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Research Note

Genetic variability studies in early cauliflower (*Brassica oleracea* var. *botrytis* L.)

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Abstract
Genetic variability was studied for eighteen quantitative characters and five qualitative characters in forty genotypes of early cauliflower. Analysis of variance revealed significant differences among the genotypes for all the characters except for days to curd initiation, days to curd maturity and curd depth. The genotypes *viz.*, PCF-95, PCF-106, Inb-9-5 and Inb-10-1 were found promising as they had more than one desirable quantitative and qualitative traits. PCF-95 had maximum curd yield per hectare (271.87 q) while PCF-101 exhibited earliest harvestable curd maturity (115.33 days). Good level of phenotypic and genotypic coefficients of variation (PCV and GCV), broad sense heritability and genetic advance as per cent of mean were observed for characters like net curd weight, marketable curd weight, curd yield per hectare, harvest index and gross plant weight. However, lowest coefficient of variation, heritability and genetic advance were observed for days to curd initiation and days to curd maturity.

Keywords
Cauliflower, genetic variability, coefficient of variation, heritability and genetic advance

Cauliflower (*Brassica oleracea* var. *botrytis* L.) commonly known as 'Phoolgobhi', a member of *Brassicaceae* family is one of the most popular vegetables in India. India, China, Italy, Europe and America are the major countries growing cauliflower on large scale. India is the second largest producer of cauliflower in the world after China. In India, area under cauliflower is about 402 thousand hectares with production of 7887 thousand metric tons and productivity is 19.60 tons/ha (National Horticulture Board, 2013). Cauliflower was introduced in India in 1822 by Dr. Jemson. The original introductions were Cornish type which originated in England followed by temperate types, originated from Germany and Netherlands in 18th century. Presently, tropical Indian cauliflower is a result of inter-crossing between European and Cornish type, which is more adopted and resistant to high temperature and high rainfall. The edible part of cauliflower is pre-floral fleshy apical meristem or flowering primordial known as curd which is a good source of vitamins and minerals. The growing season of cauliflower is quite prolonged in the North Indian plains. The curds start to get available in the market from September to March in north Indian plains and from March to November in the hills. Seed of Indian cauliflower can be produced in northern plains, but snowball and allied types can produce their seed only in hills. That's why the Indian cauliflower was chosen for breeding work in plains. Estimation of genetic variability in the germplasm of a particular crop is prerequisite for making any effective breeding programme. To bring about improvement in this crop, the knowledge of magnitude of genetic variability and the extent of heritability of desirable characteristics is essentially important because the phenotypic selection depends upon the range of genetic diversity present in the population. Therefore, an attempt was made to study the genetic variability, heritability and genetic advances among various horticultural traits of cauliflower genotypes.

The investigation was undertaken at Vegetable Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) during summer season of 2013-2014 with forty diverse genotypes of early cauliflower (available from mid-September to mid-November). The experiment was conducted in randomized block design with three replications. A spacing of 50 cm × 50 cm was given with plot size 3.5 x 3.0 m and all the recommended agronomic practices were followed. Observations were recorded for each entry on eighteen quantitative characters *viz*., plant height (cm), plant diameter (cm), number of leaves per plant, leaf length (cm), leaf stalk length (cm), leaf lamina length (cm), leaf width (cm), days to curd initiation, days to curd maturity, gross plant weight (g), marketable curd weight (g), net curd weight (g), curd diameter (cm), curd depth (cm), plant stalk length (cm), harvest index (%), curd index (cm^2) and curd yield per hectare (q/ha) and five qualitative characters *viz.*, curd colour, curd compactness, tolerance to diseases, tolerance to insect pests and tolerance to disorders. The analysis of variance was carried out as suggested by Panse

and Sukhatme (1967). Phenotypic and genotypic coefficients of variations were estimated according to Burton and DeVane (1953). Heritability in broad sense and genetic advance as per cent of mean were calculated as per formula given by Allard (1960) and Johnson *et al.* (1955) respectively.

The observations on five qualitative traits are presented in Table 1.The study revealed that twenty two genotypes were having white coloured curd, fourteen genotypes were having creamy white curd and four were with yellowish curd. Twenty eight genotypes had compact curd while remaining twelve genotypes possessed loose curd. Eighteen genotypes were reported to be tolerant to major diseases, sixteen moderately tolerant and remaining six genotypes were susceptible to diseases. According to tolerance to major insect pests twenty five genotypes were classified as tolerant, twelve as moderately tolerant and remaining three genotypes as susceptible. Twenty five genotypes were observed with no physiological disorders, seven with more occurrence of riceyness, four with more leafyness and four others with more buttoning.

