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PERFORMANCE OF DIFFERENT GENOTYPES OF CAULIFLOWER FOR HIGHER YIELD AND QUALITY UNDER MID MATURITY GROUP

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ABSTRACT

A research trial was conducted on performance of different genotypes of cauliflower for higher yield and quality under mid maturity group. The overall values of PCV were higher than those of GCV. The highest estimates of GCV were observed for duration of leaf size in the mid maturity groups of cauliflower. The highest heritability was recorded to be leaf and High heritability along with high genetic advance as per cent mean was recorded for curd compactness, leaf size, plant height and vitamin C content. Correlation studies revealed that total yield had significant positive correlation with number of leaves per plant, curd diameter, net curd weight and curd compactnes and Yield was negatively correlated with duration of curd harvesting and days to 50% curd formation in the mid maturity groups. Path coefficient analysis revealed that net curd weight and curd compactness had the highest positive contribution towards the total yield respectively.

Key words : Yield, quality, mid maturing cauliflower, variability, path correlation and analysis

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most widely grown vegetable crops in many parts of the world. It is one of the important winter vegetables grown under varying agro-climatic conditions in India. But with the evolution of Indian cauliflower it is being grown during summer and rainy season also. There is a need to increase overall production to meet the inflating demand. This can be achieved by adopting the high yielding F_1 hybrids. The development of an effective plant-breeding programme depends upon the existence of genetic variability and knowledge of genotypic and phenotypic correlation of yield components and path analysis will be very useful in formulating breeding strategy to develop elite genotypes through selection in advanced generations. Thus, the nature and magnitude of variability present in the gene pool for that character and relationship of these characters with each other determine the success of genetic improvement in any character. The pattern of inheritance of quantitative characters is highly complex and can be understood through the study of genetic parameters such as variability, heritability, genetic advance, correlation and path analysis in conjunction.

MATERIALS AND METHODS

The present investigation was conducted at the research farm of the Division of Vegetable Science and biochemical analysis was carried out in the laboratories of the Division of Vegetable Science and Division of Soil Science and Agricultural Chemistry, IARI, New Delhi, during the rainy and winter season of the year 2002-03. The experimental material comprised of 32 genotypes. There were 16 plants in each plot having 5.76 m^2 area planted at 50 x 45 cm distance between and with in the row in a Randomized Block Design, with three replications. Observations were recorded on five randomly selected competitive plants per replication for each entry on fifteen quantitative and four quality traits viz; Days to 50% curd formation, stem length (cm), plant height (cm), number of leaves per plant, gross plant weight (kg), leaf size (LXR) cm^2, curd depth (cm), curd diameter (cm), net curd weight (kg), curd compactness, marketable curd weight (kg), harvest index (%), duration of curd harvesting (days), percent defective/unmarketable curd, calculated marketable yield (q/ha), dry matter (%), vitamin C (mg/100g), potassium (mg/100g) and sulphur (mg/100g) contents. The genotypic (GCV) and the phenotypic (PCV) coefficient of variations were calculated by the formulae given by Burton (1952). Heritability (in broad sense) and genetic advance as per cent of mean were computed following the methods of Allard (1960) and Johnson *et. al.* (1955), respectively. Correlation and

Table-1 : Coefficient of variation, heritability and genetic advance for different characters in mid maturity group of cauliflower.

