



RESEARCH ARTICLE

Performance of mid-late/late cauliflower genotypes & CMS lines for various horticultural traits

Neha Rana, Akhilesh Sharma*, Srishti and Vivek Singh

Abstract

The present investigation was undertaken at the Research Farm, Department of Vegetable Science and Floriculture, College of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, during winter season 2021-22. The experiment was laid out in α -RBD design with three replications. About 36 mid-late and late cauliflower genotypes, including three checks, were evaluated to study the mean performances for marketable curd weight along with 19 component traits. The mean sum of squares depicts sufficient genetic variability for all morphological, yield and quality traits. The evaluation of mean performance revealed that 'DPCaCMS-1' was top ranked with an advantage of 25.69 % for marketable curd weight over best check 'Palam Uphar' followed by 'DPCaf-29', 'DPCaf-US', 'DPCaf-CMS5' and 'DPCaf-W131W' which was mainly due to significant contribution of curd polar diameter, curd equatorial diameter, leaf length, leaf width, optimum plant frame, curd solidity, curd size index, gross plant weight and net curd weight.

Keywords: Cauliflower, CMS lines, Marketable curd weight.

Department of Vegetable Science & Floriculture, College of Agriculture, Choudhary Sarwan Kumar Himachal Pradesh Krishi Visvavidyalaya, Palampur-176062, India.

*Corresponding author; Email: asharmaakhil1@gmail.com

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Introduction

Cauliflower (*Brassica oleracea* var. *botrytis* L., $2n = 2x = 18$) is one of the most important vegetable crops belonging to the family Brassicaceae with a genome size of 584.60 Mb (Sun et al., 2019). It is grown in many countries across the world for its nutritive value as well as for its value-added foods in the processing sector. The plant family Brassicaceae contains 338 genera and approximately 3709 species (Al-Shehbaz et al., 2006; Warwick et al., 2006). The name cauliflower is derived from two Latin words 'caulis' and 'floris' which means stem and flower, respectively (Sharma et al., 2018) and is the only cole crop in which the intermediate stage of curding lies between the vegetative and reproductive stage (Nieuwhof, 1969). It is grown for white soft curd which is often consumed as a vegetable, in soups, curries and pickles (Savita et al., 2014). Because of its wonderful taste, flavour and nutritional value, it is designated as "India's pride", "queen of winter vegetables" and "aristocrat of vegetables" (Nimkar and Korla, 2014).

All the cultivated forms of the cole group were believed to have evolved from the wild cabbage plant, *Brassica oleracea* var. *sylvestris* L., a leafy kale-like plant that became fully domesticated and began producing a wide variety of cultivated forms in the Eastern Mediterranean region about 2000 years ago. Cauliflower was originated in the island of Cyprus and introduced in different parts of the world

like Syria, Turkey, Egypt, Italy, Spain and North Western Europe (Rakshita et al., 2021). In 1822, it was introduced in India from England by Dr. Jemson during the period of East India Company. Since its introduction, it has been acclimatized to Indian growing conditions for summer and rainy seasons and evolved as new type known as Indian cauliflower having long stalked with loosely arranged broad and weavy leaves, yellow to creamy unprotected and highly flavoured curds (Swarup and Chatterjee, 1972). Based on specific temperature requirements for curd initiation and development, it is classified into five distinct maturity sub groups: extra early (20-27°C), early (20-25°C), mid early (16-20°C), mid late (12-16°C) and late or snowball types (10-16°C) (Singh et al., 2018).

India is the second largest producer of cauliflower in the world after China having an area, production and productivity of 467 thousand hectares, 8941 thousand metric tonnes and 19.14 metric tonnes per hectares, respectively (Anonymous, 2019). Despite being a popular vegetable in India, cauliflower breeding progresses slowly, hindering significant yield increases. Yield is a complex trait influenced by various agronomic factors and can be shaped by both genetic and environmental factors (Uddin et al., 1985). Enhancing both the quantity and quality of curd yield through selective breeding requires a thorough understanding of the extent and nature of variability in yield and its contributing characteristics within the population. In order to develop new cultivars with desired yield and quality traits in the present situation, a breeder must have a thorough understanding of the variability found in the existing germplasm (Srishti and Yogita, 2023; Verma and Singh, 2024). Therefore, knowledge about the genetic variability within a population serves as a fundamental prerequisite for systematic breeding initiatives, with the magnitude of this variability directly impacting the success of crop improvement programme. Thus, the present study was undertaken to evaluate the mean performances for morphological, yield and quality traits in cauliflower that would help in selecting superior genotypes with better horticultural traits, which can further be used in future hybridization programme to either exploit heterosis or isolation of transgressive segregants.

