
Correlation and Path analysis studies of economic traits in cauliflower (*Brassica oleracea* var *botrytis* L.)

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Studies on correlation coefficients, their direct and indirect effects were conducted for economic traits of cauliflower cultivated in North-Indian plains. Estimates of phenotypic and genotypic correlation coefficient revealed that net curd weight was significantly and positively correlated with total plant weight. Path analysis of correlation coefficients revealed that total plant weight had highest positive direct effect on net curd weight, harvest index and curd depth.

Key words: Correlation, Path analysis, cauliflower and yield.

Introduction

Among cole crops, cauliflower is very important with respect to area and production in the world. India ranks first, contributing nearly 35 percent of total area and production in the world as reported by Singh (2003). Cauliflower is a cool season crop, tolerating temperature as low as 4⁰C and as high as 38⁰C. However, optimum temperature varies between 20⁰C and 25⁰C in September-October and 5⁰C to 10⁰C in December-January according to Kumar *et al* (2005). It has long duration availability and can be broadly classified in to four maturity groups depending up on the time of curd availability; Gp-1 (September – Early November), Gp-2 (Mid November – Early December), Gp-3 (Mid December – Mid January), Gp-4 (Mid January – Early March). First three groups are referred to as Indian cauliflower and the last group as Snowball. Cauliflower cultivation during this part of the year is very popular in northern states of India and it is routinely consumed in cooked, pickled and processed forms. Great popularity of cauliflower calls for development of high yielding good quality cauliflower varieties. As yield is decided by several component traits, the knowledge of correlation among these components and between the components and the yield is necessary.

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The present study was conducted to study correlation and path analysis of economically important characters in cauliflower germplasm prevalent in north Indian agro-climatic conditions. Knowledge about association between horticultural traits is of great value in planning a breeding programme. Coefficients of correlation between different important traits and their path analysis help cauliflower breeders to decide suitable selection criteria to improve yield (net curd weight) and /or certain other trait.

Material and methods

The present investigation was undertaken at Vegetable Experimental Area and Biochemistry Laboratory at the Department of Vegetable Crops, Punjab Agricultural University, Ludhiana. The experimental materials comprised thirty genotypes, including hybrids and varieties of cauliflower. The experiment was performed in Randomized Complete Block Design (RCBD). The spacing was maintained at 45cm X 45cm. Each replication accommodated ten plants. Recommended Punjab Agricultural University's Agronomic and Plant Protection Practices were followed to raise the crop. Five randomly chosen plants (excluding border plants) were used for taking observations. The observations were recorded on various horticultural and biochemical traits. The genotypic and phenotypic coefficients of correlation were calculated as suggested by Al-Jibouri *et al* (1958). The direct and indirect paths were obtained by following the method suggested by Dewey and Lu (1959). The traits-were plant height at 50% curd maturity (cm), days to 50% curd maturity, leaf length (cm), leaf width (cm), number of leaves per plant, plant spread (cm), curd diameter (cm), curd depth (cm), net curd weight (g), total plant weight (g), curd size index (cm²), curd compactness index (g/cm³), harvest index, curd angle (degree), stem length (cm), curd colour, dry matter content (%), total protein (mg/100g), mineral matter content (%), and ascorbic acid (mg/100g).

Results and discussions

Significant differences were observed among all the genotypes for all the traits under study. The data pertaining to correlation coefficient are presented in Table 1. Correlation among different traits is of vital importance to know their association, as yield is an important outcome of many correlated characters. Correlation coefficients have been worked out at genotypic and phenotypic levels. Net curd weight had highest significant positive correlation with total plant weight (0.7335) and leaf width (0.5371). Significant correlation was also found between total plant weight and leaf width (0.7771) followed by leaf length (0.5578), stem length (0.5287), number of leaves per plant (0.5194)

and curd compactness index (0.4343). Net curd weight, curd depth and curd diameter were significantly correlated with days to 50% curd maturity and mineral matter content. Thus, net curd weight can be increased through selection based on total plant weight and leaf width.

