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Correlation Coefficient and Path Analysis Studies on Various Horticultural Attributes of Cauliflower (*Brassica oleracea* Var. Botrytis)

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ABSTRACT

Background: Cauliflower is one of the foremost vegetable among all Cole crops. It contains an incredible amount of essential nutrients and vitamins. Being the second most important crop among all Cole crops, cauliflower contributes to overall vegetable productivity. The principal objective of this study is to evaluate the different genotypes on the basis of horticultural traits, so that can be further utilized in crop improvement programs.

Methods: The present experimentation was initiated with fifteen diverse cauliflower genotypes. The trial was set up with a RCBD along with 3 replications, during the year of 2018-2019 at Lovely Professional University, Phagwara (Punjab).

Result: Correlation analysis showed that yield of curd per hectare exhibited highest positive and significant correlation with leaf width, curd diameter, depth of curd, stalk length of plant, leaf length, net curd weight, days to curd initiation, gross plant weight, harvest index, marketable curd weight and days to curd maturity. Highest positive and direct effect was observed on yield of curd with marketable curd weight, leaf width, net curd weight, gross plant weight, length of plant stalk, harvest index, days to curd maturity, days to curd initiation, curd depth, Leaf lamina length, curd index and curd diameter.

Key words: Correlation, Curd index, Curd maturity, Genotypic, Harvest index, Phenotypic.

INTRODUCTION

India is second in overall vegetable output after China and has attained a high level of sustainability in food production. However, food security has become an important problem in order to meet the needs of the undernourished population through a well-balanced diet. Vegetables serve as an important part in a balanced diet since they are high in nutrients and key elements.

Cauliflower (*Brassica oleracea* var. *botrytis*) is the one of the most popular cole crops and belongs to the family Brassicaceae with chromosomal number of 2n=2X=18. Bihar, West Bengal, Uttar Pradesh, Orissa, Assam, Haryana and Maharashtra are India's major producers. Furthermore, it is extensively grown in the southern Nilgiri highlands and in the northern Himalayas. In India, hybrid cultivar of cauliflower share is about fewer than 11% (Muthukmar and Selvakumar, 2014). Curd, or pre-floral fleshy apical meristem, is the edible portion of cauliflower (Sidki, 1962). Cauliflower is high in vitamin A (70IU/100 g), vitamin B (50 mg/100 g) and vitamin C (75 mg/100 g). It has a sufficient quantity of calcium (30 mg), iron (17 mg), phosphorus (76 mg), calcium (30 mg) and ascorbic acid (75 mg/100 g). The optimum temperature required for the growth and development of cauliflower ranges from 5-8°C (night) to 25-28°C (day). Excessive consumption of cauliflower have been reported with reduction in the hazard of prostate cancer (Kushwaha *et al*., 2013). This plant can also withstand with temperature of 10 to 40°C. It is grown across the country from latitudes 11°N to 35°N (Swarup and Chatterjee, 1972).

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Cauliflower can be categorized according to curd ripening and curd availability and broadly divided into five types *i.e*. early varieties, mid varieties, mid-early varieties, mid late varieties and late varieties. The first three of the above groups are typical of Indian cauliflower, flowering and seeding in the northern plains. The fourth group, Snowball (Cauliflower variety Erfurt or Alpha), produces seeds only on hills. *Brassica oleracea* var. botrytis L. gene pools are highly variable due to the inclusion of a wide range of maturity groups. Gene flow is not regulated in these horticultural forms. Growers confront the challenge of decreased variability and yield improvement due to a lack of understanding about variability among various cauliflower groupings. The breeder's initial goal is to create as many genetic resource collections as feasible. The cauliflower's narrow genetic base can be addressed to some level by

implementing derivatives from crosses in between wild species. The choice of yield component has been demonstrated to be more successful than the choice of yield for most crops. A habitation unit is more than a conglomeration of independent units; it is an intricate web of complex relationships between several characters, where choosing one character has an associated outcome for another attribute. Yield being a complex quality feature governed by several constituents' attributes. So choices for characters associated to yield have to be taken in to consideration (Selvi *et al*., 2016). Correlation assists in determining the real component of the return that is a complicated feature. The correlation coefficient illustrates the information regarding degree of link in between several characters, but it is incapable to provide comprehensive details of the characters' relationships. Correlation reveals just the link between two or more features, not the reason of that association. Path analysis is also useful in terms of correlation since it reveals the underlying source of correlations between distinct functions. Overall, understanding of coefficient correlation and path analysis aid breeder's to find out the existent constituent of the yield and postulate an effectual basis for selection at phenotypic level Gudmewad *et al*. (2016).