Analysis of variances for experimental design revealed significant differences among the genotypes for all the traits studied except for days to curd initiation, days to curd maturity and curd depth (Data not shown). The highest curd yield per hectare was recorded in PCF-95 (271.87 q) followed by PCF-106 (263.33 q), Inb-10-2 (236.80 q) and PCF-22 (234.67 q). The lowest curd yield was found in PCF-97 (125.60 q). The genotype PCF-95 was reported to have highest marketable curd weight, net curd weight and curd yield per hectare, while PCF-106 was reported to have highest curd diameter and harvest index. Curd maturity was found earliest in PCF-101 (115.33) followed by PCF-7 (116), PCF-70 (117), PCF-79 (117) and PCF-120 (117). On the basis of different quantitative and qualitative characters observed, the genotypes *viz.*, PCF-95, PCF-106, Inb-9-5 and Inb-10-1 were found promising.

The extent of variability present in forty genotypes of early cauliflower was measured in terms of range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advance as per cent of mean which has been presented in Table 2. Considerable range was found for all the characters under study. Curd yield ranged from 126.00 q/ha to 271.87 q/ha. Marketable curd weight ranged between 314.00 g and 679.67 g while net curd weight ranged between 218.00 g and 551.33 g. Moderate values of PCV and GCV were found in net curd weight (PCV= 26.10 %, GCV= 22.38 %), marketable curd weight (PCV=21.44 %, GCV=18.48 %), curd yield per hectare (PCV=21.44 %, GCV=18.48 %) and harvest index (PCV=20.10 %, GCV=16.24 %). Curd index (17.63 %) and gross plant weight (15.49 %) also showed medium range of PCV. Rest of the parameters exhibited low coefficients of variation. Similar reports have also been put forward by Kanwar *et al.* (2010) who reported moderate PCV and GCV for net curd weight and marketable curd weight. Moderate GCV and PCV for harvest index have been earlier reported by Sharma *et al.* (2006) and Kumar *et al.* (2011).

High estimate of broad sense heritability was recorded for gross plant weight (85.54 %). This is in conformity with Dubey *et al.* (2003). However, moderate range of broad sense heritability was exhibited by marketable curd weight (74.30 %), curd yield per hectare (74.29 %), net curd weight (73.53 %), harvest index (65.34 %), stalk length, plant diameter, plant height, leaf length, curd diameter and leaf lamina length. The results are in conformity with Kumar *et al.* (2011) who reported high heritability for net curd weight, marketable curd weight and curd yield per hectare. Highest genetic advance as per cent of mean was observed for net curd weight (39.54 %) followed by marketable curd weight (32.82 %), curd yield per hectare (32.81 %), harvest index (27.08%) and gross plant weight (27.30 %). The results are in conformity with Kumar *et al.* (2011) who also reported moderate range of genetic advance for net curd weight, marketable curd weight, harvest index and curd yield per hectare. Kanwar *et al.* (2010) also observed moderate genetic advance as per cent of mean for marketable curd weight and net curd weight. However, in contrast to present findings, high heritability for days to curd maturity and number of leaves per plant were reported by Kanwar *et al.* (2010).

Johnson *et al.* (1955) suggested that the estimates of heritability coupled with genetic advance provide better information rather than heritability alone. High heritability along with moderate genetic advance was observed for gross plant weight. Moderate heritability along with moderate genetic advance was noticed for net curd weight (Atter *et al.*, 2009 in cabbage), marketable curd weight, curd yield per hectare and harvest index (Sharma *et al.*, 2006).

Conclusion

Early group of cauliflower has wide range of variability for different economic traits. From above study it can be concluded that net curd weight, marketable curd weight, curd yield per hectare and gross plant weight are the most important traits followed by harvest index for applying the selection in cauliflower genotypes.

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Table 1. Qualitative characters of different genotypes of early cauliflower

S. No.	Genotypes	Curd Colour	Curd Compactness	Tolerance to diseases (Black rot, Alternaria rot)	Tolerance to insect pests (Leaf eating caterpillar, aphid)	Occurrence of disorders
1.	PCF-1	White	Compact	Susceptible	Moderately tolerant	No
2.	PCF-2	Creamy white	Compact	Tolerant	Moderately tolerant	Riceyness
3.	PCF-5	White	Compact	Tolerant	Tolerant	No
4.	PCF-7	White	Compact	Tolerant	Tolerant	No
5.	PCF-8	Creamy white	Loose	Moderately tolerant	Tolerant	Leafyness
6.	PCF-14-2	White	Compact	Moderately tolerant	Moderately tolerant	No
7.	PCF-22	Creamy white	Loose	Moderately tolerant	Moderately tolerant	Riceyness
8.	PCF-23-2	Creamy white	Compact	Susceptible	Susceptible	No
9.	PCF-27	White	Compact	Tolerant	Moderately tolerant	No
10.	PCF-29	White	Compact	Tolerant	Tolerant	Riceyness
11.	PCF-34	Yellowish	Loose	Moderately tolerant	Tolerant	Riceyness
12.	PCF-54	Yellowish	Compact	Moderately tolerant	Tolerant	Buttoning
13.	PCF-57	Creamy white	Loose	Tolerant	Tolerant	Riceyness
14.	PCF-70	White	Compact	Tolerant	Tolerant	No
15.	PCF-74	White	Loose	Tolerant	Moderately tolerant	No
16.	PCF-79	White	Compact	Tolerant	Tolerant	No
17.	PCF-81	Creamy white	Loose	Moderately tolerant	Moderately tolerant	Leafyness
18.	PCF-84	Creamy white	Compact	Tolerant	Tolerant	Buttoning
19.	PCF-95	White	Loose	Moderately tolerant	Tolerant	Riceyness
20.	PCF-97	Creamy white	Compact	Tolerant	Tolerant	Riceyness
21.	PCF-101	White	Compact	Moderately tolerant	Moderately tolerant	No
22.	PCF-102	White	Loose	Moderately tolerant	Susceptible	No
23.	PCF-103	Creamy white	Compact	Moderately tolerant	Tolerant	No
24.	PCF-104	White	Compact	Susceptible	Tolerant	No
25.	PCF-106	White	Compact	Susceptible	Tolerant	No
26.	PCF-108	Creamy white	Loose	Tolerant	Tolerant	No
27.	PCF-109	Yellowish	Compact	Moderately tolerant	Moderately tolerant	Leafyness
28.	PCF-114	Yellowish	Loose	Moderately tolerant	Tolerant	Buttoning
29.	PCF-118	Creamy white	Compact	Moderately tolerant	Tolerant	No
30.	PCF-118-2	Creamy white	Compact	Tolerant	Tolerant	No