These results support the findings of Kumar *et al* (2010) Kumar *et al* (2005), Garg and Lal (2004), Radhakrishnan and Korla (1995) and Dutta *et al* (1992).

Path coefficient analysis helps in partitioning the genotypic and phenotypic correlation coefficients into direct and indirect effects. As depicted by Table 2, total plant weight had highest positive direct effect on net curd weight (1.2) followed by harvest index (0.56) and curd depth (0.27). Similar results were obtained in studies conducted by Khar (1995), who observed positive direct effect of gross weight per plant and harvest index on net curd weight. On the contrary, curd size index (-0.26) showed highest negative direct effects followed by dry matter content (-0.24) and number of leaves per plant (-0.22). Chand *et al* (1984) and Khar (1995) observed the same results.

Summary

The experiment was conducted to study correlation and path analysis in cauliflower (*Brassica oleracea* var. *botrytis*. L.) in thirty genotypes. In general, genotypic coefficients of correlation for all traits were higher in magnitude as compared to phenotypic coefficients of correlation. Net curd weight had highest significant positive correlation with total plant weight and leaf width. Significant positive correlation was found between total plant weight and leaf width. Conclusively, net curd weight can be increased through selection based on total plant weight and leaf width, as path analysis revealed that these characters had highest positive direct effect on net curd weight.

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Table 1. Genotypic and Phenotypic Correlation Coefficient of Different Characters Studied in Cauliflower

CHARACTER		Curd Depth (cm)	Curd Diameter (cm)	Net Curd Weight (g)	Total Plant Weight (g)	Stem Length (cm)	Number of Leaves	Leaf Length (cm)	Leaf Width (cm)	Plant Spread (cm)	Curd Angle (degree)	Curd Size Index (cm ²)	Height at 50% Curd Maturity (cm)	Ascorbic Acid (mg/100g)	Mineral Matter Content (%)	Harvest Index	Curd Compactness Index (g/cm ³)	Dry Matter (%)	Days to 50% Curd Maturity	
Curd Diameter	G	0.0701																		
	P	0.0702																		
Net Curd Weight (g)	G	0.1996	0.4405**																	
	P	0.1982	0.4379**																	
Total Plant Weight (g)	G	-0.1867	0.5908**	0.7335**																
	P	-0.1863	0.5899**	0.7305**																
Stem Length (cm)	G	-0.4377**	0.3198**	0.0925	0.5287**															
	P	-0.4372**	0.3193**	0.0923	0.5282**															
Number of Leaves per plant	G	-0.0145	0.5757**	0.1337	0.5194**	0.2451*														
	P	-0.0147	0.575**	0.1338	0.5188**	0.2447*														
Leaf Length (cm)	G	-0.3148**	0.4072**	0.1964	0.5578**	0.7401*	0.2603*													
	P	-0.3145**	0.4069**	0.1955	0.5574**	0.7397*	0.2601*													
Leaf Width (cm)	G	-0.3669**	0.4747**	0.5371**	0.7771**	0.5324*	0.3264*	0.6339**												
	P	-0.3666**	0.4742**	0.5342**	0.7762**	0.5323*	0.3258*	0.6338**												
Plant Spread (cm)	G	-0.3119**	-0.0889	0.1988	0.2114*	-0.0835	0.1245	0.1299	0.1921											
	P	-0.3068**	-0.0864	0.1972	0.2068	-0.0827	0.1224	0.1277	0.1893											
Curd Angle (degree)	G	-0.268*	-0.1841	0.2269*	0.2139*	-0.1575	-0.0637	-0.1635	0.0848	0.181										
	P	-0.2672*	-0.1825	0.2225*	0.2117*	-0.1568	-0.0634	-0.1626	0.0848	0.1779										
Curd Size Index (cm ²)	G	0.7912*	-0.2273*	-0.1141	0.3849*	0.5904**	0.1515	-0.5316**	0.5931*	0.2753*	-0.1814									
	P	0.7905*	-0.227*	-0.1136	0.3846*	0.5902**	0.1514	-0.5316**	0.5929*	0.2708*	-0.1805									
Plant Height at 50% Curd Maturity	G	-0.3861*	0.1422	0.0788	0.2628*	0.4261**	-0.1083	0.4181**	0.4053*	0.0891	-0.0984	-0.5887*								