Materials and Methods

The present investigation was carried out at the Research Farm of the Department of Vegetable Science and Floriculture, College of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya, Palampur during the winter season 2021-22. Thirty-six genotypes including three checks 'Palam Uphar', 'Pusa Snowball K-1' and 'Pusa Snowball K-25' were evaluated in α -RBD design with three replications including 9 blocks per replication and four entries per block. The seedlings were raised in nursery

beds of size 3m $\times$ 1m $\times$ 0.15 m and were transplanted with inter and intra-row spacing of 45 $\times$ 45 cm, respectively. All the standard package of practices and plant protection measures were timely adopted to raise the crop successfully. The observations were recorded on five competitive plants selected randomly from each entry over the replications for 20 traits viz., days to curd initiation, days to first marketable curd harvest, stalk length (cm), leaf length (cm), leaf width (cm), number of leaves per plant, plant height (cm), plant frame (cm), curd polar diameter (cm), curd equatorial diameter (cm), curd size index (cm²), curd solidity (g/cm), gross plant weight (g), marketable curd weight (g), net curd weight (g), non-marketable curds (%), harvest duration (days), harvest index (%), total soluble solids ($^{\circ}$ Brix) and ascorbic acid content (mg per 100g fresh weight basis). The mean values of data were analyzed for variability (ANOVA) as suggested by Parsad et al., (2007).

Results and Discussion

Analysis of variance

The analysis of variance revealed that the mean sum of squares due to the genotypes were significant for all the 20 characters studied (Table 1). The significance of mean sum of squares was indicative of significant genetic variability among all the genotypes evaluated. Earlier workers namely, Shree et al., 2019 and Kumar et al., 2021 have also reported significant variability for different characters on the basis of results obtained from their respective genetic materials of cauliflower in their respective locations.

Mean performance of different genotypes

The mean performance of 36 genotypes of cauliflower for various traits have been presented in Table 2 and 3 which revealed wide range of variation in the performance with respect to marketable curd weight and its contributing traits that is an indicator of greater extent of genetic diversity among genotypes and would provide immense scope for genetic improvement in cauliflower through selection.

Days to curd initiation

Earliness in curd initiation is the desirable character in cauliflower crop which is an indicator of early harvest to fetch better price in the market. The mean performance ranged from 57.33 (DPCaf-12) to 103.33 (Pusa Snowball K-1) with mean value of 77.01 days. The genotypes, 'DPCaf-12', 'DPCaY-9', 'DPCaY-7', 'DPCaf-W131W', 'DPCaf-1', 'DPCaCMS-3', 'DPCaf-12-1', 'DPCaf-18', 'Pusa Paushja', 'DPCaf-30', 'DPCaCMS-4', 'DPCaf-S122', 'DPCaf-10', 'DPCaCMS-2', 'DPCaf-S121', 'DPCaY-4', 'DPCaCMS-5', 'DPCaf-13', 'DPCaf-CMS3', 'DPCaf-29', 'DPCaf-S5-1', 'DPCaf-8' and 'DPCaf-9' significantly took minimum number of days to curd initiation as compared to standard check 'Palam Uphar' (82.33). Gariya et al., 2019 and Kumar et al., 2021 have also observed variations for days to curd initiation.

Table 1: Analysis of variance for α -RBD design with respect to marketable curd weight and other traits in cauliflower genotypes

Source of variation	Replication	Blocks with in replication	Genotype	Error
df→	2	24	35	47
Days to curd initiation	3.90	6.16	419.51*	4.56
Days to first marketable curd harvest	26.84	4.70	196.07*	4.39
Stalk length (cm)	0.032	0.006	0.968*	0.004
Leaf length (cm)	23.00	5.73	19.92*	2.45
Leaf width (cm)	6.00	0.89	3.78*	0.81
Number of leaves per plant	1.44	0.44	1.73*	0.35
Plant height (cm)	33.16	3.21	31.81*	2.47
Plant frame (cm)	12.22	3.81	61.97*	3.75
Curd polar diameter (cm)	0.14	0.05	0.61*	0.02
Curd equatorial diameter (cm)	0.39	0.07	1.88*	0.09
Curd size index (cm ²)	63.61	9.99	250.94*	7.89
Curd solidity (g/cm)	1.63	1.30	197.36*	1.13
Gross plant weight (g)	1253.37	232.76	52798.53*	175.89
Marketable curd weight (g)	877.54	118.35	21361.16*	113.09
Net curd weight (g)	578.54	73.04	13212.01*	56.51
Non marketable curd (%)	10.17	6.53	70.25*	4.92
Harvest duration (days)	0.95	2.91	23.02*	1.65
Harvest Index	2.83	0.66	74.69*	0.96
Total soluble solid (°Brix)	0.82	0.07	2.02*	0.06
Ascorbic acid content (mg/ 100g fresh weight basis)	0.01	0.35	20.66*	0.39

Days to first marketable curd harvest

The genotypes showed variation for days to first marketable curd harvest which was ranging from 89.67 (DPCaf-12) to 122.67 (DPCaY-1) with population mean of 97.71 days. In total, 21 genotypes viz., 'DPCaf-12', 'DPCaf-1', 'DPCaY-9', 'DPCaf-30', 'DPCaf-S121', 'DPCaCMS-4', 'Pusa Paushja', 'DPCaY-4', 'DPCaCMS-3', 'DPCaf-29', 'DPCaY-7', 'DPCaf-12-1', 'DPCaf-S122', 'DPCaf-2', 'DPCaf-13', 'DPCaCMS-2', 'DPCaf-10', 'DPCaCMS-5', 'DPCaf-S121W', 'DPCaf-W131W' and 'DPCaf-18' significantly took minimum number of days to marketable curd maturity as compared to standard check 'Palam Uphar' (99.00).