Cont. Table: 1

S. No.	Genotypes	Curd Colour	Curd Compactness	Tolerance to diseases	Tolerance to insect pests	Tolerance to disorders
31.	PCF-120	White	Compact	Tolerant	Tolerant	No
32.	PCF-121	Creamy white	Compact	Susceptible	Tolerant	No
33.	PCF-186	White	Loose	Moderately tolerant	Moderately tolerant	Buttoning
34.	Inb-5-2	White	Compact	Tolerant	Tolerant	No
35.	Inb-9-5	White	Compact	Tolerant	Tolerant	No
36.	Inb-10-1	White	Compact	Moderately tolerant	Moderately tolerant	No
37.	Inb-10-2	White	Compact	Susceptible	Susceptible	No
38.	Inb-16-2	Creamy white	Compact	Moderately tolerant	Tolerant	No
39.	Inb-20-2	White	Loose	Tolerant	Moderately tolerant	Leafyness
40.	Inb-20-3	White	Compact	Tolerant	Tolerant	No

Table 2. Range, General Mean (GM) and Variability parameters for 18 characters in early cauliflower

Character	Range	GM±SEm	PCV (%)	GCV (%)	ECV (%)	Heritability (h^2)	Genetic Advance (GA)	GA as % of mean
Plant height (cm)	57.00-79.27	65.41±2.03	8.27	6.29	5.37	57.83	6.446	9.85
Plant diameter (cm)	65.07-91.53	79.62±2.43	8.32	6.43	5.29	59.62	8.141	10.22
No. of leaves per plant	22.67-32.00	26.65±1.81	13.09	5.78	11.75	19.49	1.40134	5.26
Leaf length (cm)	39.07-56.60	47.87±1.50	8.49	6.51	5.44	58.82	4.92318	10.28
Leaf stalk length (cm)	10.73-15.33	13.07±0.53	9.53	6.40	7.06	45.12	1.15825	8.86
Leaf lamina length (cm)	28.33-43.93	34.80±1.48	10.47	7.44	7.37	50.41	3.78539	10.88
Leaf width (cm)	18.67-24.80	20.91±0.66	7.44	5.03	5.48	45.71	1.46503	7.00
Days to curd initiation	106.67-119.67	111.43±2.98	4.64	0.39	4.63	0.71	0.07535	0.068
Days to curd maturity	115.33-129.33	120.67±3.14	4.59	0.89	4.51	3.73	0.42677	0.354
Gross plant weight (g)	1340.33-2640.67	1779.50±60.52	15.49	14.33	5.89	85.54	485.760	27.30
Marketable curd weight (g)	314.00-679.67	466.74±29.29	21.44	18.48	10.87	74.30	153.175	32.82
Net curd weight (g)	218.33-551.33	358.69±27.81	26.10	22.38	13.43	73.53	141.8256	39.54
Curd diameter (cm)	11.43-17.07	14.30±0.58	10.73	8.10	7.04	56.95	1.80099	12.59
Curd depth (cm)	9.50-12.40	11.02±0.64	10.74	3.91	9.99	13.25	0.32316	2.93
Plant Stalk length (cm)	11.23-18.20	13.33±0.67	13.81	10.68	8.76	59.79	2.26758	17.01
Harvest index (%)	13.42-28.30	20.12±1.37	20.10	16.24	11.83	65.34	5.44344	27.05
Curd index(cm^2)	110.32-211.77	158.36±11.85	17.63	11.95	12.96	45.92	26.4108	16.68
Yield(q/ha)	126.00-271.87	186.70±11.72	21.44	18.48	10.87	74.29	61.2543	32.81