(cm)	P	-0.3857*	0.1421	0.0784	0.2626*	0.426*	-0.1082	0.4181**	0.4052*	0.0877	-0.098	-0.5887*							
Ascorbic Acid (mg/100g)	G	0.326**	-0.2036	0.2037	0.0609	-0.0842	0.0034	0.049	-0.0838	-0.1108	0.1384	0.2174*	-0.4633**						
	P	0.3257*	-0.2034	0.2029	0.0608	-0.0841	0.0034	0.049	-0.0838	-0.1091	0.1376	0.2173*	-0.4633**						
Mineral Matter Content (%)	G	-0.1421	0.1713	-0.2498*	0.0305	0.1039	0.233*	0.0945	0.1104	-0.2077	-0.1544	-0.1586	0.3263**	-0.36**					
	P	-0.1413	0.17	-0.2472*	0.0301	0.104	0.2312*	0.0939	0.1101	-0.2008	-0.1518	-0.1579	0.325**	-0.3586**					
Harvest Index	G	0.6123*	-0.3011*	0.1873	-0.4958*	-0.6074**	-0.5024**	-0.5507**	-0.414**	-0.1203	-0.1048	0.496**	-0.349*	0.2441*	-0.3621**				
	P	0.6056*	-0.299**	0.1945	-0.4928*	-0.602**	-0.4976**	-0.5461**	-0.4108*	-0.1095	-0.105	0.4919*	-0.3461**	0.242*	-0.3565**				
Curd Compactness Index (g/cm ³)	G	-0.5892*	0.0265	0.4095**	0.4343*	0.0346	0.0415	-0.0314	0.4783*	0.4045*	0.4558*	-0.3889*	0.0058	-0.0949	-0.0835	-0.1616			
	P	-0.5878*	0.0269	0.406**	0.4335*	0.0343	0.0414	-0.0313	0.4776*	0.398**	0.4537*	-0.3885*	0.0057	-0.0949	-0.084	-0.1615			
Dry Matter Content (%)	G	-0.0101	0.2268*	-0.1923	0.0893	0.2036	0.1768	0.215*	0.1357	-0.2584*	-0.2322*	-0.0772	0.3697**	-0.3596**	0.9233**	-0.3301*	-0.254*		
	P	-0.01	0.2264*	-0.1913	0.0894	0.2035	0.1765	0.2149*	0.1357	-0.2547*	-0.2312*	-0.0772	0.3696**	-0.3594**	0.9193**	-0.3275*	-0.2539*		
Days to 50% Curd Maturity	G	-0.3153*	-0.1666	-0.2018	-0.021	0.1549	0.1186	0.1012	0.1001	0.0077	0.0512	-0.2833*	0.083	0.0156	0.2528**	-0.2873*	0.1251	0.1256	
	P	-0.3142*	-0.1663	-0.1994	-0.0208	0.1541	0.1182	0.1008	0.0997	0.0077	0.0517	-0.2824*	0.0828	0.0155	0.251*	-0.2829*	0.1247	0.1249	
Total Protein (mg/100g)	G	-0.1301	-0.1436	0.0635	0.0923	-0.0182	0.0694	-0.049	0.1664	0.0619	-0.0468	-0.1509	0.0574	0.1056	0.1348	-0.0186	0.2627*	0.0567	0.0247
	P	-0.13	-0.1435	0.0631	0.0922	-0.0182	0.0693	-0.049	0.1663	0.061	-0.0464	-0.1509	0.0574	0.1056	0.1342	-0.0186	0.2624*	0.0567	0.0246