	Characters	Range	Mean	H^2	GA	GCV	PCV	GA as % mean	CV
1.	Days to 50% curd formation	90.54-111.34	105.85	0.976	8.23	3.82	3.87	7.78	0.61
2.	Stem length (cm)	3.35-9.32	6.38	0.973	2.93	22.57	22.87	45.92	3.73
3.	Plant height (cm)	34.85-71.97	53.97	0.974	17.81	16.23	16.45	32.99	2.65
4.	Number of leaves per plant	13.33-25.35	19.35	0.903	6.59	17.39	18.30	34.06	5.7
5.	Gross plant weight (kg)	0.800-2.50	1.43	0.926	0.73	25.73	26.75	51.05	7.29
6.	Leaf size (L×R) cm^2	460.58-3724.57	1257.96	0.998	1258.22	48.60	48.66	100.02	2.22
7.	Curd depth (cm)	5.26- 9.80	7.34	0.937	1.99	13.56	14.01	27.11	3.52
8.	Curd diameter (cm)	9.05- 13.50	10.73	0.951	2.37	10.98	11.26	22.08	2.48
9.	Net curd weight (kg)	0.250-0.860	0.560	0.938	0.39	34.82	35.95	69.64	8.953
10.	Curd compactness	32.78-154.06	76.83	0.895	57.09	38.12	40.28	74.31	13.03
11.	Marketable curd weight (kg)	0.310-0.980	0.620	0.939	0.39	31.29	32.30	62.90	8.01
12.	Harvest index (%)	20.07-62.87	38.56	0.773	15.36	21.94	24.96	39.83	11.9
13.	Duration of curd harvesting (days)	11.33 - 22.47	15.22	0.613	4.04	16.47	21.04	26.54	13.09
14.	Per cent defective/ unmarketable curd	4.66- 17.08	12.75	0.866	6.04	24.71	26.55	47.37	9.7
15.	Calculated marketable yield (q/ha)	117.81- 391.67	241.04	0.933	155.36	32.38	33.52	64.45	8.65
16.	Dry matter (%)	8.55-12.81	10.36	0.841	2.46	12.55	13.69	23.75	5.46
17.	Vitamin C (mg/100g)	15.61-76.08	35.96	0.988	37.04	50.29	50.58	103.00	5.48
18.	Potassium (mg/100g)	247.50-465.00	381.64	0.134	20.12	7.00	19.13	5.27	17.8
19.	Sulphur (mg/100g)	10.96-44.89	17.88	0.787	14.31	43.76	49.32	80.03	22.74

path coefficient analysis were calculated as per formulae suggested by Al-Jibouri *et. al.* (1958) and Miller *et. al.* (1958) and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSION

The success of breeding programme depends upon quantum of variability present in the available germplasm. In the present study of phenotypic and genotypic coefficients of variability, heritability, genetic advance and genetic advance percent of mean worked out to various morphological and quality characters (Table-1) showed higher PCV than the GCV, which indicated the importance of environment in the manifestation of these characters. On the basis of per se mean performance of the genotypes. The line 191184 was found to excel others in overall performance with respect to morphological parameters, like plant height, stem length, curd compactness, net curd weight, harvest index and yield (353.43 q/ha). In the quality parameters like Vitamin C, potassium and sulphur content, line DC-310-22 and Improved Japanese were found to be superior for the quality attributes. Phenotypic coefficients of variation were, in general, higher than the genotypic coefficient of variation indicating that the environment influenced the characters studied. This result is in line with Jamwal *et al.* (1992) and Rastogi *et al.* (1995). The phenotypic and genotypic coefficients of variation were highest for duration of curd harvesting and Vitamin C content in the mid maturity group. Similar findings were also reported by Pandey and Naik (1991), Jamwal *et al.* (1992 and 1995) and Singh *et al.* (1995). For selection of such characters, more vigorous testing of progenies over different environments may be required. Characters like days to 50% curd formation, stem length, plant height, number of leaves per plant, curd diameter, net curd weight and marketable yield had high estimates of heritability. It results that the highly heritable nature of variability in these characters responds to selection more effectively. The estimates of heritability were moderate to high for other characters like curd depth, marketable curd weight, duration of curd harvesting, potassium and sulphur 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. Similar reports have also been put forward by Rastogi *et al.* (1995), Singh *et al.* (1995) and Reddy and Varalakshmi (1995). High heritability coupled with high genetic advance were noted for curd compactness, net curd weight and Vitamin C content thus suggesting that these traits could be considered as reliable indices for selection and higher responses Correlation studies exhibited positive and significant association of yield with plant height,

Table-2 : Genotypic correlation among different morphological and biochemical parameters in cauliflower of mid maturity group.

