The maximum value of PCV and GCV was recorded for floret diameter. High heritability coupled with high genetic advance was observed for plant height, leaves/pseudobulb, florets/spike, floret diameter and pedicel length. Selection on the basis of these characters would be more effective for the improvement of orchids. Spike length showed positive and highly significant association with spike longevity and number of florets/spike at genotypic and phenotypic level. Highly significant correlation of spike yield was found with pseudobulbs/plant, leaf dimensions, flowers/spike and number of spike/pseudobulb at both the levels of correlation coefficient.

Key words*:* Correlation, Genetic variability, Heritability, Orchids, Path analysis

Orchidaceae represent the most highly evolved family among monocotyledons comprising 30 000-35 000 species within 800 genera out of which 1300 species are found in India (Chowdheri 2001, Singh 2001). The Eastern Himalayas comprises about 839 Orchid species, distributed in various States of the region and is known as "Orchid paradise" of our country. Out of them, 187 species are endemic, 108 endangered and threatened and about 18 species are feared extinct or nearly extinct. About 150 species are ornamental having commercial value, whereas 53 species are medicinally useful (Hedge 2005). North East region of India is one of the world's richest centres of crop genetic diversity due to diverse climatic conditions and socioeconomic and cultural variation (Pandey *et al*. 2011). Nearly 70 percent of the country's total orchid taxa are reported from this region (comprising Assam, Meghalaya, Mizoram, Manipur, Tripura and Arunachal Pradesh) and Himalayan regions of Bhutan, Sikkim and Darjeeling hills (Kataki *et al*. 1984). The extensive survey by Thapa and Sahoo (2003) in the State forests of Mizoram reported a total of 105 orchid species and Botanical Survey of India (BSI), North East region had also enlisted 253 species of orchids in Mizoram. The identified species were with their botanical names but without any description or systematic studies. The State is quite underexplored and adequate information regarding the vast genetic resources and biodiversity is lacking. Exploring the existing genetic diversity is an emerging need so as to use the diversity available for broadening the genetic base of cultivars for crop improvement. The objective of this study was to evaluate orchid genotypes, to study yield attributing components, their heritability and genetic advance.

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MATERIALS AND METHODS

Efforts were made on augmentation of orchids germplasm through exploration in different parts of Mizoram including Pakyong (Sikkim) and Pedong (Darjeeling hills

of West Bengal) during the period from 2011-2013**.** The survey was carried out from March to May and November to January comprising 79 species of orchids (Table 1) . The climate differs with difference in geographical distribution. The recommended package of practices was followed and the data were recorded on five randomly selected plants from each species. Observations were recorded on 14 yield and its attributing characters, viz. plant height, number of pseudobulb/plant, number of leaves/pseudobulb, leaf length, leaf breadth, length of spike, internodal length of spike, number of florets/spike, length of florets, diameter of florets, length of pedicel, spike longevity on plant, number of spikes/ pseudobulb and spike yield/shoot. Mean values were taken for analysis of variance as per Panse and Sukhatme (1978). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variability (PCV) were calculated by using formulae suggested by Burton and Devane (1953), Heritability and genetic advance (GA) as suggested by Hanson *et al.* (1956). The Pearson's correlation coefficient was estimated from analysis of variance and covariance for all the characters as suggested by Al-Jibouri *et al*. (1958). Path co-efficient analysis was carried out at the genotypic level as suggested by Wright (1921).