Critical Value of 'r' at 5% = 0.2083 * Significant at 5% at 1% = 0.2692 **Significant at 1%

Table. 2. Direct and Indirect Effects of Different Characters on Net Curd Weight

CHARACTER		Curd Depth (cm)	Curd Diameter (cm)	Total Plant Weight (g)	Harvest Index	Days to 50% Curd Maturity	Stem Length (cm)	Number of Leaves	Leaf Length (cm)	Leaf Width (cm)
Curd Depth (cm)	G	0.3862	0.0018	-0.2229	0.3045	-0.0108	0.0653	0.0034	-0.0267	0.0676
	P	0.2762	0.0034	-0.227	0.3417	-0.0139	0.0611	0.0033	-0.0246	0.0621
Curd Diameter (cm)	G	0.0271	0.0252	0.7055	-0.1497	-0.0057	-0.0477	-0.1367	0.0345	-0.0874
	P	0.0194	0.0488	0.7189	-0.1687	-0.0074	-0.0446	-0.1307	0.0319	-0.0803
Total Plant Weight (g)	G	-0.0721	0.0149	1.1941	-0.2465	-0.0007	-0.0789	-0.1234	0.0473	-0.1432
	P	-0.0515	0.0288	1.2187	-0.278	-0.0009	-0.0738	-0.118	0.0436	-0.1315
Harvest Index	G	0.2365	-0.0076	-0.592	0.4973	-0.0098	0.0906	0.1193	-0.0467	0.0763
	P	0.1673	-0.0146	-0.6006	0.5641	-0.0125	0.0842	0.1131	-0.0428	0.0696
Days to 50% Curd Maturity	G	-0.1218	-0.0042	-0.025	-0.1429	0.0342	-0.0231	-0.0282	0.0086	-0.0184
	P	-0.0868	-0.0081	-0.0253	-0.1596	0.0442	-0.0215	-0.0269	0.0079	-0.0169
Stem Length (cm)	G	-0.169	0.0081	0.6313	-0.302	0.0053	-0.1492	-0.0582	0.0628	-0.0981
	P	-0.1208	0.0156	0.6437	-0.3396	0.0068	-0.1398	-0.0556	0.0579	-0.0902
Number of Leaves per Plant	G	-0.0056	0.0145	0.6202	-0.2498	0.0041	-0.0366	-0.2375	0.0221	-0.0601
	P	-0.0041	0.0281	0.6323	-0.2807	0.0052	-0.0342	-0.2274	0.0204	-0.0552
Leaf Length (cm)	G	-0.1216	0.0103	0.6661	-0.2738	0.0035	-0.1104	-0.0618	0.0848	-0.1168
	P	-0.0869	0.0199	0.6793	-0.3081	0.0045	-0.1034	-0.0591	0.0783	-0.1074
Leaf Width (cm)	G	-0.1417	0.012	0.928	-0.2059	0.0034	-0.0795	-0.0775	0.0538	-0.1842
	P	-0.1013	0.0232	0.946	-0.2317	0.0044	-0.0744	-0.0741	0.0496	-0.1694
CHARACTER		Curd Depth (cm)	Curd Diameter (cm)	Total Plant Weight (g)	Harvest Index	Days to 50% Curd Maturity	Stem Length (cm)	Number of Leaves	Leaf Length (cm)	Leaf Width (cm)
Plant Spread (cm)	G	-0.1205	-0.0022	0.2524	-0.0598	0.0003	0.0125	-0.0296	0.011	-0.0354
	P	-0.0847	-0.0042	0.2521	-0.0618	0.0003	0.0116	-0.0278	0.01	-0.0321
Curd Angle (degree)	G	-0.1035	-0.0046	0.2554	-0.0521	0.0017	0.0235	0.0151	-0.0139	-0.0156
	P	-0.0738	-0.0089	0.258	-0.0592	0.0023	0.0219	0.0144	-0.0127	-0.0144
Curd Size Index (cm ²)	G	0.3055	-0.0057	-0.4596	0.2467	-0.0097	0.0881	0.036	-0.0451	0.1093
	P	0.2183	-0.0111	-0.4687	0.2775	-0.0125	0.0825	0.0344	-0.0416	0.1004
Curd Compactness Index (g/cm ³)	G	-0.2275	0.0007	0.5186	-0.0804	0.0043	-0.0052	-0.0098	-0.0027	-0.0881
	P	-0.1624	0.0013	0.5283	-0.0911	0.0055	-0.0048	-0.0094	-0.0024	-0.0809

