Genetic Variability in Aghani Group of Indian Cauliflower (*Brassica oleracea* var. *botrytis*)

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Highest variability was observed in leaf size, curd weight without guard leaves and curd weight with guard leaves. Phenotypic coefficient of variance was invariably higher than corresponding genotypic coefficient of variance for all the morphological traits. More than 80% heritability was recorded for curd weight with guard leaves, curd weight without guard leaves and leaf size. Leaf size, curd weight with guard leaves and curd weight without guard leaves exhibited high genetic advance along with high heritability. Yield was significant and positive correlated with curd width and curd weight with guard leaves. Leaf size had positive correlation with curd weight with guard leaves. Head compactness exhibited negative significant correlation with curd width. The highest positive direct effect was exerted by curd weight with guard leaves and curd width whereas negative effect observed for leaf size. Multivariate Cluster Analysis based on Ward's method showed that the genotypes were mainly divided at the first node into 2 clusters with 7 and 23 genotypes in different groups.

Key words: Aghani cauliflower, PCV, GCV, h^2, Genetic advance, Multivariate clustering

Introduction

Cauliflower (*Brassica oleracea* L. var. botrytis) commonly known as 'Phool gobhi', is most popular vegetable in India among the cole crops. Indian cauliflower are characteristically different from European type, as tolerant to high temperature and humid conditions. Most of the Indian cultivars are named after the month of maturity like Aghani (25^{th} September) etc. The mid group cultivars are of short plant type, bluish green leaves with waxy bloom and with very small to medium curd size. Cauliflower was introduced to India in 1822 when Dr. Jemson, a botanist Kew, took change of the Company Bagh (United Provinces, Saharanpur in the Northern plains) to carry out some horticulture experiments during the period of the East India Company (Swarup and Chatterjee, 1972). The original introductions were cornish type which originated in England followed by temperate type, originated in Germany and Netherlands in 18^{th} Century (Swarup and Chatterjee, 1972). Presently, tropical Indian cauliflower is a result of intercrossing between European and Cornish type, which is more adopted and resistant to high temperature and high rainfall.

Materials and Methods

The present investigation was carried out at the research farm of Indian Institute of Vegetable Research; Varanasi during 2004-05. The experiment was laid out in Randomized Block Design with three replication and recommended agronomical practices were followed to raise good crop. Data were recorded on 12 morphological characters *viz.* plant height, number of leaves/ plants, leaf length, leaf width. curd length, curd width, stalk length, curd weight with gourd leaves, leaf area, leaf size, head compactness, and curd weight without gourd leaves or yield of thirty Aghani genotypes of cauliflower collected all over the country. Recorded values were subjected to statistical analysis of variance and co-variance as prescribed by Burton (1952). Correlation coefficients were carried out according to the method suggested by Panse and Sukhatme (1967) and path coefficient analysis was followed as explained by Dewey and Lu (1959), while heritability (%) and expected genetic advance were worked out as suggested by Johnson *et al.*, (1955), respectively. Multivariate clustering analysis has been carriedout to choose the parents for hybridization. This approach help in reducing the large amount of data about the parents to manageable proportions (Peter and Martinalli, 1989).

Results and Discusion

Variability Analysis

The analysis of variance (ANOVA) revealed that all genotypes expressed highly significant differences for twelve quantitative characters under study, indicating adequate scope for selection of superior and diverse genotypes (Table 1). The maximum genotypes showed wide range of variability for leaf size (620-1341), curd weight without guard leaves (603-1043), curd weight with guard leaves (830-1412) plant height (54-63) and leaf width (14-25). The genotypes with high mean value can

Table 1. Variability, heritability and expected genetic advance for Aghani cauliflowers

Character	Range	Grand Mean	Variability		Habitability %	Genetic advance	Genetic advance as % of mean
			GCV	PCV			
Plant height (cm)	54.67-63.00	58.06	3.39	4.69	52.2	2.39	2429.3
No of Leaves per Plant	25.00-35.33	30.71	7.59	9.17	68.5	3.97	773.6
Leaf Length (cm)	43.33-56.00	50.59	5.61	6.62	71.7	4.95	1022.0
Leaf width (cm)	14.00-25.00	18.83	13.38	15.70	72.6	4.42	426.0
Curd length (cm)	13.00-18.00	15.61	10.20	14.30	50.9	2.34	667.1
Curd width (cm)	15.67-20.00	17.31	4.95	8.80	31.6	0.99	1748.5
Stalk Length (cm)	6.00-11.33	8.84	15.00	24.31	38.1	1.69	523.1
Curd weight with Gourd leaves (gm)	830.00-1411.67	1006.81	12.33	12.65	95.1	249.37	403.7
Leaf Size (cm)	620.00-1341.33	954.18	17.16	18.28	88.1	316.55	301.4
Leaf area (cm^2)	1.85-3.32	2.742	9.22	15.11	37.2	0.32	856.9
Head Compactness (%)	10.39-2059	14.93	14.80	19.95	55.0	3.38	441.7
Yield (Curd weight without gourd leaves) (gm)	603.33-1043.33	764.92	13.28	13.84	92.1	200.85	380.8