MATERIALS AND METHODS

Experimental site, layout and material observation

The current experiment was carried out at Lovely Professional University, (Punjab) in 2018-19. Total fifteen diverse genotypes of cauliflower were used in randomized complete block design along with 3 replications and the data was calculated to estimate correlation coefficient and path coefficients analysis for various horticultural traits. The cauliflower nursery was sown in the pro trays containing the mixture of cocopeat: vermiculite: perlite. Before seed sowing the cauliflower seed was treated with captan @ 2 g/kg to avoid the fungal diseases. After four weeks of sowing, seedlings were ready to transplant into the main field and the transplanting was done on 7th November 2017 at the spacing of 60 cm × 45 cm, respectively. The data was analyzed for 18 quantitative traits, which was collected from five chosen plants of every genotypes and from one and all replications, the studied traits were plant height at 30 days after sowing, leaf number at harvesting (LNAH), leaf width (LW), leaf length (LL), stalk length of plant (SLOP), net curd weight (NCW), lamina length, curd index (CI), gross plant weight (GPW), leaf stalk length (LSL), diameter of curd (DOC), curd depth (CD), harvest index (HI), days to curd maturity (DTCM) and curd yield (CY). Path analysis based on genotypic and phenotypic correlations was carried out in accordance with (Dewey and Lu, 1959) and the approach described by (Searle, 1961) was used to determine correlationns at both the phenotypic and genotypic levels between all possible pairings of traits.

RESULTS AND DISCUSSION

Correlation studies

Utilizing the association between several qualities could enhance selections. While the phenotypic relation demonstrated a relationship between two traits and included both environmental and inherited factors, the genotypic correlation provided association between two characters that is essential in the evaluation process Johnson *et al*. (1955). The data analyzed for phenotypic correlation coefficient are given in Table 1. Diameter of curd showed phenotypically positive and significant correlation with leaf width, curd yield, marketable curd yield (MCY), days to curd initiation, gross plant weight (GPW), stalk length of plant (SLOP), CI, DOC, NCW, DTCM and HI, while it showed significant and negative correlation with stalk length of leaf. Depth of curd had significant and positive correlation with curd yield, curd index, curd maturity, marketable curd weight and net curd weight, days to curd initiation, harvest index and leaf width, while it was significant and negatively correlated with stalk length of leaf. In addition to this the trait namely LLL and leaf length found non-significant but positive correlation with studied trait. MCW was observed positively and highly significant association with days to curd index, curd maturity (CM), CI, DTCI, HI and NCW, meanwhile the studied trait showed positive but non-significant association with leaf length. Moreover on that, some of the attributes such as curd yield, DTCI, CI, HI and curd maturity exhibited highly significant but positive association with net curd weight, whilst the leaf length was showed positive and non-significant correlation with studied trait. A positively significant correlation of DTCI was noticed with days to curd maturity, HI, CI and curd yield.

Table 2 examines the genotypic correlation coefficient estimates for several variables. The attributes such as harvest index, depth of curd, curd index, net curd weight, days to curd initiation, LW and DTCM, stalk length of plant, CW, GPW and curd yield were showed their positively significant association with curd diameter. In continuation to this, another studied character *i.e*. curd diameter established positively significant association by way of harvest index, gross plant weight, plant stalk length, curd yield, days to curd initiation, days to curd maturity, net curd weight, leaf width, curd index and marketable curd weight, whereas, it showed non-significantly positive association with LLL. One of the traits namely, leaf stalk exhibited significantly negative and leaf length non-significant but negative correlation with curd diameter. Similarly, genotypic correlation coefficient was estimated for curd depth, which established significantly positive association with some of the studied attributes *viz*., LW, CY, NCW, DTCI, CI, HI, MCY, CM, GPW and stalk length of plant, besides this it expressed positively non-significant association with lamina length and leaf length, but negatively significant with leaf stalk, correspondingly. A significant and positive correlation was established by marketable curd weight with net curd weight,

Table 1: Inter character correlation coefficient between distinct traits of Cauliflower at phenotypic level.