Stalk length (cm)

Smaller stalk length is a desirable trait in cauliflower as it can withhold higher curd weight (Sharma et al. 2018). Mean values pertaining to stalk length for 36 genotypes ranged from 1.70 cm (DPCaf-US) to 4.31 cm (DPCaf-CMS5) with the average value of 2.77 cm. The minimum stalk length was observed for 'DPCaf-US' (1.70 cm) followed by 'DPCaf-CMS7' (1.71cm), 'DPCaY-1' (1.79 cm) and 'DPCaf-W4' (1.85 cm) which was at par with best check 'Pusa Snowball K-25' (1.77 cm). Gariya et al., 2019 have also observed variations for stalk length.

Leaf Length (cm)

The mean performance for leaf length varied from 25.14 cm (DPCaf-10) to 37.67 cm (DPCaCMS-2) with average value of 31.59 cm. Of the 36 genotypes, eleven genotypes namely, 'DPCaCMS-2', 'DPCaf-29', 'DPCaf-CMS4', 'DPCaf-13', 'DPCaf-CMS5', 'DPCaf-8', 'DPCaf-1', 'DPCaCMS-3', 'DPCaf-18', 'DPCaf-12' and 'DPCaf-CMS7' had significantly more leaf length over best check 'Pusa Snowball K-25'. Further, 20 genotypes significantly recorded leaf length better than check 'Palam Uphar'.

Leaf width (cm)

The mean performance for leaf width varied from 12.02 cm (DPCaf-10) to 18.40 cm (DPCaf-CMS5) with average value of 15.65 cm. Two genotypes namely, 'DPCaf-CMS5 Y' (18.40 cm) and 'DPCaf-18' (18.27 cm) had significantly more leaf width over best check 'Pusa Snowball K- 25' (16.66 cm) while 20 genotypes performed at par with the same check.

Number of leaves per plant

The leaves are an integral part that directly affects the weight of the curd and are a key component of photosynthetic activity. The number of leaves per plant ranged from 9.00

Table 2: Mean values of thirty-six cauliflower genotypes for various quantitative and qualitative traits

Genotypes	Days to curd initiation	Days to first marketable harvest	Stalk length (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaves per plant	Plant height (cm)	Plant frame (cm)	Curd polar diameter (cm)	Curd equatorial diameter (cm)
DPCaf-US	88.67	104.67	1.70 ¹	29.08	15.46	12.20	40.31	46.57	7.89 ⁵	11.87 ⁵
DPCaf-S121W	80.67	94.33	3.08	29.86	16.31	10.73	36.05	46.73	7.02	10.71
DPCaf-S121	69.67	90.67 ⁵	2.45	30.14	14.03	13.40 ¹	40.22	49.29	7.66	11.35
DPCaf-S122	68.67	92.67	3.22	31.20	14.74	11.53	36.79	51.17	7.35	11.43
DPCaf-S-1	76.00	95.67	2.43	26.66	15.77	10.40	33.23	43.32	6.26	9.07
DPCaf-W131W	61.67 ⁴	95.00	3.37	32.97	15.24	11.93	41.77	49.78	7.60	12.24 ⁴
DPCaf-W4	94.00	107.67	1.85 ⁴	27.93	13.85	10.27	32.00	47.23	6.73	10.83
DPCaY-1	101.67	122.67	1.79 ³	32.87	16.94	10.67	38.03	51.19	7.16	9.59
DPCaY-4	71.33	91.67	2.77	28.94	15.12	11.47	33.85	44.01	6.54	9.89
DPCaY-7	61.33 ³	92.33	2.98	29.88	14.75	9.80	41.57	47.58	7.82	10.14
DPCaY-9	60.33 ²	89.67 ³	3.68	32.07	17.95	11.80	42.41	56.53 ⁴	6.53	10.40
DPCaf-1	64.33 ⁵	89.67 ²	2.29	35.18	15.25	11.00	41.52	51.72	7.47	11.24
DPCaf-2	74.00	93.00	2.68	30.95	15.71	12.20 ⁵	41.68	53.10	7.09	10.96
DPCaf-8	78.33	96.33	2.64	35.38	15.26	10.73	42.01	53.85	6.95	9.89
DPCaf-9	79.33	96.00	3.14	32.18	14.87 ³	10.67	40.03	46.97	7.07	9.29
DPCaf-10	69.33	93.67	2.45	25.14	12.02	11.20	34.00	39.65	6.85	9.59
DPCaf-12	57.33 ¹	89.67 ¹	2.53	33.78	16.62	12.87 ²	37.39	42.87	7.71	10.87
DPCaf-12-1	66.33	92.33	2.45	29.70	14.63	12.07	33.73	37.97	7.45	10.97
DPCaf-13	72.67	93.00	3.80	36.30 ⁴	17.44 ⁴	11.67	41.79	61.51 ¹	7.23	10.65
DPCaf-18	67.67	95.00	2.82	34.53	18.27 ²	11.47	40.03	54.19	7.89 ⁴	11.90
DPCaf-29	75.67	92.00	3.80	37.16 ²	14.60	12.80 ³	46.39 ¹	50.40	8.00 ²	12.26 ³
DPCaf-30	68.00	90.67 ⁴	2.83	30.35	12.87	12.07	36.58	46.42	7.32	11.27
DPCaCMS-1	90.33	107.67	2.25 ⁵	31.63	16.55	10.53	38.61	48.85	7.39	11.26
DPCaCMS-2	69.33	93.33	2.91	37.67 ¹	15.98	10.47	44.51 ²	60.30 ²	7.04	9.99
DPCaCMS-3	65.67	91.67	3.25	34.68	16.02	11.27	41.67	59.15 ³	7.03	9.81
DPCaCMS-4	68.00	90.67	3.12	30.68	15.76	10.80	36.16	47.04	7.69	11.34
DPCaCMS-5	71.33	93.67	2.86	28.83	15.17	11.67	35.65	49.23	7.05	10.75
DPCaf-CMS2	91.67	105.00	2.83	32.97	16.48	12.00	43.60 ³	46.02	6.70	9.40
DPCaf-CMS3	73.00	96.33	3.03	29.74	15.69	12.13	37.81	49.03	6.93	9.90
DPCaf-CMS4	90.33	105.33	2.53	36.39 ³	16.86	10.20	42.53 ⁵	55.27	6.27	9.60
DPCaf-CMS5	86.33	99.33	4.31	35.96 ⁵	18.40 ¹	12.07	43.53 ⁴	55.72 ⁵	7.95 ³	12.27 ²

