

Genetic Variability in Tropical Cauliflower (*Brassica Oleracea* L. Var. *Botrytis*) under the Plains of Southern Kerala

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Abstract: Significant differences were observed among genotypes for all the characters studied in early Indian cauliflower suggesting sufficient variability for curd yield and quality characters. Among the varieties, NS 60N was superior for curd yield, depth, diameter and curd size index followed by G 45. Earliest among the varieties was Himshort followed by NS 60N while Himpriya-60 was superior of plant height, leaves per plant, gross plant weight, leaf length, leaf breadth and leaf size. Significant differences were observed among treatments for all quality characters except vitamin C. Phenotypic and genotypic coefficients of variation were high for curd compactness and curd size index whereas, heritability along with genetic advance were high for gross plant weight. At genotypic level net curd weight showed high positive correlation with leaves per plant. Similar results were obtained in Path coefficient analysis also. The top ranking varieties based on selection index were NS 60N, G 45, White Snow, Himpriya 60 and Pusa Meghna.

Keywords: Variability, Heritability, Genetic Advance, Correlation, Path Analysis

1. Introduction

Cauliflower (*Brassica oleracea* L. var. *botrytis*) a member of Brassicaceae, is one of the most important vegetables in the world. It occupies the pride of place among the cole crops due to its delicious taste, flavour and nutritive value. Even though its cultivation is possible in the high ranges of Kerala, varieties suitable for its cultivation in plains are limited. This is mainly due to limited research on varietal development for non traditional areas. The presence of sufficient genetic variability is the basic requirement in the success of a breeding programme. It is equally important to assess the relative proportion of genetic and environmental components of variability, nature and extent of association between different yield attributes and relative importance of direct and indirect influence of each of the component traits on yield so as to improve the plant as a whole rather than the individual traits.

2. Materials and Methods

A field experiment was carried out at the Department of Olericulture, College of Agriculture, Vellayani (8° 5' N latitude and 77° 1' E longitude) during the period October 2012 to March 2013 to identify tropical cauliflower varieties suitable for plains of southern Kerala. The experimental site

was located at an altitude of 29 m above mean sea level and the area enjoys a warm humid tropical climate. In this experiment 12 varieties/hybrids of cauliflower were evaluated in randomized block design with five replications (Plate 1). The seedlings were raised in portrays and one month old seedlings were transplanted into the main field at a spacing of 60 x 60 cm. All cultural operations like weeding, fertilizer application, irrigation, earthing up and spraying of pesticides were done as per the recommendations (KAU, 2011). Observations were recorded on five randomly selected competitive plants per replication for each entry on thirteen traits, viz., plant height (cm), leaves per plant, gross plant weight (kg), leaf size (cm²), days to curd initiation, days to curd harvest, curd depth (cm), curd diameter (cm), curd size index (cm²), stalk length (cm), net curd weight (g), gross curd weight (g), harvest index, protein (%) and vitamin A (IU) contents. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated as per Burton (1952). Heritability (broad sense) and genetic advance as per cent of mean were computed by following the methods of Allard (1960) and Johnson *et al.* (1955) respectively. Correlation and path coefficient analysis were calculated following Al-Jibouri *et al.* (1958), Miller *et al.* (1958) and Dewey and Lu (1959) respectively.