Characters	Plant height (cm)	No. of leaves (45 DAS)	No. of leaves (at harvest)	CD (cm)	DOC (cm)	SLOP (cm)	LLL (cm)	SLOL (cm)	LW (cm)	GPW (kg)	MCW (Kg)	NCW (Kg)	LL (cm)	DTCI	DTCM	CI (cm²)	HI (%)	CY (q/ha)
Plant height (cm)	1	0.36*	0.36*	-0.06	0.07	0.34*	0.48**	-0.04	0.21	0.47*	0.05	0.26	0.37*	0.00	-0.00	-0.01	0.05	0.26
No. of leaves (45 DAS)		1	0.22	-0.11	-0.02	0.02	-0.08	0.11	0.11*	0.47*	-0.12	-0.03	-0.13	-0.56**	-0.59**	-0.09	-0.38*	-0.03
No. of leaves (at harvest)			1	0.20	0.13	0.16	0.29	-0.10	0.30**	0.36*	0.06	0.09	0.29	0.00**	0.02	0.21	-0.14	0.09
CD (cm)				1	0.63**	0.52**	0.25	-0.55**	0.61*	0.56**	0.84**	0.60**	-0.00	0.58**	0.59**	0.96**	0.49**	0.60**
DOC (cm)					1	0.43**	0.29	-0.51**	0.35**	0.39*	0.61**	0.53**	0.17*	0.50**	0.45*	0.80**	0.48**	0.53**
SLOP (cm)						1	0.36*	-0.45*	0.72	0.60**	0.70**	0.68**	0.40**	0.40*	0.34*	0.53**	0.56**	0.68**
LLL (cm)							1	-0.27	0.24*	0.34*	0.30*	0.43*	0.58	0.43*	0.44*	0.30*	0.38*	0.43**
SLOL (cm)								1	-0.35	-0.48**	-0.61**	-0.64**	0.02	-0.38*	-0.32*	-0.60**	-0.59**	-0.64**
LW (cm)									1	0.72**	0.69**	0.77**	0.18	0.42*	0.38*	0.58**	0.61**	0.77**
GPW (kg)										1	0.66	0.76**	0.09	0.21**	0.17	0.56**	0.40*	0.76**
MCW (Kg)											1	0.81**	0.11	0.55**	0.52**	0.84**	0.69**	0.81**
NCW (Kg)												1	0.17	0.62	0.53**	0.64**	0.89**	1.00**
LL (cm)													1	0.24	0.38*	0.07	0.16	0.17**
DTCI														1	0.91**	0.61**	0.75**	0.62**
DTCM															1	0.59**	0.65**	0.53**
CI (cm²)																1	0.54**	0.64**
HI (%)																	1	0.89
Plant height (cm)																		1

CD- Curd diameter; DOC- Diameter of curd; SLOP- Stalk length of plant; LLL- Leaf lamina length; SLOL- Stalk length of leaf; LW- Leaf weight; GPW- Gross plant weight; MCW- Marketable curd weight; NCW- Net curd weight; LL- Leaf length; DTCI- Days to curd initiation; DTCM- Days to Curd maturity; CI- Curd index; HI- Harvest index and CY- Curd yield.

Table 2: Inter character correlation coefficient between distinct traits of cauliflower at genotypic level.