RESULTS AND DISCUSSION

Genetic variability, heritability and genetic advance

The study revealed wide variations for all the characters indicating sufficient genetic variability to be exploited in a breeding programme (Table 2). Among the different traits, the value of PV ranged from 2.589 to 831.500. The maximum phenotypic variance was recorded in florets/spike, i.e. 831.500, whereas it was minimum in spikes/pseudobulb 2.589. The value of PCV ranged from 13.41-97.81 percent. Among the traits, floret diameter recorded the highest PCV (13.41 %). The genotypic coefficient of variation ranged from 2.080 to 829.530. The maximum genotypic variance was recorded in florets/spike 829.530, whereas it was minimum in spikes/pseudobulb, i.e. 2.080. The value of GCV ranged from 13.39-97.11 percent. Among the traits, floret diameter recorded the highest GCV (97.11 %). The heritability ranges from 83.26-99.70 percent. The highest heritability in broad sense was observed for florets/spike (99.70%) followed by plant height (99.69%) and spike length (99.045). Pseudobulbs/plant (83.26%) recorded the lowest value for heritability. Among the characters studied, florets/spike (27.54%) recorded the highest genetic advance followed by floret diameter (19.86 %) and leaves/pseudobulb (19.89%).

The magnitude of PCV was higher than GCV for all the characters suggesting the influences of the environmental forces on the expression of these characters. Similar results for genotypic and phenotypic coefficient of variation have also been reported in tulip by Jhon *et al.* (2006). The GCV along with heritability estimates provides a better picture of the amount of genetic advance to be expected by phenotypic selection (Burton 1952). The heritability of characters

Table 1 Treatment details of 79 Orchids (*Orchid* spp.)

Symbol	Treatment	Symbol	Treatment
T1	*Acampe rigida*	T41	*Flikingeris fugax*
T2	*Arundina graminifolia*	T42	*Oberonia iridifolia*
T3	*Cleisostoma racemiferum*	T43	*Aerides odoratum*
T4	*Coelogyne corymbosa*	T44	*Cymbidium iridifolium*
T5	*Coelogyne viscosa*	T45	*Dendrobium fimbriatum*
T6	*Dendrobium orchreatum*	T46	*Dendrobium transparens*
T7	*Renanthera imschootiana*	T47	*Porpax fibuliformis*
T8	*Bulbophyllum affine*	T48	*Thunia alba*
T9	*Dendrobium densiflorum*	T49	*Ascocentrum ampullaceum*
T10	*Dendrobium nobile*	T50	*Bulbophyllum hirtum*
T11	*Dendrobium peguanum*	T51	*Bulbophyllum scabratum*
T12	*Oberonia orbicularis*	T52	*Bulbophyllum thompsonii*
T13	*Otochilus porrecta*	T53	*Coelogyne flaccida*
T14	*Papilionanthe teres*	T54	*Coelogyne punctulata*
T15	*Peristylus constrictus*	T55	*Coelogyne stricta*
T16	*Pholidota imbricata*	T56	*Cymbidium eburneum*
T17	*Aerides multiflorum*	T57	*Cymbidium mastersii*
T18	*Cymbidium aloifolium*	T58	*Dendrobium cumulatum*
T19	*Dendrobium chrysanthum*	T59	*Dendrobium denudans*
T20	*Dendrobium primulinum*	T60	*Dendrobium eriaeflorum*
T21	*Dendrobium falconeri*	T61	*Dendrobium farmeri*
T22	*Vanda coerulea*	T62	*Dendrobium heterocarpum*
T23	*Bulbophyllum affine*	T63	*Epidendrum radicans*
T24	*Coelogyne nitida*	T64	*Eria coronaria*
T25	*Dendrobium chrysotoxum*	T65	*Paphiopedilum hirsutissimum*
T26	*Dendrobium formosum*	T66	*Pleione maculata*
T27	*Dendrobium parishii*	T67	*Pleione precox*
T28	*Vanda cristata*	T68	*Vanda parishii*
T29	*Eria coronaria*	T69	*Coelogyne flavida*
T30	*Gastrophylus calceolaris*	T70	*Coelogyne fuscescens*
T31	*Otochylus alba*	T71	*Cymbidium eburneum*
T32	*Pholidota articulata*	T72	*Cymbidium devonianum*
T33	*Papilionanthe teres*	T73	*Cymbidium mastersii*
T34	*Phaius tankervillae*	T74	*Dendrobium fimbriatum*
T35	*Coelogyne flavida*	T75	*Dendrobium jenkinsii*
T36	*Cleisosotoma racemiferum*	T76	*Oncidium anceps*
T37	*Dendrobium anceps*	T77	*Peristylus constrictus*
T38	*Dendrobium moschatum*	T78	*Phaius flavus*
T39	*Dendrobium crepidatum*	T79	*Renanthera imschootiana*
T40	*Eria spicata*		

T = Treatment

Table 2 Mean, range and estimates of variability, heritability and genetic advance as a per cent of mean for various characters in 79 orchids (*Orchid* spp.)

