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Estimation of genetic variability, heritability and genetic advance in Indian cauliflower (*Brassica oleracea* var *botrytis* L.)

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Abstract
Eight genotypes of cauliflower were evaluated to study the magnitude of genetic variability, heritability and genetic advance. The evaluation was done for fifteen quantitative characters *viz.,* plant height at harvest (cm), number of leaves per plant, stalk length (cm), gross curd weight (g), marketable curd weight (g), net curd weight (g), curd depth (cm), curd diameter (cm), curd size index (cm^2), days to 50% curd initiation, days to 50% curd maturity, days to 1st flowering, days to 50% flowering, harvest index (%) and curd yield (t/ha). The present study showed that PCV was higher than GCV for all the traits indicated the presence of environmental effect for traits expression. High magnitude of genotypic as well as phenotypic coefficient of variations were recorded for traits *viz.*, net curd weight, marketable curd weight, curd yield and harvest index, curd size index and gross curd weight suggested the substantial improvement on cauliflower through selection for these traits. High heritability coupled with high genetic advance was observed for curd diameter, days to 50% curd maturity, days to 50% flowering, days to 1st flowering, days to 50% curd initiation, curd size index, net curd weight, curd yield, marketable curd weight and gross curd weight indicating that most likely the heritability is due to additive gene effects and selection of these characters may be effective for crop improvement.

Keywords: genetic variability, heritability, genetic advance, cauliflower

Introduction
The cauliflower (*Brassica oleracea* var. *botrytis* L.) is an important vegetable not only among the cole crops but also among other groups of vegetables grown in India. Greatest range of variability exixt in Mediterranean region, therefore it is considered as centre of origin of cauliflower. It is herbaceous annual vegetable grown for its tender 'curd' and biennial for seed production. It has small, thick stem, bearing whorl of leaves and branched tap root system. The main growing point develops into shortened shoot system whose apices make up the convex surface of curd and the curd is a prefloral fleshy apical meristem. The edible part *i.e.* curd is generally white in colour and may be enclosed by inner leaves before the exposure.

Materials and Methods
A group of eight parents including four lines and four testers were taken and made sixteen cross in line × testers mating design in the present studies. They were evaluated in a randomized complete block design at Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during 2017-18 and 2018-19. In the present investigation the following characters were recorded like plant height at harvest (cm), number of leaves per plant, stalk length (cm), gross curd weight (g), marketable curd weight (g), net curd weight (g), curd depth (cm), curd diameter (cm), curd size index (cm^2), days to 50% curd initiation, days to 50% curd maturity, days to 1st flowering, days to 50% flowering, harvest index (%) and curd yield (t/ha).
Data analysis was carried out by Panse and Sukhatme (1978) [4]. Phenotypic and Genotypic coefficients of variation were calculated by the method suggested by Burton (1952) [1]. Heritability in broad sense is the ratio of genotypic variance to the total variance and genetic advance as percent of mean were obtained by the formula given by Lush (1949) [3] and Johnson *et al.* (1955) [2].

Results and Discussion
The analysis of variance revealed the significant differences among the genotypes used in the present investigation for all the characters. Data were recorded on five randomly selected plants of each genotype of each replication with respect to quantitative characters *viz.,* plant

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height at harvest (cm), number of leaves per plant, stalk length (cm), gross curd weight (g), marketable curd weight (g), net curd weight (g), curd depth (cm), curd diameter (cm), curd size index (cm^2), days to 50% curd initiation, days to 50% curd maturity, days to 1st flowering, days to 50% flowering, harvest index (%) and curd yield (t/ha).

The analysis of variance of the trial indicated that the mean sum of squares due to genotypes were highly significant for most of the studied characters are presented in Table 1. Wide range of variation was found for all characters. Most of the characters showed high broad sense of heritability except number of leaves per plant and stalk length. The heritability is due to additive gene effects and selection may be effective.

Genotypic and phenotypic coefficients of variation of different characters are presented in Table 2. High magnitude of genotypic as well as phenotypic coefficient of variations were recorded for traits *viz.*, net curd weight (40.38 and 44.66%), marketable curd weight (g) (31.21 and 34.80%), curd yield (t/ha) (31.36 and 30.59%) and harvest index (25.85 and 29.65%), curd size index (23.04 and 24.57%) and gross curd weight (21.50 and 24.18%). The results obtain and suggested the substantial improvement of cauliflower through selection for these traits. Moderate GCV and high PCV were recorded for curd diameter (17.43 and 17.46 %) and days to 50% curd initiation (10.03 and 10.60 %). Whereas, low GCV and moderate PCV was recorded for the characters like curd depth (6.89 and 10.54 %) and number of leaves per plant (5.21 and 11.91%) suggested existence of considerable variability in the population. Selection for these traits may also be given importance in the improvement programme. Character like stalk length (4.90 and 9.90%) had low genotypic and phenotypic coefficient of variation.