Plate 1: Field view of the experiment

Volume 7 Issue 9, September 2018

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3. Result and Discussion

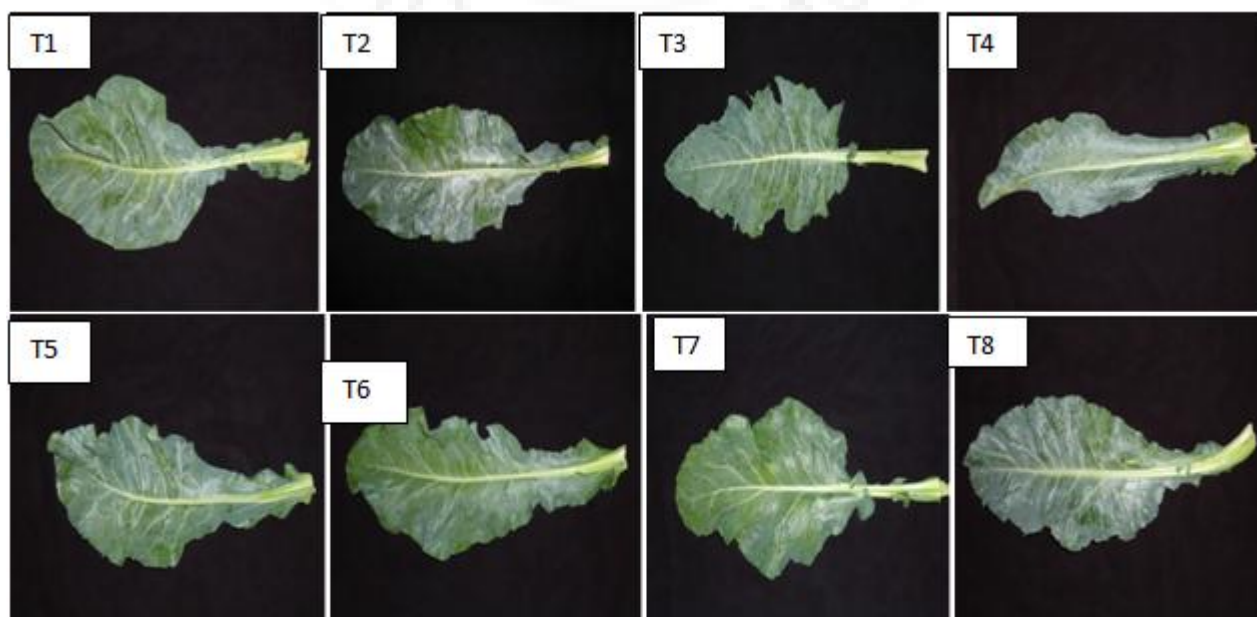
The magnitude of variability present in a population is of utmost importance as it provides the basis for effective selection (Plate 2, 3). In the present investigation, the phenotypic coefficient of variation (PCV) was greater than genotypic coefficient of variation (GCV) for all the traits, which indicates that the genotypic expression was superimposed by the environmental influence. Such environmental interference in the manifestation of these characters was earlier reported by Jamwal *et al.* (1992). The PCV and GCV were highest for curd size index, net curd weight, gross curd weight and harvest index. For selection of such characters, therefore, more vigorous testing of progenies over different environments may be required. From the foregoing discussions, it is clear that the characters *viz.*, curd size index, net curd weight, gross curd weight, harvest index offer good scope for improvement through selection in cauliflower.

A high value of heritability indicates that the phenotype of that trait strongly reflects its genotype (Table 1). The

magnitude of heritability indicates the effectiveness with which selection of the genotypes can be made based on the phenotype. In the present investigation, the heritability estimates were high for all characters studied except for Vitamin A content. High heritability can be attributed to the greater role of additive gene and additive x additive gene action, which can be exploited by following simple selection. High heritability for yield and yield attributes in cauliflower was reported by many workers earlier (Dhatt and Garg, 2008; Singh *et al.*, 2010; Mahesh *et al.* 2011). Johnson *et al.* (1955) pointed out that high heritability along with high genetic advance would be useful than heritability values alone in predicting the resultant effect of selecting the genotype. In present study net curd weight, gross curd weight, harvest index, gross plant weight, leaf size, days to curd formation, days to curd harvest, curd depth, curd diameter, curd size index and stalk length recorded high heritability coupled with high genetic advance indicates the presence of flexible additive gene effects and will be a useful criterion for selection for these characters, which confirms the findings of Dhatt and Garg (2008).

Table 1: Estimates of parameters of variability for yield and quality characters in 12 early maturing Indian cauliflower