Character	Ranges		Mean	SED	Variances			CV	GCV	PCV	H^2 broad	GA (%)
	Min.	Max.			GV	PV	EV		(%)	(%)	sense (%)	of mean
Plant height (cm)	1.80	152.77	77.29	1.054	779.585	781.251	1.667	5.04	87.938	89.244	99.69	18.325
Pseudobulbs/plant	1.00	10.00	5.50	0.833	4.548	5.588	1.040	25.48	56.191	61.582	74.54	10.562
Leaves/pseudobulb	1.00	41.77	21.39	0.928	55.042	56.333	1.291	22.36	95.164	96.177	97.91	19.397
Leave length (cm)	3.50	54.67	29.09	1.088	107.759	109.533	1.774	8.77	58.886	60.979	93.25	11.714
Leaf diameter (cm)	0.04	10.00	5.02	0.258	2.303	2.402	0.100	14.24	53.651	54.898	95.51	10.801
Florets/spike	0.73	72.50	36.62	1.146	829.530	831.500	1.970	8.00	13.392	13.412	99.70	27.548
Floret length (cm)	0.33	8.53	4.43	0.200	5.391	5.451	0.060	3.80	54.474	55.133	97.62	11.088
Floret diameter (cm)	1.00	115.00	58.00	0.312	7.009	7.156	0.146	6.70	97.112	97.817	98.56	19.861
Pedicel length (cm)	3.50	54.67	29.09	0.154	6.006	6.041	0.036	6.16	63.521	64.166	98.00	12.954
Spike length (cm)	0.17	6.70	3.44	1.123	265.896	267.789	1.893	13.35	82.726	83.127	99.04	16.959
Internodal lt. (cm)	0.26	12.70	6.48	0.099	3.057	3.072	0.015	5.19	55.563	55.742	99.36	11.409
Spike longevity (days)	5.33	40.00	22.67	0.953	65.788	67.150	1.363	8.29	54.240	55.342	96.06	10.951
Spikes/Pseudobulb	1.00	9.30	5.15	0.583	2.080	2.589	0.509	21.92	69.516	75.730	67.16	13.145
Spike yield/shoots	1.33	13.00	7.17	0.961	5.358	6.075	0.717	15.44	43.976	47.910	84.25	8.315

determine how much the phenotype of a plant is a guideline to the genotype and thus, help the breeder to base his selection on the phenotypic performance of the plant (Kumar *et al*. 2012). The heritable portion of variability was thus determined with the help of broad sense heritability. High estimates of heritability were observed for the characters, viz. plant height, leaves/pseudobulb, florets/spike, floret length, floret diameter, pedicel length, spike length and internodal length while other characters like pseudobulbs/plant and spikes/pseudobulb showed moderate heritability indicating that a major part of the phenotypic variability in these characters was controlled by additive genes and hence improvement can be made by simple selection. Similar results have been reported by Pathania *et al*. (1988). High heritability coupled with high genetic advance for plant height, leaves/pseudobulb, florets/spike, floret diameter and pedicel length indicated the scope of improvement through direct selection. High heritability coupled with high genetic advance for these traits may be because of additive gene effect (Bhatia 2004).

High heritability with moderate to low genetic advance in leaf length, leaf diameter, floret length, internodal length and spike yield may be due to dominant and epistatic gene action and simple selection may not be futile. Improvement of these trait could be made through hybridization. Low heritability estimates along with low genetic advance as a percent of mean for pseudobulbs/plant and spikes/pseudobulbs indicated contribution of non-additive gene effect and adequate progeny testing could be done for improvement.