Plant Height at 50% Curd Maturity (cm)	G	-0.1491	0.0036	0.3138	-0.1735	0.0028	-0.0636	0.0257	0.0355	-0.0747
	P	-0.1065	0.0069	0.32	-0.1953	0.0037	-0.0595	0.0246	0.0327	-0.0686
Ascorbic Acid (mg/100g)	G	0.1259	-0.0051	0.0727	0.1214	0.0005	0.0126	-0.0008	0.0042	0.0154
	P	0.09	-0.0099	0.0742	0.1366	0.0007	0.0118	-0.0008	0.0038	0.0142
Mineral Matter Content (%)	G	-0.0549	0.0043	0.0364	-0.1801	0.0086	-0.0155	-0.0553	0.008	-0.0203
	P	-0.039	0.0083	0.0367	-0.2011	0.0111	-0.0145	-0.0526	0.0074	-0.0187
Dry Matter Content (%)	G	-0.0039	0.0057	0.1066	-0.1642	0.0043	-0.0304	-0.042	0.0182	-0.025
	P	-0.0028	0.0111	0.1089	-0.1847	0.0055	-0.0285	-0.0401	0.0168	-0.023
Total Protein (mg/100g)	G	-0.0502	-0.0036	0.1102	-0.0093	0.0008	0.0027	-0.0165	-0.0042	-0.0306
	P	-0.0359	-0.007	0.1124	-0.0105	0.0011	0.0025	-0.0158	-0.0038	-0.0282
CHARACTER		Plant Spread (cm)	Curd Angle (degree)	Curd Size Index (cm ²)	Curd Compactness Index (g/cm ³)	Plant Height at 50 % Curd Maturity (cm)	Ascorbic Acid (mg/100g)	Mineral Matter (%)	Dry Matter (%)	Total Protein (mg/100g)
Curd Depth (cm)	G	0.0002	0.0049	-0.2701	-0.0738	0.0239	-0.0336	-0.0250	0.0024	0.0022
	P	-0.002	0.0005	-0.2116	-0.0352	0.0207	-0.0323	-0.0269	0.0025	0
Curd Diameter (cm)	G	0.0001	0.0034	0.0776	0.0033	-0.0088	0.0210	0.0301	-0.0535	0.0022
	P	-0.0006	0.0004	0.0608	0.0016	-0.0076	0.0202	0.0324	-0.0565	0
Total Plant Weight (g)	G	-0.0001	-0.0039	0.1314	0.0544	-0.0163	-0.0063	0.0053	-0.0211	-0.0016
	P	0.0013	-0.0004	0.1029	0.0259	-0.0141	-0.006	0.0057	-0.0223	0
Harvest Index	G	0.0001	0.0019	-0.1693	-0.0203	0.0216	-0.0251	-0.0636	0.0779	0.0003
	P	-0.0007	0.0002	-0.1317	-0.0097	0.0186	-0.0240	-0.0679	0.0818	0
Days to 50% Curd Maturity	G	0	-0.0009	0.0967	0.0157	-0.0052	-0.0016	0.0444	-0.0296	-0.0004
	P	0	-0.0001	0.0756	0.0075	0.0044	-0.0015	0.0478	-0.0312	0
Stem Length (cm)	G	0	0.0029	0.2016	0.0043	-0.0264	0.0087	0.0182	-0.0480	0.0003
	P	-0.0005	0.0003	0.1580	0.0021	-0.0229	0.0083	0.0198	-0.0508	0
Number of Leaves per Plant	G	-0.0001	0.0012	0.0517	0.0052	0.0067	-0.0004	0.0409	-0.0417	-0.0012
	P	0.0008	0.0001	0.0405	0.0025	0.0058	-0.0003	0.0440	-0.0441	0
Leaf Length (cm)	G	-0.0001	0.003	0.1815	-0.0039	-0.0259	-0.005	0.0166	-0.0507	0.0008
	P	0.0008	0.0003	0.1423	-0.0019	-0.0225	-0.0049	0.0179	-0.0537	0
Leaf Width (cm)	G	-0.0001	-0.0016	0.2025	0.0599	-0.0251	0.0086	0.0194	-0.0320	-0.0028
	P	0.0012	-0.0002	0.1587	0.0286	-0.0218	0.0083	0.0210	-0.0339	-0.0001
CHARACTER		Plant Spread (cm)	Curd Angle (Degree)	Curd Size Index (cm ²)	Curd Compactness Index (g/cm ³)	Height at 50 % Curd Maturity (cm)	Ascorbic Acid (mg/100g)	Mineral Matter (%)	Dry Matter (%)	Total Protein (mg/100g)
Plant Spread (cm)	G	-0.0006	-0.0033	0.0940	0.0507	-0.0055	0.0114	-0.0365	0.0610	-0.0010