Characters	MSS	CD	Range	Mean	GCV	PCV	Heritability	Genetic Advance at (5%)	Genetic Advance as percentage of mean
Plant height (cm)	327.91	1.13	56.30 - 73.40	66.50	5.88	6.44	83.26	7.35	11.05
Leaves per plant	86.31	0.71	19.98 - 32.00	25.85	9.72	11.44	72.13	4.39	17.00
Gross plant weight (kg)	0.61	3.40	0.93- 2.36	1.37	26.02	26.31	97.78	0.73	52.99
Leaf size (cm ²)	265325.10	35.22	757.14 - 1364.06	1159.77	13.94	15.08	85.48	272.32	23.48
Days to curd initiation	1073.15	1.37	36.67 - 66.24	53.15	15.70	16.44	91.19	16.41	30.88
Days to curd harvest	2592.34	1.44	46.40 - 89.15	66.33	16.83	17.28	94.84	22.57	34.02
Curd depth (cm)	54.55	0.33	4.20 - 12.47	8.31	23.25	23.96	94.17	3.93	47.32
Curd diameter (cm)	150.51	0.58	2.60 - 17.75	12.57	29.83	30.79	93.90	7.49	59.55
Curd size index (cm ²)	20461.02	7.08	5.46 - 199.98	104.42	43.57	44.97	93.84	94.28	90.29
Stalk length (cm)	9.01	0.13	2.87 - 5.47	3.83	19.03	20.23	88.54	1.41	36.89
Net curd weight (g)	198380.90	19.57	20.00 - 670.00	361.69	43.36	44.21	96.19	316.87	87.61
Gross curd weight (g)	212551.10	22.49	40.00 - 720.00	408.68	39.83	41.03	94.24	325.53	79.65
Harvest Index	0.12	0.02	0.01 - 0.52	0.28	45.59	46.72	95.18	0.25	91.49
Vitamin A (IU)	23268.22	95.64	59.02 - 298.96	153.80	38.61	62.24	38.48	75.88	49.34
Protein (%)	0.07	0.11	1.92 - 2.63	2.16	5.32	6.54	66.00	0.19	8.90



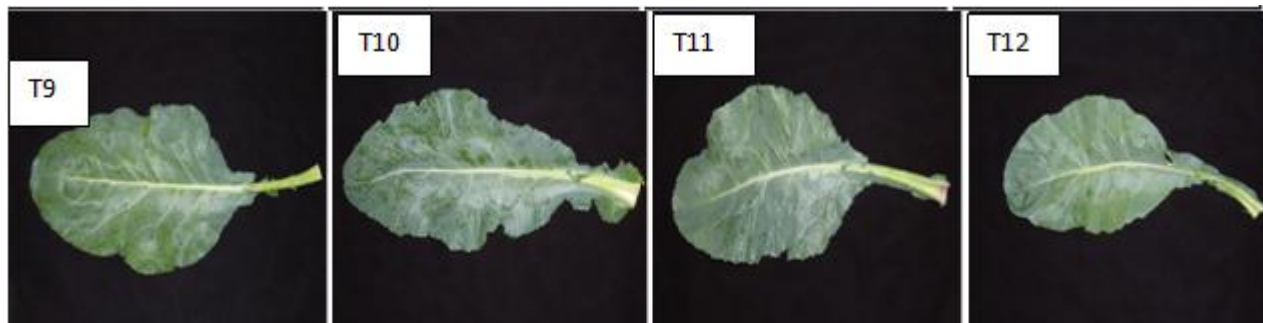


Plate 1: Variation in leaf shape and colour in different varieties of cauliflower