PCV & GCV – Phenotypic coefficient of variation and genotypic coefficient of variation

be directly used for adaptation or can be used as parents in hybridization. This indicates that the indigenous materials have sufficient amount of variation for most of the traits and selection will be very effective. The phenotypic coefficient of variation (PCV) was greater than genotypic coefficient of variation (GCV) for all the traits, being highest for stalk length (24.3 -15) followed by curd length (14.3-10.2), which indicate that the genotypic expression was super-imposed by the environmental influences.

More than 80% heritability was recorded for curd weight with guard leaves, curd weight without guard leaves and leaf size. The characters which exhibited high heritability suggested that selection will be more effective for as the characters. High genetic advance was observed in leaf size (316.55), curd weight with guard leaves (249.37) and curd weight without guard leaves (200.85). High genetic advance as percentage of mean was observed for plant height (2429), curd width (1022) and leaf length (1022). High heritability estimate in combination with high genetic advance is more useful than heritability alone in selecting the best individuals. Leaf size (88, 316), curd weight with guard leaves (95, 249) and curd weight without guard leaves (92, 201) exhibited high values. Kanwar and Korla (2002) observed that phenotypic and genotypic coefficient of variance in late maturing cauliflower was moderate for stalk length and net curd weight and high heritability with moderate genetic gain for stalk length and leaves per plant. Singh *et al.* (1976) reported considerable amount of genetic variability for leaf curd growth in late cauliflower. Net curd yield per plant exhibited high genotypic and phenotypic variation, heritability and genetic advance whereas gross weight per plant, curd size index and leaves per plant exhibited moderate values in late cauliflower as reported by Kumar *et al.* (2001), Khar *et al.* (1997), and Kanwar and Korla (2003).

Correlation Calculations

Leaf length, curd width, curd weight with guard leaves and leaf size had positive significant correlation with curd weight without guard leaves (Table 2). Curd width had significant correlation with curd length (0.46). Significant positive correlation was observed for curd weight with guard leaves with leaf length and curd width. Leaf size had significant positive correlation with leaf length, leaf width and curd weight with guard leaves. Leaf width had significant negative correlation with number of leaves per plant. Highly significant negative correlation was observed for head compactness with curd width and curd length. Highly significant negative correlation was found between leaf area and leaf size. Kanwar and Korla (2002) observed that net curd weight was significantly and positively correlated with stalk length, gross plant weight and harvest index in late cauliflower. Aditya *et al.* (1989), reported that gross weight was positively and significantly correlated with stalk length, leaves per plants, curd diameter and curd depth whereas day to curd initiation showed negative association with net curd weight and harvest index.

Direct and Indirect Analysis

The highest positive direct effect was exerted by curd weight with guard leaves (0.621), followed by curd with (0.535), head compactness (0.468), leaf length (0.343), leaf width (0.338), leaf plant height (0.037) and curd length (0.026), while highest negative direct effect was