Correlation and Path coefficient analysis

Correlation studies were carried out to reveal the nature and extent of association between growths, flower and spike related traits. Spike yield along with spike length, numbers and size of florets and height of pseudobulbs deserves special attention as these are economically important traits in orchids breeding. From correlation matrix (Table 3), it was observed that height of pseudobulb exhibited positive and highly significant association with leaf production (0.454 for genotypic and 0.449 for phenotypic), floret length (0.318 for genotypic and 0.316 for phenotypic), floret diameter (0.307 for genotypic and 0.304 for phenotypic) and length of spike (0.302 for genotypic and 0.300 for phenotypic) at genotypic and phenotypic level. Positive and significant correlation was noticed between leaf length and spike length (0.530 for genotypic and 0.526 for phenotypic). Leaf length also had positive and significant correlation with leaf diameter (0.331 for genotypic and 0.325 for phenotypic) and floret length (0.284 for genotypic and 0.280 for phenotypic). Number of florets/spike showed positive and significant correlation with floret length (0.346 for genotypic and 0.345 for phenotypic), length of spike (0.292 for genotypic and 0.290 for phenotypic) and spike longevity (0.332 for genotypic and 0.314 for phenotypic). Positive and significant correlation was noticed between floret length and number of florets/spike (0.346 for genotypic and 0.345 for phenotypic). Positive and significant association between pedicel length and internodal length was also noticed (0.279 for genotypic and 0.278 for phenotypic). Spike length showed positive and highly significant association with spike longevity (0.403 for genotypic and 0.398 for phenotypic) and number of florets/spike (0.292 for genotypic and 0.290 for phenotypic) genotypic and phenotypic level. Number of spikes/pseudobulb exhibited positive and highly significant correlation with pseudobulb/plant (0.322 for genotypic and 0.279 for phenotypic), leaf production (0.299 for genotypic and 0.275 for phenotypic) and yield (0.398 for genotypic and 0.320 for phenotypic). Spike yield showed positive and highly significant correlation with number of pseudobulbs/plant (0.671 for genotypic), leaf diameter (0.262 for genotypic and 0.235 for phenotypic), number of flowers/spike (0.332 for genotypic and 0.314 for

Table 3 Genotypic and phenotypic correlation among the fourteen characters of 79 orchids (*Orchid* spp.)

Character		Pseudobulbs/ plant	Leaves/ pseudobulb	Leaf length (cm)	Leaf dia. (cm)	Florets/ spike	Floret length (cm)	Floret dia. (cm)	Pedicel length (cm)	Spike length (cm)	Internodal length (cm)	Longevity of spike (days)	Spikes/ pseudobulb	Spike yield/ shoot
Plant height (cm)	G	-0.138	0.454 **	0.155	-0.036	-0.134	0.318**	0.307**	0.046	0.302**	0.110	0.208	-0.029	0.022
	P	- 0.124	0.449**	0.154	-0.035	-0.134	0.316**	0.304**	0.045	0.300 **	0.110	0.206	-0.025	0.019
Pseudobulbs/plant	G	1.000	0.017	0.074	-0.197	-0.254*	0.179	-0.037	-0.068	-0.034	0.014	-0.145	0.322**	0.671**
	P	1.000	0.024	0.069	-0.181	-0.230	0.166	-0.035	-0.059	-0.030	0.014	-0.133	0.279 *	0.166
Leaves/pseudobulb	G		1.000	-0.021	-0.068	-0.042	0.164	0.182	-0.124	0.261*	0.303**	0.356 **	0.299 **	0.064
	P		1.000	-0.023	-0.062	-0.041	0.162	0.179	-0.122	0.257*	0.299 **	0.348 **	0.275 *	0.064
Leave length (cm)	G			1.000	0.331**	0.040	0.284**	0.148	0.176	0.530**	-0.241*	0.301**	-0.066	0.132
	P			1.000	0.325**	0.040	0.280*	0.146	0.176	0.526**	-0.238*	0.297**	-0.063	0.127
Leaf diameter (cm)	G				1.000	0.128	0.003	-0.100	0.235*	0.149	-0.120	0.155	-0.191	0.262*
	P				1.000	0.126	0.003	-0.002	0.231*	0.146	-0.115	0.152	-0.165	0.235*
Florets/spike	G					1.000	0.346**	-0.264*	-0.012	0.292**	-0.216	0.326 **	-0.100	0.332**
	P					1.000	0.345**	-0.261*	-0.012	0.290 **	-0.215	0.323 **	-0.092	0.314**
Floret Length(cm)	G						1.000	0.409**	0.174	0.211	0.089	0.093	0.122	0.294**
	P						1.000	0.405 **	0.172	0.208	0.087	0.092	0.106	0.281*
Floret diameter (cm)	G							1.000	0.216	0.144	0.181	0.150	-0.029	0.018
	P							1.000	0.213	0.142	0.178	0.146	-0.027	0.014
Pedicel length (cm)	G								1.000	0.169	0.279 *	-0.065	0.201	0.107
	P								1.000	0.169	0.278 *	-0.064	-0.047	0.100
Spike length (cm)	G									1.000	-0.082	0.403**	-0.051	0.025
	P									1.000	-0.082	0.398**	-0.047	0.022
Internodal length (cm)	G										1.000	0.007	0.297 **	0.065
	P										1.000	0.008	0.268 *	0.063
Spike longevity (days)	G											1.000	0.014	0.103
	P											1.000	0.007	0.089
Spikes/pseudobulb	G												1.000	0.398**
	P												1.000	0.320**