Genotypes	Days to curd initiation	Days to first marketable harvest	Stalk length (cm)	Leaf length (cm)	Leaf width (cm)	Number of leaves per plant	Plant height (cm)	Plant frame (cm)	Curd polar diameter (cm)	Curd equatorial diameter (cm)
DPCaf-CMS7	103.33	119.33	1.71 ²	33.35	17.10 ⁵	11.60	38.81	51.80	6.99	9.87
Pusa Paushja	67.67	91.00	3.63	29.78	15.99	10.20	39.53	52.49	6.67	10.51
Palam Uphar	82.33	99.00	2.70	27.56	15.86	10.87	34.20	42.14	8.25 ¹	10.90
Pusa Snowball K-1	103.33	112.00	1.91	25.75	13.02	9.00	32.45	42.50	6.42	9.61
Pusa Snowball K-25	102.67	115.00	1.77	29.99	16.66	12.67 ⁴	36.01	46.75	6.32	12.50 ¹
Mean	77.01	97.71	2.77	31.59	15.65	11.34	38.79	49.40	7.17	10.67
Range	57.33-103.33	89.67-122.67	1.70-4.31	25.14-37.67	12.02-18.40	9.00-13.40	32.00-46.39	37.97-61.51	6.26-8.25	9.07-12.50
S.E(m)±	1.31	1.23	0.04	1.10	0.53	0.36	0.96	1.13	0.10	0.16
C.D (P≤ 0.05)	3.71	3.48	0.11	3.10	1.51	1.02	2.71	3.19	0.29	0.46
C.V (%)	2.95	2.19	2.37	6.01	5.90	5.49	4.28	3.96	2.45	2.66

¹Superscript (1, 2, 3, 4 and 5) indicates top five ranking genotypes and C- Check

(Pusa Snowball K-1) to 13.40 (DPCaf S121) with a population mean of 11.34). Fourteen genotypes performed at par with check 'Pusa Snowball K-25' for number of leaves per plant wherein, 'DPCaf-S121' (13.40), 'DPCaf-12' (12.87) and 'DPCaf-29' (12.80) were placed among top ranked three inbred lines with leaf number more than check. Kumar *et al.*, 2018 also reported significant differences in number of leaves per plant in their germplasm.

Plant height (cm)

In order to achieve the best curd size, it is preferable to select genotypes with the optimum plant growth in cauliflower. Therefore, it is essential to identify genotypes that yield superior marketable curds with ideal plant height. The mean performance of different genotypes for plant height ranged from 32.00 cm (DPCaf-W4) to 46.39 cm (DPCaf-29) with population mean of 38.79 cm. A critical examining of the data revealed that 19 genotypes viz., 'DPCaf-29', 'DPCaCMS-2', 'DPCaf-CMS2', 'DPCaf-CMS5', 'DPCaf-CMS4', 'DPCaY-9', 'DPCaf-8', 'DPCaf-13', 'DPCaf-W131W', 'DPCaf-2', 'DPCaCMS-3', 'DPCaY-7', 'DPCaf-1', 'DPCaf-US', 'DPCaf-S121', 'DPCaf-9', 'DPCaf-18', 'Pusa Paushja' and 'DPCaf-CMS7' significantly outperformed best check 'Pusa Snowball K-25'.