Characters	Plant height (cm)	No. of leaves (45 DAS)	No. of leaves (at harvest)	CD (cm)	DOC (cm)	SLOP (cm)	LLL (cm)	SLOL (cm)	LW (cm)	GPW (kg)	MCW (Kg)	NCW (Kg)	LL (cm)	DTCI	DTCM	CI (cm^2)	HI (%)	CY (q/ha)
Plant height (cm)	1	0.48*	0.37*	-0.07	0.06	0.51*	0.65**	-0.04	0.30	0.58*	0.08	0.31*	0.42	0.02	-0.02	-0.02	0.03	0.31
No. of leaves (45 DAS)		1	0.24	-0.11	-0.04	0.06	-0.13	0.09	0.14	0.50*	-0.11	-0.02	-0.14*	-0.59*	-0.63*	-0.10	-0.39*	-0.02
No. of leaves (at harvest)			1	0.20	0.19	0.24	0.41	-0.12	0.35*	0.38	0.08	0.09	0.22*	0.01*	-0.01	0.23	-0.16	0.09
CD (cm)				1	0.71**	0.58**	0.33	-0.57*	0.67*	0.57*	0.87*	0.62	-0.01*	0.62*	0.60*	0.97*	0.51*	0.62
DOC (cm)					1	0.49*	0.36	-0.55*	0.40*	0.44*	0.67*	0.57	0.18*	0.56*	0.48*	0.85*	0.50*	0.57
SLOP (cm)						1	0.59*	-0.53*	0.89*	0.71*	0.79*	0.77*	0.47*	0.45*	0.42*	0.61*	0.64*	0.77
LLL (cm)							1	-0.34	0.35	0.43*	0.41*	0.55*	0.70*	0.57*	0.55*	0.38*	0.48*	0.55*
SLOL (cm)								1	-0.44*	-0.50*	-0.64*	-0.67	0.06*	-0.42*	-0.33*	-0.62*	-0.62*	-0.67*
LW (cm)									1	0.81**	0.79*	0.84	0.19*	0.49*	0.43**	0.63*	0.65*	0.84*
GPW (kg)										1	0.70*	0.79	0.11*	0.23*	0.16*	0.57*	0.43*	0.79*
MCW (Kg)											1	0.83	0.14**	0.56*	0.55**	0.86*	0.71*	0.83***
NCW (Kg)												1	0.18	0.65**	0.53*	0.65*	0.89*	1.00**
LL (cm)													1	0.29	0.42*	0.06	0.18	0.19
DTCI														1	0.97*	0.64*	0.80*	0.65*
DTCM															1	0.61*	0.67*	0.53*
CI (cm^2)																1	0.55*	0.65*
HI (%)																	1	0.8955*
Plant height (cm)																		1

CD- Curd diameter; DOC- Diameter of curd; SLOP- Stalk length of plant; LLL- Leaf lamina length; SLOL- Stalk length of leaf; LW- Leaf weight; GPW- Gross plant weight; MCW- Marketable curd weight; NCW- Net curd weight; LL- Leaf length; DTCI- Days to curd initiation; DTCM- Days to Curd maturity; CI- Curd index; HI- Harvest index and CY- Curd yield.

Table 3: Path coefficient analysis showing the direct and indirect effect of twelve characters on yield at phenotypic and genotypic level in cauliflower.