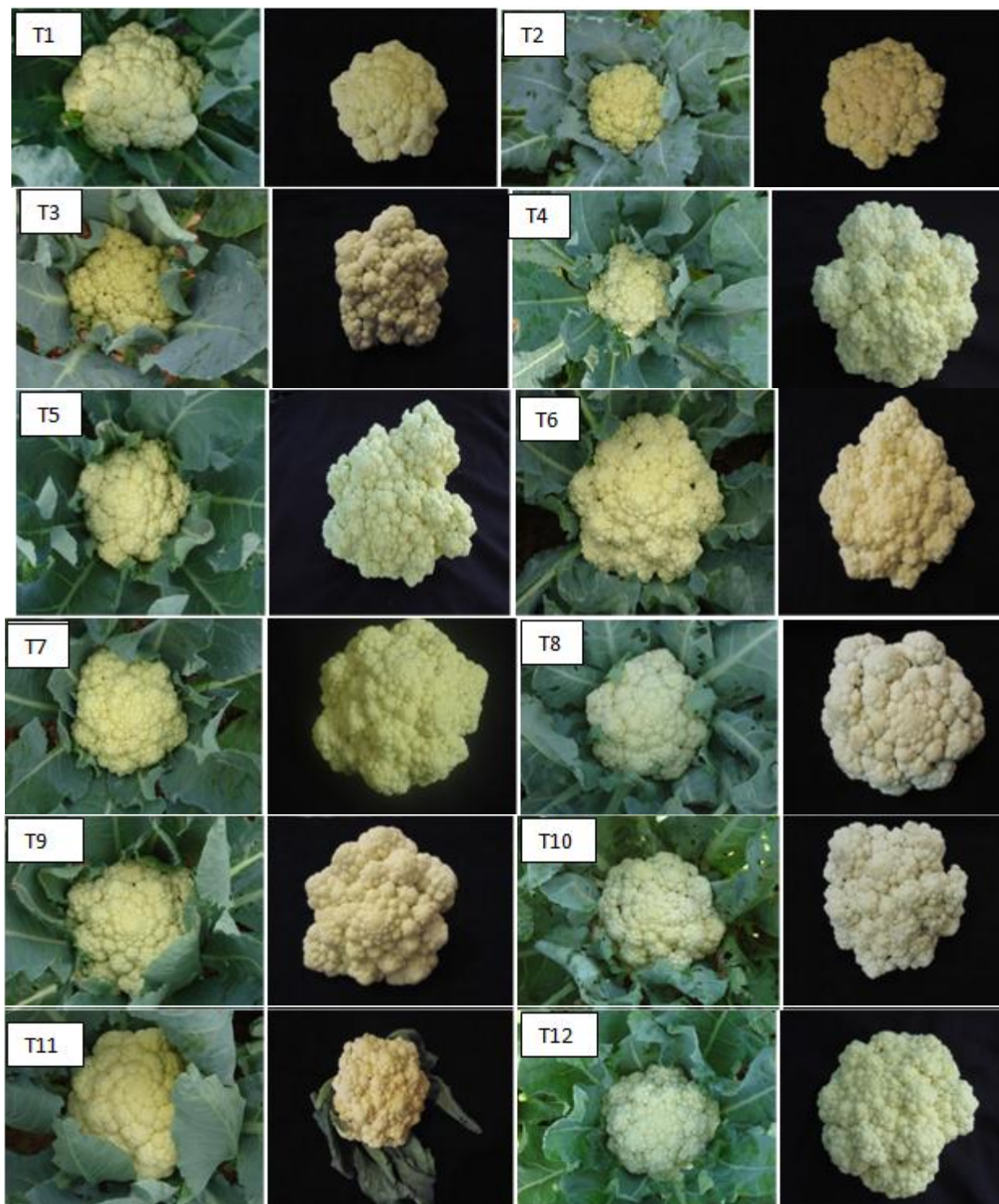


Plate 3: Cud characters of different varieties of cauliflower

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement in yield. Correlation provides information on the nature and extent of relationship between all pairs of characters. So when the breeder applies selection for a particular character, not only it improves that trait, but also provides a reliable measure of genetic association between them, which is useful in the breeding programmes. In the present study, high and positive phenotypic and genotypic correlation was obtained between net curd weight and leaves per plant, leaf size, gross plant weight, curd depth, curd diameter, curd size index and harvest index (Table 2 & 3). It exhibited significant negative correlation with plant height, days to curd initiation, days to curd harvest, and stalk length. Net curd weight was positively correlated with leaves per plant, leaf size, gross plant weight, curd diameter, curd depth, curd size index, gross curd weight, harvest index. Positive and high phenotypic and genotypic correlation of net curd weight with other characters implies that these characters can be taken into consideration for indirect selection for yield improvement in cauliflower. In general magnitude of genotypic correlation coefficients was higher than the corresponding phenotypic correlation coefficients for the characters positively correlated with yield indicating low environmental influence on these characters.

The path analysis unravels whether the association of the component characters with yield is due to their direct effect on yield, or is a consequence of their indirect effect via some other trait(s). Thus path analysis helps in partitioning the

genotypic correlation coefficient into direct and indirect effects of the component characters on the yield on the basis of which improvement programmes can be devised effectively. If the correlation between yield and any of its components is due to the direct effect, it reflects a true relation between them and selection can be practiced for such a character in order to improve yield. But if the correlation is mainly due to indirect effect of the character another component trait, the breeder has to select the latter trait through which the indirect effect is exerted. Here, leaves per plant, gross plant weight, leaf size, curd depth and curd size index showed positive direct effect and plant height, days to curd initiation and stalk length had negative direct effect on net curd weight (Table 4).