Plant frame (cm)

Plant frame is also one of the important parameters that determines the spacing of a particular variety but optimum plant frame is essential to obtain desirable curd size. Keeping this in view, it was found that mean performance for plant frame ranged from 37.97 cm (DPCaf-12-1) to 61.51 cm (DPCaf-13) with a population mean of 49.40 cm. Fourteen genotypes viz., 'DPCaf-13', 'DPCaCMS-2', 'DPCaCMS-3', 'DPCaY-9', 'DPCaf-CMS5', 'DPCaf-CMS4', 'DPCaf-18', 'DPCaf-8', 'DPCaf-2', 'Pusa Paushja', 'DPCaf-CMS7', 'DPCaf-1', 'DPCaY-1' and 'DPCaf-S122' were significantly superior than the best check 'Pusa Snowball K-25'. Kumar *et al.*, 2017 also reported significant variations for this trait.

Curd polar diameter (cm)

Curd diameter is the most essential parameter that determines the shape of curd and based on consumer's preference the most suitable curd should have hemi spherical shape that points towards the most equal polar and equatorial diameter. The curd polar diameter ranged from 6.26 cm (DPCaf-S5-1) to 8.25 cm (Palam Uphar) with a population mean of 7.17 cm. Genotype 'DPCaf-29' (8.00 cm) recorded curd polar diameter at par with the best check 'Palam Uphar'. On the other hand, 28 and 29 genotypes had significantly better curd polar diameter than checks 'Pusa Snowball K-1' and 'Pusa Snowball K-25', respectively.

Curd equatorial diameter (cm)

The mean performance for this trait ranged from 9.07 cm (DPCaf-S5-1) to 12.50 cm (Pusa Snowball K-25) with mean value of 10.67 cm for the trait curd equatorial diameter.

Three genotypes namely, 'DPCaf-CMS5' (12.27 cm), 'DPCaf-29' (12.26 cm) and 'DPCaf-W131W' (12.24 cm) were found to have statistically similar curd equatorial diameter to that of best check 'Pusa Snowball K-25' (12.50 cm). In addition to these three genotypes, three other genotypes namely, 'DPCaf-18' (11.90 cm), 'DPCaf-US' (11.87) and 'DPCaf-S122' (11.43 cm) performed significantly better than second best check 'Palam Uphar' (10.90 cm).

Curd size index (cm²)

Curd size index is directly related to net curd weight and hence more the curd size index more will be the net curd weight. The mean performance ranged from 56.77 cm² (DPCaf-S5-1) to 98.11 cm² (DPCaf-29) with mean value of 76.84 cm² for the trait curd size index. Two genotypes namely, 'DPCaf-29' (98.11 cm²) and 'DPCaf-CMS5' (97.44 cm²) recorded significantly more curd size index over the best check 'Palam Uphar' (89.96 cm²). Chatterjee *et al.*, 2018a have also observed significant differences for curd size index.

Curd solidity (g/cm)

Curd solidity is one of the most important traits of cauliflower and it is mainly dependent on its inside architecture. Compact curds have short stalks and high solidity (Zhao *et al.*, 2020). The consumers always prefer compact curds and curd solidity provide its compactness. For curd solidity, mean performance significantly varied from 20.75 g/cm (DPCaY-4) to 56.61 g/cm (DPCaCMS-1) with general mean 39.73. Twelve genotypes namely, 'DPCaCMS-1' (56.61 g/cm), 'DPCaf-S122' (53.63 g/cm), 'DPCaf-29' (52.99 g/cm), 'DPCaf-18' (51.72 g/cm), 'DPCaf-US' (51.11 g/cm), 'DPCaf-CMS5' (50.86 g/cm), 'DPCaf-CMS2' (48.81 g/cm), 'DPCaf-S121' (48.65 g/cm), 'DPCaCMS-5' (48.44 g/cm), 'DPCaCMS-4' (48.08 g/cm), 'DPCaf-W4' (45.03 g/cm) and 'DPCaf-W131W' (45.03 g/cm) had showed significantly more curd solidity whereas, 'DPCaf-CMS4' (41.84 g/cm) performed at par to the best checks 'Pusa Snowball K-25' (43.12 g/cm) and 'Palam Uphar' (40.99 g/cm).

Gross plant weight (g)

In cauliflower, plants with more foliage may result in higher gross plant weight but it may also produce smaller sized curds. Therefore, in order to attain the highest economic yield *i.e.*, marketable curd yield, it is essential to select genotypes with the optimum foliage. Data pertaining to this trait demonstrated significant variation among all the genotypes. The range recorded here was 428.07 g (DPCaY-4) to 993.33 g (DPCaCMS-1) with population mean of 736.46 g. Of the 36 genotypes, twelve genotypes namely, 'DPCaCMS-1', 'DPCaf-US', 'DPCaf-CMS5', 'DPCaf-29', 'DPCaf-CMS7', 'DPCaf-W131W', 'DPCaf-CMS2', 'DPCaf-2', 'DPCaCMS-4', 'DPCaf-S122', 'DPCaf-18' and 'DPCaf-1' had significantly higher gross plant weight over best check 'Pusa Snowball K-25' (787.73 g) whereas, all these 12 genotypes along with two genotypes namely, 'DPCaf-S122' and 'DPCaY-1'

significantly outpaced the gross plant weight over second-best check 'Palam Uphar' (750.92 g). Kumar *et al.*, 2021 also revealed significant variations in their research material for gross plant weight.