Characters	Direct effect	Indirect effect																
		Plant height (cm)	No. of leaves (45 DAS)	No. of leaves (at harvest)	CD (cm)	DOC (cm)	SLOP (cm)	LLL (cm)	SLOL (cm)	LW (cm)	GPW (kg)	MCW (Kg)	NCW (Kg)	LL (cm)	DTCI	DTCM	CI (cm^2)	HI (%)
Plant height (cm) (P)	0.2654	0.0002	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
(G)	0.2654	-0.0209	-0.0102	-0.0077	0.0015	-0.0013	-0.0106	-0.0135	0.0008	-0.0063	-0.0121	-0.0017	-0.0064	-0.0088	-0.0005	0.0008	0.0005	-0.0006
No. of leaves at 45 DAS (P)	-0.0305	-0.0004	-0.0012	-0.0003	0.0001	0.0000	0.0000	0.0001	-0.0001	-0.0001	-0.0006	0.0001	0.0000	0.0002	0.0007	0.0007	0.0001	0.0004
(G)	-0.0305	0.0118	0.0240	0.0057	-0.0028	-0.0010	0.0015	-0.0032	0.0022	0.0033	0.0120	-0.0027	-0.0006	-0.0033	-0.0142	-0.0151	-0.0024	-0.0095
No. of leaves at harvest (P)	0.0895	-0.0005	-0.0003	-0.0014	-0.0003	-0.0002	-0.0002	-0.0004	0.0001	-0.0004	-0.0005	-0.0001	-0.0001	-0.0003	0.0000	0.0000	-0.0003	0.0002
(G)	0.0895	0.0060	0.0039	0.0163	0.0032	0.0031	0.0039	0.0066	-0.0019	0.0056	0.0063	0.0013	0.0014	0.0036	0.0001	-0.0001	0.0037	-0.0026
CD (cm) (P)	0.6047	-0.0005	-0.0010	0.0017	0.0085	0.0054	0.0044	0.0022	-0.0047	0.0052	0.0047	0.0071	0.0051	0.0000	0.0050	0.0049	0.0082	0.0042
(G)	0.6047	-0.0065	-0.0106	0.0184	0.0921	0.0653	0.0537	0.0300	-0.0530	0.0615	0.0522	0.0799	0.0572	-0.0012	0.0571	0.0555	0.0898	0.0474
DOC(cm) (P)	0.5344	0.0002	-0.0001	0.0004	0.0021	0.0032	0.0014	0.0009	-0.0016	0.0011	0.0013	0.0020	0.0017	0.0005	0.0016	0.0015	0.0026	0.0015
(G)	0.5344	0.0035	-0.0022	0.0105	0.0385	0.0543	0.0269	0.0197	-0.0302	0.0216	0.0241	0.0364	0.0308	0.0101	0.0306	0.0263	0.0464	0.0271
SLOP (cm) (P)	0.68	0.0003	0.0000	0.0001	0.0004	0.0003	0.0008	0.0003	-0.0004	0.0006	0.0005	0.0006	0.0005	0.0003	0.0003	0.0003	0.0004	0.0004
(G)	0.68	-0.0024	-0.0003	-0.0011	-0.0027	-0.0023	-0.0046	-0.0027	0.0025	-0.0041	-0.0033	-0.0037	-0.0036	-0.0022	-0.0021	-0.0020	-0.0028	-0.0030
LLL (cm) (P)	0.4316	-0.0004	0.0001	-0.0002	-0.0002	-0.0002	-0.0003	-0.0008	0.0002	-0.0002	-0.0003	-0.0002	-0.0003	-0.0005	-0.0003	-0.0003	-0.0002	-0.0003
(G)	0.4316	0.0025	-0.0005	0.0016	0.0013	0.0014	0.0023	0.0039	-0.0014	0.0014	0.0017	0.0016	0.0021	0.0027	0.0022	0.0022	0.0015	0.0019
SLOL (cm) (P)	-0.6397	0.0001	-0.0001	0.0001	0.0007	0.0006	0.0006	0.0003	-0.0012	0.0004	0.0006	0.0007	0.0008	0.0000	0.0005	0.0004	0.0007	0.0007
(G)	-0.6397	0.0002	-0.0005	0.0006	0.0028	0.0027	0.0026	0.0018	-0.0049	0.0022	0.0025	0.0032	0.0033	-0.0003	0.0020	0.0016	0.0030	0.0030
LW (cm) (P)	0.7682	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
(G)	0.7682	-0.0063	-0.0028	-0.0071	-0.0138	-0.0082	-0.0185	-0.0073	0.0092	-0.0207	-0.0167	-0.0163	-0.0173	-0.0041	-0.0103	-0.0089	-0.0131	-0.0135
GPW (Kg) (P)	0.7637	-0.0026	-0.0026	-0.0020	-0.0030	-0.0021	-0.0033	-0.0018	0.0026	-0.0039	-0.0054	-0.0036	-0.0041	-0.0005	-0.0011	-0.0009	-0.0030	-0.0022
(G)	0.7637	0.0861	0.0746	0.0574	0.0844	0.0662	0.1057	0.0640	-0.0752	0.1205	0.1491	0.1047	0.1174	0.0160	0.0339	0.0240	0.0855	0.0642
MCW (P)	0.8092	-0.0002	0.0004	-0.0002	-0.0027	-0.0019	-0.0022	-0.0010	0.0019	-0.0022	-0.0021	-0.0032	-0.0026	-0.0004	-0.0017	-0.0017	-0.0027	-0.0022
(G)	0.8092	0.0050	-0.0069	0.0049	0.0537	0.0415	0.0488	0.0252	-0.0400	0.0487	0.0435	0.0619	0.0513	0.0087	0.0348	0.0342	0.0536	0.0438
NCW (P)	1	0.2690	-0.0305	0.0913	0.6133	0.5414	0.6889	0.4377	-0.6482	0.7790	0.7746	0.8206	1.0137	0.1728	0.6250	0.5374	0.6496	0.9037
(G)	1	0.2142	-0.0168	0.0613	0.4316	0.3939	0.5356	0.3832	-0.4671	0.5827	0.5476	0.5763	0.6956	0.1305	0.4529	0.3725	0.4550	0.6227
LL (cm) (P)	0.1711	0.0005	-0.0002	0.0003	0.0000	0.0002	0.0005	0.0008	0.0000	0.0002	0.0001	0.0001	0.0002	0.0013	0.0003	0.0005	0.0001	0.0002
(G)	0.1711	0.0026	-0.0009	0.0014	-0.0001	0.0012	0.0030	0.0044	0.0004	0.0012	0.0007	0.0009	0.0012	0.0063	0.0018	0.0027	0.0004	0.0011
DTCI(P)	0.6168	0.0000	-0.0004	0.0000	0.0004	0.0004	0.0003	0.0003	-0.0003	0.0003	0.0002	0.0004	0.0005	0.0002	0.0007	0.0007	0.0005	0.0006
(G)	0.6168	0.0011	-0.0292	0.0003	0.0307	0.0278	0.0222	0.0283	-0.0206	0.0246	0.0113	0.0278	0.0322	0.0142	0.0495	0.0478	0.0318	0.0397
DTCM (P)	0.5304	0.0000	0.0005	0.0000	-0.0005	-0.0003	-0.0003	-0.0003	0.0002	-0.0003	-0.0001	-0.0004	-0.0004	-0.0003	-0.0007	-0.0008	-0.0005	-0.0005
(G)	0.5304	0.0005	0.0093	0.0001	-0.0089	-0.0071	-0.0062	-0.0082	0.0049	-0.0063	-0.0024	-0.0081	-0.0079	-0.0062	-0.0142	-0.0147	-0.0089	-0.0098
CI (cm^2) (P)	0.6406	0.0001	0.0009	-0.0020	-0.0092	-0.0076	-0.0051	-0.0028	0.0057	-0.0055	-0.0053	-0.0080	-0.0061	-0.0007	-0.0058	-0.0056	-0.0095	-0.0051
(G)	0.6406	0.0048	0.0197	-0.0439	-0.1894	-0.1660	-0.1180	-0.0733	0.1208	-0.1229	-0.1115	-0.1681	-0.1272	-0.0126	-0.1252	-0.1181	-0.1944	-0.1067