	X_1	X_2	X_3	X_4	X_5	X6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}
X_1	1.000	0.046	0.054	-0.108	-0.045	-0.057	0.043	0.032	-0.112	-0.067	-0.112	-0.113	-0.301	-0.117	-0.053	0.023	-0.044	-0.075	-0.108
X_2		1.000	0.753	0.526	0.306	0.289	0.161	0.234	0.327	0.485	0.456	0.357	0.019	-0.419	0.504	0.152	0.237	-0.690	-0.101
X_3			1.000	0.342	0.296	0.426	-0.015	0.006	0.428	0.411	0.303	0.151	-0.148	-0.275	0.416	0.116	0.445	-0.915	0.212
X_4				1.000	0.339	0.190	0.120	0.223	0.288	0.339	0.305	0.058	0.099	-0.481	0.374	-0.120	0.174	0.107	0.046
X_5					1.000	0.453	0.340	0.420	0.513	0.905	0.826	0.170	0.139	-0.155	0.891	-0.105	0.413	-0.318	-0.055
X_6						1.000	-0.074	0.036	0.601	0.574	0.361	0.124	0.070	0.082	0.551	0.013	0.385	-0.882	0.098
X_7							1.000	0.865	-0.515	0.347	0.313	0.062	0.200	-0.308	0.362	0.256	0.212	0.002	-0.060
X_8								1.000	-0.367	0.456	0.431	0.169	0.248	-0.213	0.462	0.263	0.159	-0.249	-0.219
X_9									1.000	0.575	0.498	0.223	-0.127	0.044	0.556	-0.374	0.200	-0.421	0.061
X_{10}										1.000	0.900	0.396	0.087	-0.220	0.996	-0.184	0.391	-0.524	-0.046
X_{11}											1.000	0.677	0.067	-0.202	0.898	-0.215	0.206	-0.413	-0.055
X_{12}												1.000	-0.040	-0.118	0.403	-0.251	-0.163	-0.523	0.009
X_{13}													1.0000	0.153	0.050	-0.041	-0.209	0.283	-0.218
X_{14}														1.000	-0.298	0.387	-0.347	-0.180	-0.128
X_{15}															1.000	-0.210	0.420	-0.454	-0.028
X_{16}																1.000	0.194	-0.629	0.023
X_{17}																	1.000	-0.543	0.143
X_{18}																		1.000	0.097
X_{19}																			1.000

X_1 = Days to 50% curd formation ; X_2 = Stem length (cm) ; X_3 = Plant height (cm) ; X_4 = No. of leaves per plant ; X_5 = Gross plant weight ; X_6 = Leaf size (L×B) cm^2 ; X_7 = Curd depth (cm); X_8= Curd diameter (cm) ; X_9 = curd compactness; X_{10} = Marketable curd weight (kg) ; X_{11} = Net curd weight (kg); X_{12} = Harvest index (%); X_{13} = Duration of curd harvesting (days); X_{14} = Percent defective/unmarketable curd ; X_{15} = Calculated marketable yield (q/ha); X_{16} : Dry matter (g); X_{17} = Vitamin C (mg/100g); X_{18} = Potassium (mg/100g); X_{19} = Sulphur (mg/100g)

number of leaves per plant, gross plant weight, curd diameter, net curd weight, marketable curd weight and curd compactness. However, yield was negatively correlated with duration of curd harvesting and days to 50% curd formation in mid maturity groups indicating that selection for mid maturity may have adverse effect on yield. Significant positive correlation with yield was reported by Sharma *et al.* (1982), for curd diameter and number of leaves by Singh (1984), for number of leaves per plant and plant height Khar and Pathania (1998) for gross plant weight and harvest index.The inter-correlation involving plant height with harvest index, number of leaves per plant with yield, curd diameter with marketable curd weight, curd depth and curd compactness with gross plant weight and harvest index and marketable curd weight with curd diameter and yield revealed the relative influence of these characters on the total yield. The significant positive association among these characters suggested further the scope for improvement of these traits. Similar observations have also been recorded by Genko *et al.* (1969), Sharma *et al.* (1982), Thakur *et al.* (1994) and Shakuntala *et al.* (1999). With regard to quality attributes in the mid maturity group, The inter correlation showed negative association of potassium content with dry matter and Vitamin C and of dry matter with yield. The negative association present among some of the biochemical parameters observed especially in the mid maturity groups, suggested individual character selection for the improvement.

Correlation studies give an idea about the positive and negative association of different characters with yield and also among themselves. However, the nature and extent of contribution of these characters towards yield is not obtained. Hence, path coefficient analysis was used to partition the correlation coefficient of the different characters studied to direct and indirect effects on yield. The information obtained helps in giving proper weight age to the various characters during selection or other