	P	0.0064	-0.0004	0.0725	0.0238	-0.0047	0.0108	-0.0382	0.0636	0
Curd Angle (degree)	G	-0.0001	-0.0184	0.0619	0.0571	0.0061	-0.0142	-0.0271	0.0548	0.0008
	P	0.0011	-0.002	0.0483	0.0271	0.0053	-0.0136	-0.0289	0.0577	0
Curd Size Index (cm ²)	G	0.0002	0.0033	-0.3414	-0.0487	0.0365	-0.0224	-0.0278	0.0182	0.0026
	P	-0.0017	0.0004	-0.2676	-0.0232	0.0316	-0.0215	-0.0301	0.0193	0
Curd Compactness Index (g/cm ³)	G	-0.0002	-0.0084	0.1328	0.1253	-0.0004	0.0098	-0.0147	0.0599	-0.0044
	P	0.0026	-0.0009	0.1040	0.0598	-0.0003	0.0094	-0.0160	0.0634	-0.0001
Plant Height at 50% Curd Maturity (cm)	G	-0.0001	0.0018	0.2010	0.0007	-62	0.0477	0.0573	-0.0872	-0.0010
	P	0.0006	0.0002	0.1576	0.0003	-0.0537	0.0459	0.0619	-0.0923	0
Ascorbic Acid (mg/100g)	G	0.0001	-0.0025	-0.0742	-0.0119	0.0287	-0.1029	-0.0632	0.0848	-0.0018
	P	-0.0007	-0.0003	-0.0582	-0.0057	0.0249	-0.0991	-0.0683	0.0898	0
Mineral Matter Content (%)	G	0.0001	0.0028	0.0541	-0.0105	-0.0202	0.0371	0.1756	-0.2178	-0.0023
	P	-0.0013	0.0003	0.0423	-0.0050	-0.0175	0.0355	0.1905	-0.2296	0
Dry Matter Content (%)	G	0.0001	0.0043	0.0264	-0.0318	-0.0229	0.0370	0.1621	-0.2359	-0.0010
	P	-0.0016	0.0005	0.0207	-0.0152	-0.0199	0.0356	0.1751	-0.2497	0
Total Protein (mg/100g)	G	0	0.0009	0.0515	0.0329	-0.0036	-0.0109	0.0237	-0.0134	-0.0169
	P	0.0004	0.0001	0.0404	0.0157	-0.0031	-0.0105	0.0256	-0.0142	-0.0061