Table 1: Continue....

Table 1: Continue....

HI (%) (P)	0.2654	0.0002	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
(G)	0.8917	0.0056	-0.0753	-0.0310	0.0979	0.0948	0.1218	0.0914	-0.1184	0.1246	0.0820	0.1348	0.1705	0.0345	0.1527	0.1274	0.1045	0.1904
CY (q/ha) (P)	-0.0305	-0.0004	-0.0012	-0.0003	0.0001	0.0000	0.0000	0.0001	-0.0001	-0.0001	-0.0006	0.0001	0.0000	0.0002	0.0007	0.0007	0.0001	0.0004
(G)	0.6237	0.3078	-0.0247	0.0874	0.6202	0.5663	0.7700	0.5504	-0.6718	0.8376	0.7868	0.8282	1.0000	0.1879	0.6513	0.5359	0.6540	0.8955

Residual effect: 0.0037.

CD- Curd diameter; DOC- Diameter of curd; SLOP- Stalk length of plant; LLL- Leaf lamina length; SLOL- Stalk length of leaf; LW- Leaf weight; GPW- Gross plant weight; MCW- Marketable curd weight; NCW- Net curd weight; LL- Leaf length; DTCI- Days to curd initiation; DTCM- Days to Curd maturity; CI- Curd index; HI- Harvest index and CY- Curd yield.

curd yield, days to curd maturity, harvest index, days to curd initiation and curd index, while above all on that it showed non-significantly positive association with leaf length. Whereas, NCW by way of DTCM, DTCI, HI, curd index and curd yield expressed the positive but significant association. At the same one of the attribute *viz*., leaf length was showed a non-significant a correlation with net curd weight. Another studied attribute namely DTCI expressed positive and significant association with curd maturity. For rest of attributes, positive and significant association amongst curd index with harvest index and curd yield also of harvest index with curd yield was recorded from the recorded data. So, the recorded data confirmed that degree and nature of association varied amongst the various studied attributes. Marketable curd weight (MCW), NCW and GPW expressed the highly positive and significant correlation with trait curd yield. Our findings were found in conformity with outcomes of (Nimkar, 2013; Kumar *et al.*, 2005; Singh *et al.,* 2006, Kanwar *et al.,* 2010; Kumar *et al.,* 2011; Pal *et al.,* 2017 and Sharma *et al.,* 2018).