Table-3 : Phenotypic correlation among different morphological and biochemical parameters in cauliflower of mid maturity group.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}
X_1	1.000	0.046	0.054	-0.093	-0.032	-0.058	0.046	0.031	-0.110	-0.055	-0.107	-0.115	-0.257	-0.101	-0.042	0.006	-0.045	-0.031	-0.082
X_2		1.000	0.737**	0.496**	0.294	0.286	0.150	0.229	0.300	0.460**	0.432*	0.299	0.031	-0.381	0.476**	0.135	0.231	-0.259	-0.071
X_3			1.000	0.319	0.280	0.421*	-0.017	0.006	0.401*	0.391*	0.283	0.123	-0.120	-0.243	0.397*	0.103	0.437*	-0.340	0.186
X_4				1.000	0.321	0.181	0.099	0.201	0.279	0.314	0.282	0.037	0.069	-0.406	0.344	-0.103	0.159	0.040	0.050
X_5					1.000	0.434*	0.318	0.395*	0.474**	0.860**	0.784**	0.074	0.108	-0.118	0.841**	-0.119	0.390*	-0.165	-0.045
X_6						1.000	-0.074	0.036	0.569**	0.556**	0.350*	0.111	0.057	0.078	0.532**	0.012	0.381*	-0.318	0.087
X_7							1.000	0.831**	-0.516	0.332	0.296	0.045	0.155	-0.287	0.346	0.236	0.211	0.015	-0.040
X_8								1.000	-0.380	0.431*	0.411*	0.137	0.218	-0.187	0.435*	0.234	0.147	-0.100	-0.188
X_9									1.000	0.543**	0.470**	0.225	-0.119	0.044	0.520**	-0.330	0.186	-0.108	0.032
X_{10}										1.000	0.890**	0.369*	0.101	-0.193	0.990**	-0.176	0.374*	-0.171	-0.046
X_{11}											1.000	0.643**	0.087	-0.175	0.884**	-0.197	0.193	-0.141	-0.056
X_{12}												1.000	0.019	-0.107	0.375*	-0.167	-0.145	-0.072	-0.007
X_{13}													1.000	0.149	0.056	-0.026	-0.163	0.020	-0.130
X_{14}														1.000	-0.269	0.349*	-0.331	-0.004	-0.115
X_{15}															1.000	-0.199	0.403*	-0.165	-0.035
X_{16}																1.000	0.177	-0.171	0.009
X_{17}																	1.000	-0.197	0.130
X_{18}																		1.000	0.067
X_{19}																			1.000

* Significant at 5% level, ** Significant at 1% level

X_1 = Days to 50% curd formation ; X_2 =Stem length (cm) ; X_3 = Plant height (cm) ; X_4 = No. of leaves per plant ; X_5 = Gross plant weight ; X_6 = Leaf size (L×B) cm^2 ; X_7 = Curd depth (cm); X_8= Curd diameter (cm) ; X_9 = curd compactness; X_{10} = Marketable curd weight (kg) ; X_{11} = Net curd weight (kg); X_{12} = Harvest index (%); X_{13} = Duration of curd harvesting (days); X_{14} = Percent defective/unmarketable curd ; X_{15} = Calculated marketable yield (q/ha); X_{16} : Dry matter (g); X17 = Vitamin C (mg/100g); X_{18} = Potassium (mg/100g); X_{19} = Sulphur (mg/100g)

breeding programme so that the improvement of desirable traits can be achieved effectively.

The result of the path coefficient analysis indicated that the direct and indirect effect of the eighteen morphological and biochemical traits on the total yield. The highest direct effect on yield in the mid maturity group was exerted by curd compactness. Other characters, which indirectly influenced the yield in number of leaves per plant, curd diameter, net curd weight and net curd weight. Therefore, these characters also offer scope for inclusion in the selection programme. The highest negative direct effects were observed for gross plant weight followed by harvest index and dry matter in the mid maturity group, and for dry matter, harvest index and days to 50% curd formation in the mid maturity group. These observations suggested the selection of lower values for these traits. In the present study, the values of residual effect obtained were very less i.e. 0.0034 in the mid maturity group cauliflower. This indicates that the characters chosen for the present studies are the main components of yield and that the variability in yield is accounted by the characters chosen for this investigation to a considerable extent from the correlation and path coefficient studies, it can be concluded that selection based primarily on the component characters which exhibited significant positive correlations with yield and also had either direct or indirect effect on yield, may result in development of high yielding genotypes in the mid maturity groups of cauliflower.