Discriminant function analysis developed by Fisher (1936) gives information on the proportionate weightage to be given to a yield component. Thus, selection index was formulated to increase the efficiency of selection by taking into account the important characters contributing to yield. Further Hazel (1943) suggested that selection based on suitable index was more efficient than individual selection for the characters. The characters used for constructing selection index were days to curd initiation, days to curd harvest, curd depth, curd diameter, net curd weight and percentage of curding. Based on the selection index values, top ranking varieties in terms of yield and curd characters were NS 60N, G 45, Himpriya 60, White Snow, Himlatha, Himshort and Pusa Meghna.

Table 2: Phenotypic correlation coefficients for vegetative, curd and yield character

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.0000																		
X2	-0.1189	1.0000																	
X3	0.3054	0.3039	1.0000																
X4	0.3830	0.0019	0.7293	1.0000															
X5	0.6803	-0.3482	0.3419	0.4016	1.0000														
X6	0.5777	-0.5282	0.2495	0.3428	0.9433	1.0000													
X7	0.3452	-0.5773	0.0281	0.0329	0.6265	0.8242	1.0000												
X8	0.6167	-0.4221	0.3011	0.2951	0.9121	0.9563	0.8274	1.0000											
X9	0.1129	0.0402	0.6441	0.5410	0.1072	0.0982	0.0555	0.1056	1.0000										
X10	-0.3015	0.5254	0.0208	0.0647	-0.5900	-0.7638	-0.9319	-0.7843	0.0516	1.0000									
X11	0.3409	-0.3963	0.1063	-0.0230	0.5768	0.7295	0.9212	0.7787	0.1126	-0.9026	1.0000								
X12	-0.4028	0.5190	0.0087	0.0191	-0.6596	-0.8076	-0.8997	-0.8315	0.1065	0.9667	-0.8568	1.0000							
X13	0.0014	-0.5812	-0.2102	-0.0759	0.4137	0.5909	0.6642	0.5046	-0.2599	-0.6996	0.5357	-0.7264	1.0000						
X14	-0.3042	0.5238	0.0515	0.0920	-0.6086	-0.7714	-0.8723	-0.7759	0.1725	0.9369	-0.8012	0.9465	-0.7353	1.0000					
X15	-0.2602	0.5450	0.0813	0.1447	-0.5725	-0.7419	-0.8590	-0.7453	0.1761	0.9292	-0.7937	0.9265	-0.7370	0.9888	1.0000				
X16	-0.4657	0.4048	-0.3822	-0.2735	-0.7603	-0.8602	-0.8149	-0.8882	-0.0840	0.8388	-0.7663	0.8748	-0.6120	0.8780	0.8532	1.0000			
X17	-0.0525	0.6903	0.0649	-0.0750	-0.3953	-0.6436	-0.7722	-0.5600	-0.0684	0.7503	-0.6311	0.7049	-0.7145	0.7482	0.7623	0.6491	1.0000		
X18	-0.1142	-0.0129	-0.2394	-0.3579	-0.0779	0.0157	0.2020	0.1094	-0.2602	-0.1942	0.1993	-0.2244	0.1148	-0.2364	-0.2539	-0.0831	-0.1292	1.0000	
X19	-0.1327	-0.3511	0.0948	0.2046	0.0030	0.2196	0.4314	0.1631	0.3243	-0.3937	0.3754	-0.3268	0.3288	-0.3677	-0.3684	-0.2911	-0.5969	0.0624	1.0000

- X1. Plant height (cm)
- X2. Leaves per plant
- X3. Gross plant weight (kg)
- X4. Leaf size (cm²)
- X5. Days to curd formation
- X6. Days to curd harvest
- X7. Days to curd maturity from curd initiation
- X8. Days to curd maturity
- X9. Curd depth (cm)
- X10. Curd diameter (cm)
- X11. Curd compactness (cm²)
- X12. Curd size index (cm)
- X13. Stalk length (cm)
- X14. Net curd weight (g)
- X15. Gross curd weight (g)
- X16. Harvest index
- X17. Percentage of curding
- X18. Vitamin A (IU)
- X19. Protein (%)