Marketable curd weight (g)

High marketable yield is the main objective of all crop improvement programmes from an economic point of view. If a novel genotype cannot perform better than the existing cultivars, it will be of minimal use. The majority of the times, consumers prefer medium-sized curds over those that are either too big or too small. For marketable curd weight, a significant range of variation was noted that varied from 285.36g (DPCaY-4) to 654.77g (DPCaCMS-1) with average performance of 468.62 g. Among the genotypes, 'DPCaCMS-1' (654.77g) revealed the highest marketable curd weight and significantly outperformed the best check 'Palam Uphar' (520.92 g) along with seven other genotypes namely, 'DPCaf-29' (651.27g), 'DPCaf-US' (635.00 g), 'DPCaf-CMS5' (608.93 g), 'DPCaf-W131' (603.88 g), 'DPCaf-S122' (576.57 g), 'DPCaf-CMS7' (540.07 g) and 'DPCaf-18' (539.07 g).

Net curd weight (g)

The overall performance of the variety is determined by net curd weight and the consumers prefer better curd size than the plant parts retained to provide protection to the curds. The mean performance for this trait varied from 135.53 g (DPCaY-4) to 423.87 g (DPCaf-29) with average value of 286.57 g. Eight genotypes namely, 'DPCaf-29' (423.87 g), 'DPCaCMS-1' (417.87 g), 'DPCaf-18' (408.13 g), 'DPCaf-CMS5' (404.00 g), 'DPCaf-US' (403.33 g), 'DPCaf-S122' (394.40 g), 'DPCaf-S121' (372.53 g) and 'DPCaCMS-4' (369.53 g) had outperformed the best check 'Palam Uphar' (338.37 g) for net curd weight.

Non marketable curds (%)

Curd development in open pollinated cauliflower cultivars is a major problem. The variety which forms maximum desirable marketable curds is the most suitable. Therefore, non-marketable curds (%) should be minimum so that it does not affect the total yield of the genotype. The per cent non marketable curds ranged from 10.37 % (DPCaf-US) to 39.17 % (Pusa Snowball K-1) with a population mean of 17.36 %. Genotypes namely, 'DPCaf-US', 'DPCaf-29', 'DPCaf-30', 'DPCaf-12', and 'DPCaCMS-3' found higher per cent marketable curds among all the 36 genotypes studied.

Harvest duration (Days)

Long harvest duration is usually preferred due to the prolonged availability of curds in the market and it also has direct impact on enhancing total yield which ultimately profits the farmers. For harvest duration of cauliflower, mean performance differed from 7.33 days (DPCaf-29) to 22.00 days (DPCaf-CMS2) with population mean of 13.64 days. Genotype 'DPCaf-CMS2' performed significantly superior

Table 3: Mean values of thirty-six cauliflower genotypes for various quantitative and qualitative traits

