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Correlation and path coefficient analysis studies in Indian cauliflower (*Brassica oleracea* var. *botrytis* L.)

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Abstract
The present investigation was conducted during the year 2019-20 and 2020-21 at horticultural research cum instructional farm, IGKV, Raipur. The experimental material comprised of 24 genotypes and the experiment was layout in Randomized Block Design with 3 replications. The study was primarily focused on assessing correlation coefficient and path coefficient analysis. The genotypic correlation coefficients were of higher in magnitude than their corresponding phenotypic correlation coefficients for almost all the characters which might be due to the masking or modifying effect of the environment in genetic association between characters. Estimates of phenotypic and genotypic correlation revealed curd yield per hectare to be highly positive and significantly correlated with net curd weight, marketable curd weight, gross curd weight, curd depth, curd diameter, curd size index, harvest index and Path coefficient analysis revealed 50% curd maturity having a high positive direct effect towards the curd yield while 50% flower initiation exerting a negative direct effect on curd yield ton per hectare.

Keywords: Correlation coefficient, path coefficient analysis, curd yield

Introduction
Cauliflower, *Brassica oleracea var. botrytis* h. (2n=2x-18) belongs to the cole group of vegetables. It originated primarily from the ancestor *Brassica oleracea var. oleracea* L. (syn. *sylvestris* L.), commonly known as wild cabbage through mutation, human selection and adaptation about 2000 years ago in the Eastern Mediterranean region (Boriss *et al* 2006) [1]. Among the cole crops, cauliflower is comparatively of a later origin, about 500 years ago, probably through introgression within broccoli gene pool. It probably originated in the island of Cyprus from where it moved to other areas like Syria, Turkey, Egypt, Italy, Spain and north-western Europe. It was first introduced in Italy around 1490 and Italy became the centre of genetic diversity of cauliflower where several land races of this crop are still available even today. Cauliflower is a low-calorie food with good dietary fiber, abundant in vitamins (C, B, A, K) and minerals like phosphorus, potassium, calcium, sodium, iron, manganese, magnesium and molybdenum. It also contains fair amount of glucosinolates and isothiocyanates, those having antioxidant and anti-inflammatory properties. Compound allicin also found in cauliflower which reduces the risk of heart strokes and maintain healthy cholesterol levels in addition to phytochemical, sulphorafane (organo sulflir compound) and phyto-nutrienls. Cauliflower also helps, in preventing cancer because of the presence of compound sinigrin, glucobrassicin, gluco-raphanin, gluconasturatian Smethylcysteine sulfoxide and other compounds. These compounds act as anticarcinogenic which may help in eliminating carcinogens before they can cause the DNA damage that cause cancer. It also contains selenium which along with vitamin C, Strengthen our immune system.
The present study was undertaken to study correlation of economically important traits in mid-season cauliflower which are helpful in ascertaining the real components of yield which is complex character, the correlation coefficient indicate the degree of relationship between characters but it alone does not give clear pictures of association between the characters. Furthermore the success in selection is also directly proportional to the amount of genetic advance obtained in a generation.

Materials and Method
The present investigation was conducted during the year 2019-20 and 2020-21 at horticultural research cum instructional farm, IGKV, Raipur. The experimental material comprised of 24 genotypes. The experiment was layout in Randomized Block Design with 3 replications.

Observation were recorded for 15 characters viz., plant height at harvest (cm), Stalk length (cm), Number of leaves per plant, Days to 1st flowering, Days to 50% flowering, Days to 50% curd initiation, Days to 50% curd maturity, Curd diameter (cm), Curd depth (cm), Curd size index (cm^2), Gross curd weight (g), Net curd weight (g), Harvest index (%), Yield (q/ha). Searle's (1961) formula was used to estimate the correlation coefficient. The path coefficient analysis of component traits with fruit yield was done by method of Dewey and Lu (1959) [2].

Result and Discussion

Analysis of variance revealed significant differences among genotypes for all traits studied indicating presence of significant variability in the materials. Hence, the data was further subjected to correlation and path coefficient analysis to estimates the association existing between yield and yield attributing components and direct and indirect effects of yield related traits, respectively. The genotypic correlation coefficients were of higher in magnitude than their corresponding phenotypic correlation coefficients for almost all the characters which might be due to the masking or modifying effect of the environment in genetic association between characters. The data pertaining to correlation coefficient are presented in Table 1. Correlation analysis revealed that, curd yield (t/ha) had highly significant positive genotypic and phenotypic correlation with net curd weight (0.662, 0.608), gross curd weight (0.783, 0.679), marketable curd weight (1.059, 0.940), curd depth (0.584, 0.475), curd diameter (0.289, 0.253), curd size index (0.417, 0.381) and harvest index (0.327, 0.283). Thus the indirect selection for higher yield based on these characters would be reliable. Highly significantly and positively correlation of curd yield with the ancillary characters viz., curd diameter, weight of curd, plant height was also reported by Singh *et al.* (2014) [11]. Significant and positive correlation of net curd weight with gross curd weight was also reported by Kanwar and Korla (2002) [3], Nimkar and Korla (2008) [7], Kumar *et al*. (2005) [4], Sheemar *et al*. (2012) [10] and Nimkar (2013) [8]. Kumar *et al.* (2010) [5] and Kumar *et al*. (2011) [6] observed yield to be positive and significantly correlated with net curd weight.