Table 3: Genotypic correlation coefficients for vegetative, curd and yield characters

Character	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	X17	X18	X19
X1	1.0000																		
X2	-0.2221	1.0000																	
X3	0.3638	0.3715	1.0000																
X4	0.4380	-0.0141	0.7872	1.0000															
X5	0.7454	-0.4662	0.3686	0.4378	1.0000														
X6	0.6220	-0.6637	0.2643	0.3706	0.9446	1.0000													
X7	0.3770	-0.6865	0.0303	0.0472	0.6713	0.8520	1.0000												
X8	0.6862	-0.5250	0.3213	0.3321	0.9360	0.9708	0.8513	1.0000											

X9	0.1425	0.0576	0.6759	0.5985	0.1285	0.1098	0.0484	0.1166	1.0000											
X10	-0.3461	0.6199	0.0222	0.0835	-0.6481	-0.8176	-0.9795	-0.8232	0.0675	1.0000										
X11	0.3751	-0.5181	0.1066	0.0020	0.6399	0.7886	0.9769	0.8305	0.1369	-0.9718	1.0000									
X12	-0.4466	0.6343	0.0064	0.0272	-0.7177	-0.8606	-0.9481	-0.8728	0.1222	0.9740	-0.9163	1.0000								
X13	0.0286	-0.7201	-0.2099	-0.1169	0.4439	0.6429	0.7496	0.5454	-0.2777	-0.7684	0.6398	-0.7996	1.0000							
X14	-0.3494	0.6152	0.0539	0.1204	-0.6450	-0.8043	-0.9057	-0.8004	0.1892	0.9650	-0.8666	0.9771	-0.7784	1.0000						
X15	-0.2945	0.6239	0.0865	0.1734	-0.6055	-0.7771	-0.9042	-0.7716	0.1889	0.9661	-0.8669	0.9691	-0.7874	0.9987	1.0000					
X16	-0.5524	0.4699	-0.3810	-0.2807	-0.8142	-0.9049	-0.8532	-0.9294	-0.0796	0.8682	-0.8315	0.9080	-0.6546	0.8789	0.8613	1.0000				
X17	-0.0693	0.8625	0.0660	-0.0831	-0.4086	-0.6847	-0.8495	-0.5849	-0.0866	0.7962	-0.7235	0.7576	-0.7823	0.7896	0.8018	0.6862	1.0000			
X18	-0.1639	-0.0421	-0.3964	-0.5231	-0.0753	0.0696	0.3416	0.1677	-0.4368	-0.3159	0.2962	-0.3178	0.2016	-0.3925	-0.3979	-0.1343	-0.2581	1.0000		
X19	-0.1974	-0.4313	0.1172	0.1602	-0.0323	0.2529	0.5513	0.1938	0.4349	-0.5038	0.5107	-0.3990	0.3543	-0.4575	-0.4742	-0.3667	-0.8185	0.1819	1.0000	

- X1. Plant height (cm)
- X2. Leaves per plant
- X3. Gross plant weight (kg)
- X4. Leaf size (cm²)
- X5. Days to curd formation
- X6. Days to curd harvest
- X7. Days to curd maturity from curd initiation
- X8. Days to curd maturity
- X9. Curd depth (cm)
- X10. Curd diameter (cm)
- X11. Curd compactness (cm²)
- X12. Curd size index (cm)
- X13. Stalk length (cm)
- X14. Net curd weight (g)
- X15. Gross curd weight (g)
- X16. Harvest index
- X17. Percentage of curding
- X18. Vitamin A (IU)
- X19. Protein (%)