Genotypes	Curd size index	Curd solidity	Gross plant weight	Marketable curd weight	Net curd weight	Non marketable curd)	Harvest duration	Harvest Index	Total soluble solids	Ascorbic acid
DPCaf-US	93.67 ⁴	51.11 ⁵	985.87 ²	635.00 ³	403.33 ⁵	10.37 ¹	13.00	64.42	7.31	14.84
DPCaf-S121W	75.14	31.15	679.50	414.57	218.53	13.33	16.67	61.01	9.08 ²	12.11
DPCaf-S121	86.93	48.65	806.20	512.87	372.53	12.06	11.00	63.62	7.98	16.32
DPCaf-S122	84.03	53.63 ²	837.37	576.57	394.40	14.54	13.33	68.85	7.93	18.04 ⁴
DPCaf-S 5-1	56.77	38.17	578.75	393.07	238.77	19.40	17.00	67.93	8.02	10.89
DPCaf-W131W	93.04 ⁵	45.03	899.73	603.88 ⁵	342.20	16.67	11.33	67.12	7.36	12.93
DPCaf-W4	72.97	45.03	772.07	523.93	303.20	17.67	11.67	67.87	6.11	12.72
DPCaY-1	68.70	26.06	799.67	435.07	186.67	16.67	7.33	54.42	7.43	15.23
DPCaY-4	64.68	20.75	428.07	285.36	135.53	28.98	9.00	66.61	8.31	20.31 ¹
DPCaY-7	79.33	22.52	463.20	288.67	176.00	24.52	15.00	62.31	7.50	16.41
DPCaY-9	67.96	38.22	675.27	476.20	249.80	19.11	13.33	70.56	8.58	14.78
DPCaf-1	83.99	38.62	812.07	461.00	288.40	17.50	15.00	56.76	8.92 ⁴	13.42
DPCaf-2	77.68	41.24	846.73	479.93	292.20	17.57	16.00	56.67	5.97	9.80
DPCaf-8	68.73	29.83	584.17	356.90	207.20	13.33	14.00	61.09	8.73	13.39
DPCaf-9	65.72	31.01	498.33	359.93	219.33	19.98	10.67	72.22 ²	6.44	13.78
DPCaf-10	65.73	31.75	557.13	372.67	217.53	24.91	14.00	66.90	7.82	14.68
DPCaf-12	83.81	32.50	696.07	434.67	250.47	11.11 ⁴	15.67	62.44	8.82 ⁵	15.30
DPCaf-12-1	81.71	33.69	646.67	474.07	250.93	12.04	12.67	73.31 ¹	6.70	9.87
DPCaf-13	76.99	41.11	688.60	488.33	296.93	12.04	14.33	70.91 ³	5.73	8.74
DPCaf-18	93.94 ³	51.72 ⁴	834.87	539.07	408.13 ³	13.10	13.67	64.57	6.84	11.49
DPCaf-29	98.11 ¹	52.99 ³	933.07 ⁴	651.27 ²	423.87 ¹	10.83 ²	7.33	69.79 ⁴	7.29	10.80
DPCaf-30	82.46	38.52	709.00	437.93	281.93	10.83 ³	10.33	61.77	6.77	9.00
DPCaCMS-1	83.10	56.61 ¹	993.33 ¹	654.77 ¹	417.87 ²	13.00	16.33	65.91	6.87	14.91
DPCaCMS-2	70.30	32.95	655.87	365.93	231.87	16.67	13.33	35.35	6.63	14.59
DPCaCMS-3	68.96	36.47	617.60	409.13	256.40	11.20 ⁵	11.33	41.51	7.97	9.88
DPCaCMS-4	87.15	48.08	842.30	501.93	369.53	15.36	12.67	43.87	8.41	13.98
DPCaCMS-5	75.78	48.44	694.43	464.33	341.33	19.14	15.67	49.15	7.52	16.45
DPCaf-CMS2	62.99	48.81	895.80	511.00	327.00	21.67	22.00	57.04	8.45	14.36
DPCaf-CMS3	68.64	35.02	684.82	396.18	242.60	27.50	16.67	57.85	7.53	16.07

Genotypes	Curd size index	Curd solidity	Gross plant weight	Marketable curd weight	Net curd weight	Non marketable curd)	Harvest duration	Harvest Index	Total soluble solids	Ascorbic acid
DPCaf-CMS4	60.18	41.84	714.47	432.13	262.00	17.50	17.67	60.49	6.71	7.94
DPCaf-CMS5	97.44 ²	50.86	940.60 ³	608.93 ⁴	404.00 ⁴	13.33	16.67	64.74	6.52	16.06
DPCaf-CMS7	69.01	36.20	932.73 ⁵	540.07	253.20	22.41	8.00	57.90	9.06 ³	18.38 ³
Pusa Paushja	70.10	32.50	581.33	357.27	216.73	27.22	13.00	61.44	9.31 ¹	15.94
Palam Uphar (C)	89.96	40.99	750.92	520.92	338.37	12.31	18.33	69.37 ⁵	7.43	11.55
Pusa Snowball K-1 (C)	61.76	35.06	688.27	427.60	225.20	39.17	15.67	62.12	8.65	17.29 ⁵
Pusa Snowball K-25 (C)	78.98	43.12	787.73	479.00	272.60	12.04	11.33	60.80	8.61	20.24 ²
Mean	76.84	39.73	736.46	468.62	286.57	17.36	13.64	61.63	7.65	13.96
Range	56.77-98.11	20.75-56.61	428.07-993.33	285.36-654.77	135.53-423.87	10.37-39.17	7.33-22.00	35.35-73.31	5.73-9.31	7.94-20.31
S.E(m)±	1.71	0.63	8.11	6.23	4.58	1.43	0.85	0.64	0.15	0.36
C.D (P≤ 0.05)	4.82	1.79	22.93	17.62	12.96	4.04	2.39	1.81	0.42	1.01
C.V (%)	3.84	2.76	1.91	2.30	2.77	14.27	10.74	1.74	3.35	4.42

*Superscript (1, 2, 3, 4 and 5) indicates top five ranking genotypes and C- Check

while seven genotypes namely, 'DPCaf-CMS4' (17.67), 'DPCaf-S5-1' (17.00), 'DPCaf-S121W' (16.67), 'DPCaf-CMS3' (16.67), 'DPCaf-CMS5' (16.67), 'DPCaCMS-1' (16.33) and 'DPCaf-2' (16.00) performed at par over best check 'Palam Uphar'.