Significant at P=0.05, Significant at P=0.01

phenotypic) leaf length (0.294 for genotypic and 0.281 for phenotypic) and number of spikes/pseudobulb (0.398 for genotypic and 0.320 for phenotypic) at both the levels of correlation coefficient. In the present study, the correlation coefficients at genotypic level were higher than phenotypic correlation values, which might be due to the masking effect of environment in the total expression of genotypes resulting in reduced phenotypic association. Similar trend was also observed by Raghve *et al*. (1992) in chrysanthemum, Anuradha (1998) and Chauhan (2005) in gerbera for most of the traits. Pseudobulb height exhibited positive and highly significant association with leaf production, floret dimension and length of spike at genotypic and phenotypic level. Patil *et al*. (2004) also revealed positive correlation between plant height with stalk length and leaf production in carnation.

Number of florets/spike showed positive and significant correlation with floret length, length of spike and spike longevity but showed negative association with diameter of floret and internodal length of spike. Moniruzzaman *et al.* (2012) reported highly significant association of number of florets/spike with spike durability and spike length on *Dendrobium* orchids. Spike length showed positive and highly significant association with spike longevity and number of florets/spike at genotypic and phenotypic level. Positive correlation of spike longevity with rachis length, flower size and spike length was also reported by Moniruzzaman *et al.* (2012) in *Dendrobium* orchids. Number of spikes/pseudobulb exhibited positive and highly significant correlation with pseudobulbs/plant and leaf production. This finding is in accordance with reports made by Kumar and Sharma (2013). Spike yield showed positive and highly significant correlation with pseudobulbs/plant, leaf dimensions, flowers/spike and number of spikes/ pseudobulb at both the levels of correlation coefficient. Significant and positive association of spike yield with flower diameter was also reported by Anuja and Jahnavi (2012).

Selection of genotypes based only on correlation may be misleading because it measures only the mutual association between two variables, whereas, path coefficient analysis specifies and measures the importance of different components. In the present investigation the path coefficient analysis was performed to estimate the direct and indirect contribution of various plant characters to spike yield (Table 4). From the genotypic path analysis, positive direct effects of independent characters, viz. plant height, number of pseudobulbs/plant, leaves/pseudobulb, leave length, floret length, pedicel length, internodal length, spike longevity and spikes/pseudobulb was observed, whereas leaf diameter, number of florets/spike, floret diameter and length of spike incurred negative direct effects towards spike yield per shoot. Pseudobulbs/plant imparted maximum positive direct effect (0.543) on spike yield followed by pedicel length, leaf length, floret length, plant height, spike length, leaves/ pseudobulb and internodal length. Similarly, leaf diameter imparted maximum negative direct effect (-0.193) on spike