Path coefficient analysis helps in partitioning the genotypic and phenotypic correlation coefficients into direct and indirect effects. As depicted by Table 2, 50% curd maturity exhibited maximum positive direct effect on curd yield t/ha (5.139) followed by curd diameter (1.795), 1st flower initiation (1.592), marketable curd weight (1.002), harvest index (0.900), plant height (0.456), net curd weight (0.294) and stalk length (0.270). Hence selection based on these traits would be effective in increasing the curd yield potential of rice. On the converse, 50% curd initiation (-5.335) showed highest negative direct effects followed 50% flower initiation (-1.877), curd size index (-1.831), number of leaf (-0.550), gross curd weight (-0.472) and curd depth (-0.312). Path coefficient analysis by Kumar *et al.* (2010) [5] and Kumar *et al.* (2011) [6] revealed that net curd weight had high positive direct effect towards the total yield while harvest index exerts a negative direct effect on curd yield per hectare. Similar to the above findings Soni *et al.* (2013) [12] also observed that at phenotypic level head weight and plant spread exhibit a high order direct effect on curd yield whereas at genotypic level, head weight and leaf length retains a high order direct effect on curd yield. Nimkar (2013) [8], Sheemar *et al.* (2012) [10] and Kumar *et al.* (2011) [6] reported high direct effect on net curd weight by marketable curd weight which further supports the findings.

Table 1: Phenotypic and genotypic correlation coefficients among curd yield (t/ha) and its components in cauliflower.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	G	1														
	P	1														
2	G	0.463*	1													
	P	0.299*	1													
3	G	0.464**	0.392**	1												
	P	0.343**	0.257*	1												
4	G	0.155NS	0.258*	-0.184NS	1											
	P	0.110NS	0.222NS	-0.179NS	1											
5	G	0.418**	0.360**	0.907**	-0.043 NS	1										
	P	0.270*	0.293*	0.852**	-0.041NS	1										
6	G	0.207NS	0.164NS	0.713**	0.042NS	0.817**	1									
	P	0.071NS	0.098NS	0.560**	0.056NS	0.659**	1									
7	G	0.266*	0.121NS	0.829**	-0.129NS	0.925**	0.659**	1								
	P	0.161NS	0.065NS	0.625**	-0.137NS	0.610**	0.404**	1								
8	G	0.528**	0.396**	0.748**	-0.031NS	0.803**	0.309**	0.739**	1							
	P	0.390**	0.235*	0.688**	-0.047NS	0.711**	0.237*	0.561**	1							
9	G	0.439**	0.320**	0.833**	-0.111NS	0.894**	0.465**	0.892**	0.964**	1						
	P	0.332**	0.175NS	0.746**	-0.114NS	0.749**	0.331**	0.819**	0.920**	1						
10	G	0.156NS	0.000NS	-0.055NS	0.028NS	-0.289*	-0.181NS	-0.392**	-0.426**	-0.434**	1					
	P	0.127NS	-0.005NS	-0.058NS	0.016NS	-0.251*	-0.124NS	-0.332**	-0.379**	-0.402**	1					
11	G	0.033NS	-0.014NS	-0.118NS	0.014NS	-0.304**	-0.123NS	-0.391**	-0.509**	-0.491**	0.980**	1				
	P	0.010NS	-0.040NS	-0.104NS	-0.003NS	-0.238*	-0.060NS	-0.335**	-0.448**	-0.452**	0.931**	1				
12	G	0.113NS	0.045NS	-0.008NS	0.133NS	-0.217NS	-0.078NS	-0.319**	-0.346**	-0.356**	0.920**	0.915**	1			
	P	0.077NS	0.048NS	0.006NS	0.085NS	-0.167NS	-0.081NS	-0.248*	-0.314**	-0.325**	0.888**	0.875**	1			
13	G	0.100NS	0.018NS	-0.053NS	0.121NS	-0.274*	-0.076NS	-0.343**	-0.390**	-0.403**	0.888**	0.884**	0.991**	1		
	P	0.084NS	-0.002NS	-0.048NS	0.123NS	-0.200NS	-0.052NS	-0.295*	-0.361**	-0.381**	0.843**	0.847**	0.951**	1		
14	G	0.427**	0.280*	0.881**	-0.284*	0.580**	0.404**	0.553**	0.533**	0.589**	0.187NS	0.078NS	0.204NS	0.195NS	1	
	P	0.243*	0.086NS	0.762**	-0.252*	0.367**	0.201NS	0.437**	0.419**	0.486**	0.145NS	0.028NS	0.157NS	0.111NS	1	