Table 2. Phenotypic (rp) and genotypic (rg) correlation analysis

Plant height (cm)	No. of leaves per plant	Leaf length (cm)	Leaf width (cm)	Curd length (cm)	Curd width (cm)	Stalk length (cm)	Curd weight with gourd leaves (gm)	Leaf size (cm)	Leaf area (cm^2)	Head Compact-ness (%)	Correlation with yield
(rp)	0.228	0.203	-0.126	-0.068	0.110	-0.115	-0.098	-0.043	0.084	-0.073	0.018
(rg)	0.200	0.314	-0.231	-0.013	0.147	-0.186	-0.141	-0.079	0.339*	-0.137	0.018
	(rp)	0.023	-0.318*	-0.207	-0.190	0.032	-0.143	-0.262	0.227	0.128	-0.229
	(rg)	0.057	-0.485*	-0.261	-0.408*	0.049	-0.177	-0.357*	0.634*	0.102	-0.272
		(rp)	0.234	0.046	0.315*	0.194	0.468*	0.573*	0.027	-0.016	0.499*
		(rg)	0.573*	0.137	0.539*	0.443*	0.563*	0.871**	-0.287	0.073	0.569*
			(rp)	0.161	0.119	0.161	0.378*	0.926**	-0.761**	0.052	0.215
			(rg)	0.131	0.239	0.333*	0.429*	0.958**	-0.037	0.023	0.261
				(rp)	0.458*	-0.087	0.211	0.170	-0.077	-0.321*	0.249
				(rg)	0.582*	-0.014	0.228	0.157	-0.107	-0.356*	0.271
					(rp)	0.058	0.445*	0.231	-0.069	-0.721**	0.519*
					(rg)	0.446*	0.624*	0.378*	0.034	-0.597*	0.639*
						(rp)	0.187	0.214	0.018	-0.070	0.520*
						(rg)	0.341*	0.404*	-0.158	-0.279	0.148
							(rp)	0.502*	-0.129	0.048	0.867**
							(rg)	0.523*	-0.207	0.160	0.893**
								(rp)	-0.629**	0.026	0.371*
								(rg)	-0.892**	0.037	0.392*
									(rp)	-0.033	-0.047
									(rg)	-0.063	-0.046
										(rp)	0.079
										(rg)	**0.270**

* and **- significant at 5% and 1 % level of significance, respectively

exerted by leaf size (-0.650) followed number of leaves (-0.162) on curd weight without guard leaves. Head compactness had negative indirect effect by curd width (-0.34), leaf size by leaf width (-0.60) and curd width by head compactness (-0.39) on curd weight without guard leaves.

Leaf width exerted positive indirect effect by leaf size(0.31), curd width by leaf length (0.25) and curd weight with guard leaves (0.24), curd weight with guard leaves by leaf length (0.29), curd length (0.28) and leaf size (0.31) on curd weight without guard leaves. Similarly leaf size contributed indirect effect by leaf area on important trait positively. Bhutia *et al.* (1980) reported that curd depth and leaves per plant with gross weight and gross weight and harvest index with net curd weight showed positive direct effect in tropical cauliflower. Lui *et al.* (2004) found the significant direct effects of plant mass and curd diameter on curd mass, and indirect effects of leaf mass, leaf area, and diameter of curd stem on curd mass through plant mass and curd diameter. Jamwal *et al.* (1992) observed that curd yield/plant was strongly associated with curd size index and gross weight/plant. Curd size index and leaf size are seen as promising characters for use in selection programmes. Kanwar and Korla (2003) reported that the number of leaves per plant had the greatest direct and positive effect on net curd

Table 3. Direct (diagonal) and Indirect effect of yield contributing traits

Plant height (cm)	No. of leaves per plant	Leaf length (cm)	Leaf width (cm)	Curd length (cm)	Curd width (cm)	Stalk length (cm)	Curd weight with gourd leaves (gm)	Leaf size (cm)	Leaf area (cm^2)	Head compact-ness (%)	Correlation with yield
0.037	-0.037	0.070	-0.043	-0.002	0.059	0.004	-0.061	0.028	-0.003	-0.034	0.018
0.009	**-0.162**	0.008	-0.107	-0.005	-0.102	-0.001	—0.089	0.170	-0.009	0.060	-0.229
0.008	-0.004	**0.343**	0.079	0.001	0.169	-0.006	0.290	-0.373	-0.001	-0.008	0.499**
-0.005	0.051	0.080	**0.338**	0.004	0.063	-0.005	0.235	-0.602	0.031	0.024	0.215
-0.003	0.033	0.016	0.054	**0.026**	0.245	0.003	0.131	-0.110	0.003	-0.150	0.249
0.004	0.031	0.108	0.040	0.012	**0.535**	-0.002	0.276	-0.150	0.003	-0.337	0.519**
-0.004	-0.005	0.067	0.054	-0.002	0.031	**-0.032**	0.116	-0.139	-0.001	-0.033	0.052
-0.004	0.023	0.161	0.128	0.005	0.238	-0.006	**0.621**	-0.327	0.005	0.023	0.867**
-0.002	0.042	0.197	0.313	0.004	0.124	-0.007	0.312	**-0.650**	0.025	0.012	0.371*
0.003	0-03	0.009	-0.257	-0.002	-0.037	-0.001	-0.080	0.409	**-0.040**	-0.015	0.047
-0.003	-0.021	-0.006	0.018	-0.008	-0.386	0.002	0.030	-0.017	-0.001	**0.468**	0.079

weight. Based on correlation and path analyses, the number of leaves per plant, gross plant weight may be considered for selection of promising genotypes.