Table 4 Genotypic path coefficient of 13 characters of 79 orchids (*Orchid* spp.) on dependable variable yield

Character	Plant height (cm)	Pseudobulb/ plant	Leaves/ pseudobulb	Leave length (cm)	Leaf dia. (cm)	Florets/ spike	Floret lt. length (cm)	Floret dia. (cm)	Pedicel lt. length (cm)	Spike lt. length (cm)	Internodal length (cm)	Spike longevity (days)	Spikes/ pseudobulb	Spike yield/ shoot
Plant ht. (cm)	0.058	-0.075	0.175	0.020	-0.008	0.019	0.031	-0.030	0.008	-0.023	-0.007	0.008	-0.004	0.022
Pseudobulbs/plant	-0.008	0.543	0.000	0.009	0.038	0.037	0.031	0.004	-0.012	0.003	-0.001	-0.006	0.045	0.671**
Leaves/pseudobulb	0.027	0.009	0.019	-0.003	0.013	0.006	0.016	-0.018	-0.022	-0.020	-0.020	0.015	0.042	0.064
Leaf length (cm)	0.009	-0.000	-0.000	0.131	-0.064	-0.006	0.027	-0.015	0.031	-0.041	0.016	0.013	-0.009	0.132
Leaf dia. (cm)	-0.002	-0.107	-0.001	0.043	-0.193	-0.019	0.000	-0.015	0.041	-0.012	0.008	0.013	-0.02	0.262*
Florets/spike	-0.008	-0.138	-0.001	0.005	-0.025	-0.025	0.033	0.026	-0.002	-0.023	0.0145	0.004	-0.014	0.332**
Floret length (cm)	0.018	0.097	0.003	0.037	0.000	0.000	0.096	-0.040	0.031	-0.016	-0.006	0.006	0.017	0.294**
Floret dia. (cm)	0.018	-0.020	0.003	0.019	0.000	0.039	0.039	-0.040	0.037	-0.011	-0.018	-0.003	-0.004	0.018
Pedicel length (cm)	0.003	-0.037	-0.002	0.019	-0.045	0.002	0.017	-0.021	0.175	-0.013	-0.018	-0.003	0.028	0.107
Spike length (cm)	0.017	-0.018	0.005	0.069	-0.028	-0.043	0.020	-0.014	0.029	-0.078	0.017	0.017	-0.007	0.025
Internodal length (cm)	0.006	0.008	0.005	-0.031	0.023	0.032	0.008	-0.018	0.049	0.006	0.017	0.007	0.041	0.065
Spike longevity (days)	0.012	-0.078	0.004	0.039	-0.029	-0.048	0.009	-0.015	-0.0113	-0.031	0.042	0.042	0.002	0.103
Spikes/pseudobulb	-0.002	0.175	0.006	-0.008	0.037	0.015	0.012	0.003	0.035	0.004	0.003	0.005	0.141	0.398**

Residual effect = 0 .64

yield followed by floret diameter and number florets/spike. Yield was positively and significantly correlated with pseudobulbs/plant, leaf diameter, number of florets/spike, floret length and number of spikes/pseudobulb .On the basis of genotypic path analysis , pseudobulbs/plant had the highest positive direct effect on yield. Comparatively higher direct effects on yield was also exerted by pedicel length, leaf length, flower length and spike longevity. The significant positive correlation coefficients were recorded for leaf diameter and number florets/spike despite their negative effect and positive correlation may be influenced via indirect positive effect of pseudobulbs/plant, pedicel length and leaf length. Number of pseudobulbs/plant, pedicel length, leaf length and floret length were found to be the most important attributable components for increased yield. Therefore, direct selection for these characters would be effective for yield improvement in orchids. Moniruzzaman *et al.* (2012) also indicated spike longevity as an influencing contributor to yield.

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