Harvest index (%)

High harvest index is one of the most essential traits in determining marketable yield since it is directly proportional to marketable curd weight. Since genotypes with high marketable curd weight have high harvest index, this indicates a higher physiological capacity to mobilize photosynthates and their transfer to important attributes. The mean performance for harvest index varied from 35.35% (DPCa-CMS2) to 73.31% (DPCaf-12-1) with a population mean of 61.63%. Two genotypes namely, 'DPCaf-12-1' and 'DPCaY-9' had significantly better harvest index and six genotypes viz., 'DPCaf-13', 'DPCaY-9', 'DPCaf-29', 'DPCaf-S122', 'DPCaf-S5-1' and 'DPCaf-W4' performed at par to that of best check 'Palam Uphar'. Kumar et al., 2018 also revealed wide variation in mean performances of different genotypes for harvest index in their breeding material.

Total soluble solids (°Brix)

The total soluble solids ranged from 5.73 °Brix (DPCaf-13) to 9.31°Brix (Pusa Paushja) with a population mean of 7.65 °Brix. Two genotypes namely, 'Pusa Paushja' and 'DPCaf-S121W' had significantly higher total soluble solids whereas, eight genotypes namely, 'DPCaf-CMS7', 'DPCaf-1', 'DPCaf-12', 'DPCaf-8', 'DPCaY-9', 'DPCaf-CMS2', 'DPCaCMS-4' and 'DPCaY-4', performed at par with the best check 'Pusa snowball K-1'.

Ascorbic acid content (mg/100g fresh weight basis)

Ascorbic acid is one of the major phytochemicals we obtained from cauliflower and it plays an important role in reducing the risk of arteriosclerosis, cardiovascular diseases, breast and reproductive cancers (Verma and Kalia, 2017). The average mean performance for ascorbic acid content varied from 7.94 mg/100g (DPCaCMS-4) to 20.31 mg/100g (DPCaY-4) with mean of 13.96 mg/100g. 'Pusa Snowball K-25' recorded the highest value for ascorbic acid content. In addition to this, two genotypes namely, 'DPCaY-4' and 'DPCaf-CMS7' had significantly higher ascorbic acid content while, four genotypes viz., 'DPCaf-S122', 'DPCaf-CMS5', 'DPCaY-7' and 'DPCaf-S121' performed at par over the second-best check 'Pusa Snowball K-1'.

Conclusion

Based on the mean performance it can be concluded that the genotypes viz., 'DPCaCMS-1', 'DPCaf-29', 'DPCaf-US', 'DPCaf-CMS5Y', 'DPCaf-W131W' and 'DPCaf-S122' appeared to be promising on the basis of marketable curd weight and other related traits such as, leaf length, leaf width, plant frame, stalk length, curd polar diameter, curd equatorial diameter, curd solidity, curd size index, gross plant weight, net curd weight and harvest index. Besides, 'DPCaCMS-2'

had better plant height and plant frame. Further, it was observed that 'DPCaf-12' had minimum number of days to curd initiation and days to first marketable curd harvest. Thus, the findings revealed that curd polar diameter, curd equatorial diameter, curd solidity, curd size index, stalk length and optimum plant frame have a direct effect on marketable curd weight. Thus, these genotypes can be used as parents in future breeding programmes to isolate transgressive segregants.

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सारांश

वर्तमान जाँच शीतकालीन सत्र 2021-22 के दौरान अनुसंधान फार्म, सब्जी विज्ञान और पुष्प विभाग, कृषि महाविद्यालय, चौधरी सरवन कुमार हिमाचल प्रदेश कृषि विश्वविद्यालय, पालमपुर में की गई थी। प्रयोग को तीन प्रतिकृतियों के साथ α -RBD डिज़ाइन में प्रस्तुत किया गया था। 19 घटक लक्षणों के साथ विपणन योग्य गोभीफूल वजन के लिए औसत प्रदर्शन का अध्ययन करने के लिए तीन जांचों सहित छत्तीस मध्य देर और देर से फूलगोभी जीनोटाइप का मूल्यांकन किया गया था। वर्गों का औसत योग सभी रूपात्मक, उपज और गुणवत्ता लक्षणों के लिए पर्याप्त आनुवंशिक परिवर्तनशीलता दर्शाता है। औसत प्रदर्शन के मूल्यांकन से पता चला कि DPCaCMS-1 को सर्वश्रेष्ठ चेक 'पालम उपहार' की तुलना में विपणन योग्य गोभीफूल वजन के लिए 25.69% के लाभ के साथ शीर्ष स्थान दिया गया था, इसके बाद 'DPCaf-29', 'DPCaf-US', 'DPCaf-CMS5' और 'DPCaf-W131W' थे, जो मुख्य रूप से गोभीफूल के धुरवीय व्यास, गोभीफूल के भूमध्यरेखीय व्यास, पत्ती की लम्बाई, पत्ती की चौड़ाई, इष्टतम पौधे के ढाँचे, गोभीफूल की ठोसता, गोभीफूल के आकार सूचकांक, सकल पौधे के वजन और शुद्ध गोभीफूल के वजन के महत्वपूर्ण योगदान के कारण था।