In the present investigation high magnitude of heritability was recorded for almost all characters except number of fruits per cluster. The highest heritability was recorded for the characters curd diameter (99.81%), days to 50% curd maturity (96.12%), days to 50% flowering (96.04%), days to 1st flowering (95.66%), days to 50% curd initiation (94.67%), curd size index (93.79%), net curd weight (90.41%), curd yield (89.77%), marketable curd weight (89.66%), gross curd weight (88.90%), harvest index (87.18%), and plant height at harvest (75.84%). Moderate heritability was recorded for curd depth (65.34%). Low heritability was recorded for stalk length (49.51%) and number of leaves per plant (43.75%).

High genetic advance as percent of mean was observed for net curd weight (75.19%), marketable curd weight (57.63%), curd yield (56.56%), harvest index (46.43%), curd size index (44.52%), gross curd weight (39.36%) and curd diameter (35.83) whereas, moderate genetic advance as percent of mean was observed for days to 50% curd initiation (19.56%), days to 50% curd maturity (14.92%), followed by days to 1st flowering (13.85%), days to 50% flowering (13.27)and plant height at harvest (10.97%). Low genetic advance as percent of mean was observed for curd depth (9.26%), stalk length (4.99%) and number of leaves per plant (4.69%).

Heritability estimates along with genetic advance are more useful than the heritability value alone for selecting the best individual. High heritability coupled with high genetic advance was observed for curd diameter, days to 50% curd maturity, days to 50% flowering, days to 1st flowering, days to 50% curd initiation, curd size index, net curd weight, curd yield, marketable curd weight and gross curd weight indicating that most likely the heritability is due to additive gene effects and selection may be effective for the above characters in respect, to crop improvement.

Table 1: Analysis of variance for curd yield and its component characters in cauliflower

S. No.	Characters (Df)	Mean sums of square		
		Replication	Treatment	Error
		2	23	46
1	Plant height at harvest (cm)	8.74	33.54**	6.62
2	Number of leaves per plant	0.81	7.79**	4.56
3	Stalk length (cm)	1.70	1.12	0.56
4	Gross curd weight (g)	15912.05	151311.50**	12296.04
5	Marketable curd weight (g)	14646.87	72211.82**	5428.39
6	Net curd weight (g)	5400.00	56861.45**	3939.85
7	Curd depth (cm)	0.92	1.00	0.31
8	Curd diameter (cm)	0.05	14.38**	0.01
9	Curd size index (cm^2)	153.08	1302.41**	56.81
10	Days to 50% curd initiation	11.21	107.93**	4.00
11	Days to 50% curd maturity	3.85	101.91**	2.72
12	Days to 1st flowering	10.69	138.99**	4.17
13	Days to 50% flowering	8.83	153.10**	4.17
14	Harvest index (%)	24.55	206.78**	19.68
15	Curd yield (t/ha)	17.75	96.02**	7.14

Table 2: Genetic parameters of variability for curd yield and its component characters in cauliflower

S. No.	Characters	Mean	Range		Coefficient of variation (%)		Heritability	GA as percent of mean
			mini^m	max^m	GCV	PCV	(h2 %)	
1	Plant height at harvest (cm)	42.63	36.00	47.41	7.03	9.26	75.84	10.97
2	Number of leaves per plant	19.94	16.67	22.53	5.21	11.91	43.75	4.69
3	Stalk length (cm)	8.77	7.62	9.87	4.90	9.90	49.51	4.99
4	Gross curd weight (g)	1001.36	706.67	1516.67	21.50	24.18	88.90	39.36
5	Marketable curd weight (g)	478.12	228.33	846.67	31.21	34.80	89.66	57.63
6	Net curd weight (g)	329.65	133.33	628.33	40.38	44.66	90.41	75.19
7	Curd depth (cm)	6.98	6.03	8.03	6.89	10.54	65.34	9.26
8	Curd diameter (cm)	12.55	8.45	15.78	17.43	17.46	99.81	35.83
9	Curd size index (cm^2)	88.42	58.44	126.77	23.04	24.57	93.79	44.52

10	Days to 50% curd initiation	58.65	47.27	68.40	10.03	10.60	94.67	19.56
11	Days to 50% curd maturity	76.29	64.93	82.30	7.54	7.84	96.12	14.92
12	Days to 1st flowering	95.34	83.00	104.67	7.03	7.35	95.66	13.85
13	Days to 50% flowering	104.99	92.27	116.67	6.71	6.99	96.04	13.27
14	Harvest index (%)	30.54	18.96	44.62	25.85	29.65	87.18	46.43
15	Curd yield (t/ha)	17.79	11.04	31.36	30.59	34.08	89.77	56.56

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