15	G	0.178 NS	0.151NS	0.662**	0.046NS	0.783**	1.059**	0.584**	0.289*	0.417	-0.159NS	-0.103NS	-0.076NS	-0.064NS	0.327**	1
	P	0.096NS	0.108NS	0.608**	0.050NS	0.679**	0.940**	0.475**	0.253*	0.381**	-0.148NS	-0.081NS	-0.081NS	-0.065NS	0.283*	1
* Significant at p = 0.05 level ** Significant at p = 0.01 level																

1. Plant height at harvest (cm)	2. Number of leaves per plant	3.Stalk length (cm)	4. Gross curd weight (g)	5. Marketable curd weight (g)
6. Net curd weight (g)	7. Curd depth (cm)	8. Curd diameter (cm)	9. Curd size index (cm^2)	10. Days to 50% curd initiation
11. Days to 50% curd maturity	12. Days to 1st flowering	13. Days to 50% flowering	14. Harvest index (%)	15. Curd yield (t/ha)

Table 2: Estimates of direct and indirect effect of different characters on curd yield (t/ha) at genotypic level in cauliflower.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.46454	-0.25473	0.13658	0.04191	-0.19735	0.20785	-0.08311	0.94762	-0.80278	-0.83027	0.17204	0.17912	-0.18755	0.38393
2	0.21513	-0.55006	0.11517	0.06972	-0.16977	0.16447	-0.03769	0.71131	-0.58604	-0.00151	-0.06957	0.07125	-0.0334	0.25185
3	0.21573	-0.21541	0.2941	-0.0498	-0.42778	0.715	-0.25871	1.34278	-1.52399	0.29408	-0.60406	-0.01241	0.09883	0.79343
4	0.07209	-0.142	-0.05423	0.27008	0.02026	0.04209	0.04021	-0.05548	0.20384	-0.1496	0.06981	0.21121	-0.22677	-0.25541
5	0.19435	-0.19797	0.26671	-0.0116	-0.47171	0.81862	-0.28896	1.44229	-1.63707	1.54043	-1.56306	-0.34594	0.51479	0.52204
6	0.09635	-0.09028	0.20983	0.01134	-0.38534	1.00212	-0.20568	0.55514	-0.85078	0.9646	-0.63043	-0.12354	0.14184	0.3638
7	0.12365	-0.0664	0.24369	-0.03478	-0.43655	0.66013	-0.31223	1.32578	-1.6323	2.09004	-2.01137	-0.50743	0.64338	0.49805
8	0.24522	-0.21796	0.21999	-0.00835	-0.37899	0.3099	-0.23059	1.79514	-1.76426	2.27156	-2.61426	-0.55029	0.73239	0.47962
9	0.20372	-0.1761	0.24484	-0.03007	-0.42185	0.46575	-0.27841	1.73011	-1.83057	2.31488	-2.52575	-0.56612	0.75616	0.53028
10	0.07229	-0.00016	-0.01621	0.00757	0.1362	-0.18118	0.12231	-0.76431	0.79426	-5.33523	5.0386	1.46498	-1.6663	0.16806
11	0.01555	0.00745	-0.03457	0.00367	0.14347	-0.12293	0.1222	-0.91318	0.89967	-5.23084	5.13915	1.4567	-1.66013	0.07029
12	0.05228	-0.02463	-0.00229	0.03584	0.10253	-0.07779	0.09955	-0.6207	0.65115	-4.91102	4.7038	1.59152	-1.86001	0.18362
13	0.04641	-0.00979	-0.01548	0.03262	0.12935	-0.07571	0.10701	-0.70035	0.73734	-4.73565	4.5447	1.57689	-1.87727	0.17588
14	0.19814	-0.15391	0.25924	-0.07664	-0.27358	0.40503	-0.17276	0.95654	-1.07844	-0.99613	0.40134	0.32466	-0.36682	0.90011
* Significant at p = 0.05 level ** Significant at p = 0.01 level Residual Effect (Genotypic) : 0.08262														

1. Plant height at harvest (cm)	2. Number of leaves per plant	3.Stalk length (cm)	4. Gross curd weight (g)	5. Marketable curd weight (g)
6. Net curd weight (g)	7. Curd depth (cm)	8. Curd diameter (cm)	9. Curd size index (cm^2)	10. Days to 50% curd initiation
11. Days to 50% curd maturity	12. Days to 1st flowering	13. Days to 50% flowering	14. Harvest index (%)	15. Curd yield (t/ha)

Conclusion

Estimates of phenotypic and genotypic correlation revealed curd yield per hectare to be highly positive and significantly correlated with net curd weight, marketable curd weight, gross curd weight, curd depth, curd diameter, curd size index, harvest index and Path coefficient analysis revealed 50% curd maturity having a high positive direct effect towards the curd yield while 50% flower initiation exerting a negative direct effect on curd yield ton per hectare, so it could be concluded that these parameters could be considered for the development of elite hybrids via heterosis breeding or for the development of inbred lines.

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