Table 4: Direct and indirect effects of yield components of cauliflower

Characters	Plant height	Leaves per plant	Gross plant weight	Leaf size	Days to curd initiation	Curd depth	Curd size index	Stalk length	Total correlation
Plant height	<u>-0.0453</u>	-0.5799	0.1556	0.2773	0.4419	0.1492	-0.7591	0.0109	-0.3494
Leaves per plant	-0.1926	<u>0.8673</u>	0.4022	-0.0122	-0.4043	0.0494	0.5301	-0.6245	0.6152
Gross plant weight	0.0357	0.0407	<u>0.0479</u>	0.4431	0.1088	0.2228	-0.0552	-0.7899	0.0539
Leaf size	0.2106	-0.6086	0.6809	<u>0.4109</u>	0.2158	0.0656	0.0166	-0.8714	0.1204
Days to curd initiation	0.5599	-0.4600	0.1091	<u>0.0926</u>	<u>-0.2145</u>	0.0276	-0.8549	0.0952	-0.6450
Curd depth	0.0971	0.0393	0.1608	0.3080	0.0886	<u>0.1817</u>	0.1033	-0.7893	0.1892
Curd size index	-0.3943	0.5600	0.0356	0.2240	-0.6337	0.6079	<u>0.8829</u>	-0.306	0.9771
Stalk length	0.3790	-0.2216	-0.1684	-0.0943	0.6023	-0.4528	-0.4665	<u>-0.3561</u>	-0.7784

Residue (R) = 0.1856 (Underlined figures are direct effects)

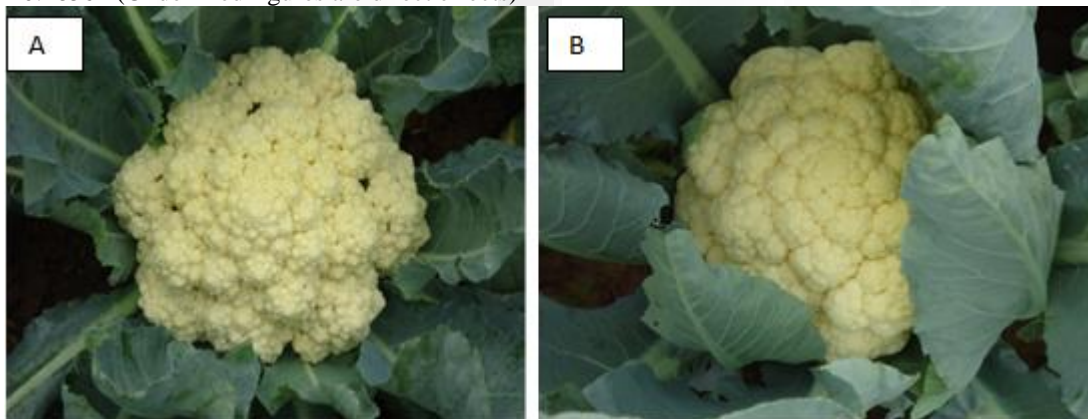


Plate 4: Top Yielders- A. NS 60N B. G 45

The results of the present study identified two hybrids namely NS 60 N and G 45 and a variety Pusa Meghna as promising for cultivation in the southern parts of Kerala (Plate 4).

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Plate 1: Field view of the experiment

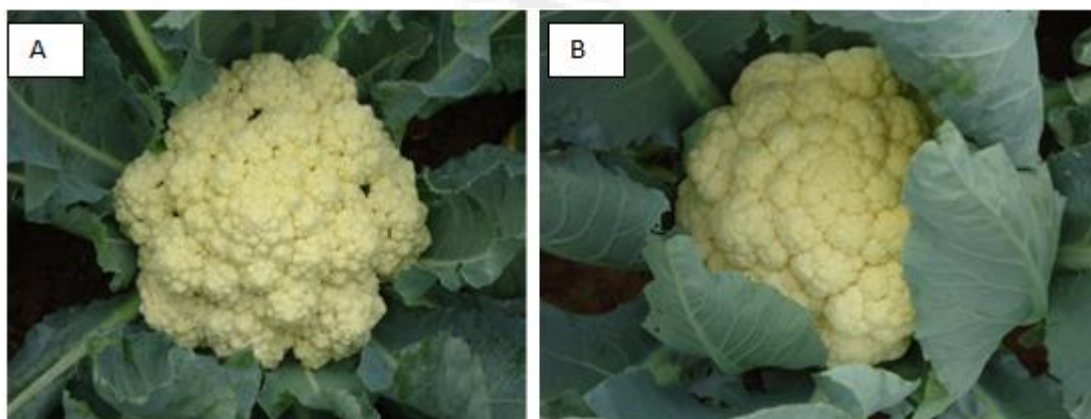


Plate 4: Top Yielders- A. NS 60N B. G 45