Path analysis

Important character, specifically the MCY per plant was treated as a dependent variable in the current experiment while other identifying characteristics were used as independent variables. Path-coefficients for all the variables that contribute to yield were studied at the genotypic level to determine the direct and indirect effects of various factors on one another. The estimated values of the path coefficient are shown in (Table 3).

Direct effects

A critical perusal of path-coefficient analysis recorded that NCW had the highest direct effect on CY per hectare followed by MCW, HI, DTCM, SLOP, LW, GPW, CI, LLL, DTCI, CD, LL, DOC, leaf number at harvest plant height, whereas number of leaves at forty five days expressed negatively direct effect on curd yield per hectare at the genotypic level.

Indirect effects

Plant height imparts the highest and positive indirect impact on CD, DTCM, SLOL and CI, at the same time as it exhibited negative indirect effect on LL, LW, HI, SLOP, CD, DTCI, MCW, leaf number at harvest, leaf number at 45 days, LLL and GPW. Number of leaves at harvest showed highly positive indirect effect on LLL, PH, GPW, SLOP, LW and DTCI, even as leaf number at harvest showed negatively indirect effect on SLOL, DTCM and HI. Curd diameter imparts highly positive and indirect effect on depth of curd, LW, NCW, CI, MCW, whereas negative indirect effect at higher level was found on LL, SLOL, PH and leaf number at 45 days.

Curd depth imposed the positively highest indirect effect on DTCI, NCW, curd index, harvest index, curd diameter and MCW, whilst it directed the negative indirect effect on leaves at 45 days and stalk length of leaves. Gross plant weight showed indirectly positive effect on curd depth, LL, days to curd maturity, SLOP, LW, curd diameter, PH, curd

index, MCW and DTCI. Marketable curd weight exhibited indirectly negative effect on leaf number at 45 days and leaf stalk, while it showed positive indirect effect on SLOP, DOC, CI, DTCM, HI, PH, DTCI, GPW, LL, NCW and leaves at harvest. Net curd weight showed indirectly positive effect on HI, LW, GPW, CI, MCW and SLOP, although it expressed indirectly negative effect on number of leaves at 45 days and SLOL. Days to curd initiation exhibited indirectly positive effect on days to NCW, CM, LLL, HI, CI and CD, even as it expressed indirectly negative effect on stalk length of leaves and leaves at 45 days. Days to curd maturity exhibited indirectly positive effect on SLOL, PH and number of leaves at harvest; although it showed indirectly negative effect on CD, SLOP, GPW, LW, DOC, MCW and LL and LLL. Curd index expressed highly positive indirect effect on number of leaves at 45 days, SLOL and PH, how so ever it also showed negative indirect effect on LL, LLL and number of leaves at harvest, HI and GPW. Harvest index exhibited highly positive indirect effect on NCW, DTCI, MCW, SLOP, LW, DOC, CI, DTCM and CD; though it showed indirectly negative effect on SLOL, number of leaves at harvest, number of leaves at forty five days. According to path coefficient analysis, the yield of curd per plant was the most crucial factor since it contributed directly and indirectly through other factors to the yield of curd per hectare, which was used to improve the genotypes of cauliflower. Highest direct effect of marketable curd weight on net curd weight was previously observed by (Nimkar, 2013; Singh *et al.,* 2006; Kumar *et al.,* 2011). Kumar *et al.,* (2017); Kanwar and Korla,(2002) recorded with indirectly positive effect of LL, HI and DTCM on NCW.

CONCLUSION

The general conclusions of the present investigation led to the conclusion that the type and degree of association among different traits differed. GPW (Gross plant weight), MCW (Marketable curd weight) and NCW (net curd weight) were found to positively and extremely significantly correlate with yield of curd per hectare. Due to its direct and indirect effects on curd yield per hectare through other features, path coefficient analysis of cauliflower genotypes revealed that curd yield per plant was the most significant trait.

Conflict of interest: None.

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