Hierarchical Cluster Analysis

Multivariate hierarchical clustering was carried for twelve different morphological characters (Fig. 1). Distance between all pairs of genotypes was calculated using squared Euclidean distance method and genotypes were clustered based on Ward's method. Cluster analysis showed mainly 2 clusters. From the dendrogram, it can be concluded that the genotypes were mainly divided at the first node into 2 clusters with 7 and 23 genotypes in different groups. Cluster with 23 genotypes was again divided into 2 groups at the second node with 20 and 3 genotypes. Similarly, 20 genotypes further divided into 2 groups at the third node with 18 and 2 genotypes, respectively.

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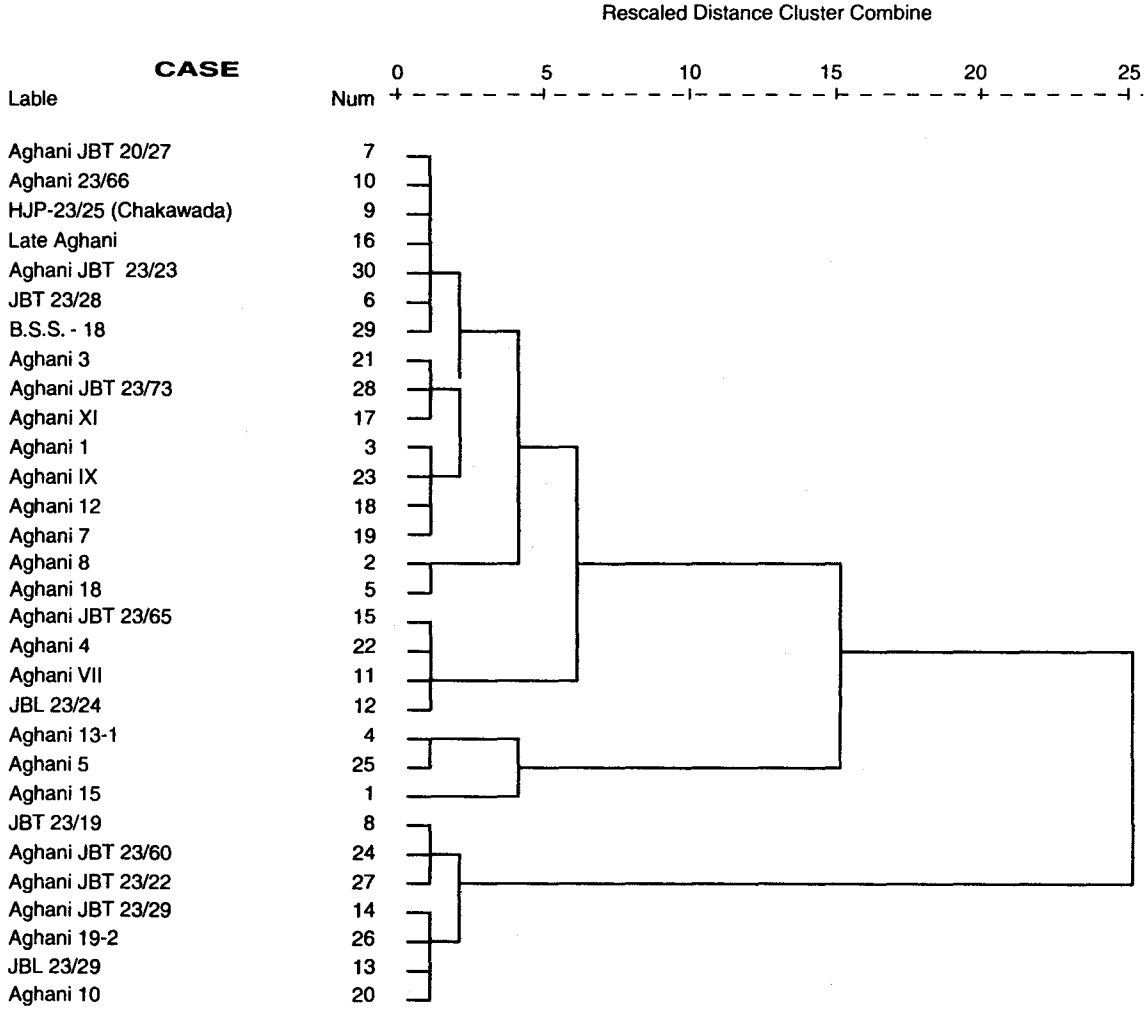

***Fig. 1:** Multivariate cluster analysis of 30 genotypes using Ward's Method*

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