Table 4 : Genotypic path coefficient analysis (direct and indirect effect) for different morphological and biochemical parameters in cauliflower of mid maturity group.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	Corr. with yield (q/ha)
X_{17}	-0.019	0.023	-0.010	0.001	-0.004	-0.008	-0.009	0.003	0.053	-0.047	-0.038	0.024	0.046	-0.034	-0.009	-0.008	-0.002	-0.013	-0.053
X_2	-0.001	0.494**	-0.134	-0.003	0.029	0.042	-0.032	0.019	-0.155	0.342	0.154	-0.077	-0.003	-0.121	-0.060	0.041	-0.018	-0.012	0.504**
X_3	-0.001	0.372*	0.178	-0.002	0.028	0.062	0.003	0.000	-0.203	0.290	0.102	-0.033	0.022	-0.079	-0.046	0.077	-0.024	0.026	0.416*
X_4	0.002	0.260	-0.061	-0.005	0.032	0.028	-0.024	0.018	-0.137	0.239	0.103	-0.013	-0.015	-0.139	0.047	0.030	0.003	0.006	0.374*
X_5	0.001	0.151	-0.053	-0.002	0.094	0.066	-0.068	0.034	-0.244	0.638**	0.280	-0.037	-0.021	-0.045	0.041	0.071	-0.008	-0.007	0.891**
X_6	0.001	0.143	-0.076	-0.001	0.042	0.145	0.015	0.003	-0.285	0.405*	0.122	-0.027	-0.011	0.024	-0.005	0.066	-0.023	0.012	0.551**
X_7	-0.001	0.079	0.003	-0.001	0.032	-0.011	-0.200	0.069	0.244	0.245	0.106	-0.013	-0.030	-0.089	-0.101	0.037	0.000	-0.007	0.362*
X_8	-0.001	0.116	-0.001	-0.001	0.039	0.005	-0.173	0.080	0.174	0.322	0.146	-0.037	-0.038	-0.061	-0.103	0.028	-0.006	-0.027	0.462**
X_9	0.002	0.161	-0.076	-0.001	0.048	0.087	0.103	-0.029	-0.474	0.405*	0.169	-0.048	0.019	0.013	0.147	0.035	-0.011	0.007	0.556**
X_{10}	0.001	0.240	-0.073	-0.002	0.085	0.083	-0.069	0.037	-0.273	0.705**	0.305	-0.086	-0.013	-0.064	0.072	0.068	-0.014	-0.006	0.996**
X_{11}	0.002	0.225	-0.054	-0.001	0.077	0.052	-0.062	0.035	-0.236	0.634**	0.339	-0.146	-0.010	-0.058	0.085	0.036	-0.011	-0.007	0.898**
X_{12}	0.002	0.176	-0.027	0.000	0.016	0.018	-0.012	0.014	-0.106	0.279	0.229	-0.216	0.006	-0.034	0.099	-0.028	-0.014	0.001	0.403*
X_{13}	0.006	0.009	0.026	0.000	0.013	0.010	-0.040	0.020	0.060	0.062	0.023	0.009	-0.152	0.044	0.016	-0.036	0.007	-0.027	0.050
X_{14}	0.002	-0.207	0.049	0.002	-0.015	0.012	0.062	-0.017	-0.021	-0.155	-0.068	0.026	-0.023	0.289	-0.152	-0.060	-0.005	-0.016	-0.298
X_{15}	0.000	0.075	-0.021	0.001	-0.010	0.002	-0.051	0.021	0.178	-0.130	-0.073	0.054	0.006	0.112	-0.394	0.034	-0.016	0.003	-0.210
X_{16}	0.001	0.117	-0.079	-0.001	0.039	0.056	-0.042	0.013	-0.095	0.276	0.070	0.035	0.032	-0.100	-0.077	0.173	-0.014	0.017	0.420*
X_{17}	0.001	-0.341	0.163	-0.001	-0.030	-0.128	0.000	-0.020	0.200	-0.369	-0.140	0.113	-0.043	-0.052	0.248	-0.094	0.026	0.012	-0.454
X_{18}	0.002	-0.050	-0.038	0.000	-0.005	0.014	0.012	-0.018	-0.029	-0.032	-0.019	-0.002	0.033	-0.037	-0.009	0.025	0.003	0.012	-0.028

Residual effect =0.0034

* Significant at 5% level ; ** Significant at 1% level

X_1 = Days to 50% curd formation ; X_2 =Stem length (cm) ; X_3 = Plant height (cm) ; X_4 = No. of leaves per plant ; X_5 = Gross plant weight ; X6 = Leaf size (L×B) cm^2; X_7 = Curd depth (cm) ; X_8= Curd diameter (cm) X_9 = curd compactness; X_{10} = Marketable curd weight (kg) ; X_{11} = Net curd weight (kg); X_{12} = Harvest index (%); X_{13} = Duration of curd harvesting (days); X_{14} = Percent defective/unmarketable curd ; X_{15} = Dry matter (g); X_{16} = Vitamin C (mg/100g); X_{17} = Potassium (mg/100g); X_{18} = Sulphur (mg/100g)

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