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Mean Performance Studies in Mid Late and Late Group of Cauliflower (*Brassica oleracea* L. var. *botrytis*)

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ABSTRACT

The experimental material comprising of 26 genotypes belonging to mid late and late group was evaluated in Randomized Complete Block Design with three replications for two consecutive years during winter season of 2018-19 and 2019-20. Data were recorded on marketable curd yield per hectare and its 17 related traits. Sufficient genetic variability was observed for yield and component traits. The perusal of mean values of different genotypes showed wide variation in the performance with respect to marketable curd yield and its contributing traits. This indicates great extent of genetic diversity among genotypes which would provide immense opportunities for genetic improvement of cauliflower. The evaluation of mean performance revealed that DPCa CMS 1 showed advantage of 27% for marketable curd yield over standard check Palam Uphar followed by DPCaf W3, DPCaf US and DPCaf 30 which was mainly due to significant contribution of curd depth, curd diameter, leaf length, leaf width, optimum plant frame, curd compactness/solidity, gross and net plant weight.

Keywords Genetic variability, Genotypes, Mean performance, Traits, Yield.

INTRODUCTION

Cauliflower belongs to family Brassicaceae and botanically known as *Brassica oleracea* L. var. *botrytis* with chromosome number 2n = 2x = 18. It is an herbaceous annual vegetable whose main growing point develops into shortened shoot system with apices build the convex surface of curd, known as prefloral fleshy apical meristem. It is grown for its tender white curds in many countries across the world on account of its great economic importance (Singh *et al.* 2019) and good nutritive value.

Cauliflower is an important source of human nutrition that contains good amount of dietary fibers, vitamins and minerals. It also contains anti-cancer compound sulphoraphane which reduces the risk of prostate cancer (Kushwaha *et al.* 2013). Vegetable brassicas are also rich in different bioactive

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compounds and phytochemicals. It is, therefore, important to identify the promising genotypes with high productivity and increasing nutritional value (Ram *et al.* 2017).

In India, cauliflower is grown for the last 200 years after its introduction in the early 19th century (Dey *et al.* 2019). Indian cauliflower belongs to the maturity group I and II which are developed from Cornish types, originated in England whereas the temperate types i.e., Erfurt or Snowball type were originated in Germany and Netherlands in the 18th century (Swarup and Chatterjee 1972). Genes accountable for traits such as long stalk, yellowish and strong flavored curds with open growth habit are likely to be transferred in Indian cauliflower from Cornish types. The Indian or tropical cauliflower have been widely used in developing heat tolerant cultivars (Dey *et al.* 2019).

All the cultivated varieties of the genus Brassica having genome CC (n = 9) are known as cole vegetables and carry excellent genetic diversity (Maggioni *et al.* 2018). However, the productivity per unit area in cauliflower is comparatively very low in developing countries which is mainly due to the non-availability of the promising cultivars with high yield potential (Elahi *et al.* 2015).

The extent of genetic variability in the germplasm is relatively proportional to the improvement potential of a crop (Singh *et al.* 2009) and provides an opportunity to enhance the yield and quality through planned breeding program. The curd yield and related traits provide important criteria for selection of desirable genotypes having higher productivity (Yanglem and Tumbare 2014) which could be achieved by planning an initial breeding program to analyze the genetic variability in the cauliflower genotypes (Chatterjee *et al.* 2018).

MATERIALS AND METHODS

The experimental material consists of 26 cauliflower genotypes including standard checks (Table 1). These genotypes were laid out over three replications in Randomized Complete Block Design (RBD). Nursery beds of size 3m × 1m × 0.15 m were prepared and the seedlings were raised by sowing seeds on 8th September, 2018 and 10th September, 2019, respectively. Each genotype was planted in two rows of 2.7 m length with a spacing of 45 cm each between and within rows and transplanting was done on 12th October 2018 and 16th October 2019, respectively. The recommendations as per the package of practices by CSKHPKV, Palampur were followed to raise the healthy crop.

Table 1. List of genotypes.

Genotype	Source
DPCa CMS 1	Department of Vegetable Science and Floriculture, COA, CSKHPKV, Palampur
DPCa CMS 2	-do-
DPCa CMS 3	-do-
DPCaf 8	-do-
DPCaf 10	-do-
DPCaf 1	-do-
DPCaf 2	-do-
DPCaf W3	-do-
DPCaf US	-do-
DPCaf S5-1	-do-
DPCaY 1	-do-
DPCaY 7	-do-
DPCaf 9	-do-
DPCaf 12	-do-
DPCaf 13	-do-
DPCaf 18	-do-
DPCaf 24	-do-
DPCaf 29	-do-
DPCaf 30	-do-
DPCaf 35	-do-
Pusa Paushja	ICAR-IARI, New Delhi
Pusa Himjyoti	ICAR-IARI, Regional Station, Katrain, Kullu, HP
Pusa Snowball KT-25	ICAR-IARI, Regional Station, Katrain, Kullu, HP
Pusa Snowball-1	ICAR-IARI, Regional Station, Katrain, Kullu, HP
Pusa Snowball K-1 (Check)	ICAR-IARI, Regional Station, Katrain, Kullu, HP
Palam Uphar (Check)	Department of Vegetable Science and Floriculture, COA,CSKHPKV, Palampur

Farmyard manure was applied at the recommended rate of 20 tonnes/ha and also the synthetic fertilizers were applied @ 150 kg/ha N, 100 kg/ha P_2O_5 and 50 kg/ha K_2O. Nitrogen was applied through urea, phosphorus was applied through single super phosphate and potassium was applied through muriate of potash, respectively. At the time of transplanting,

Table 2. Mean values of twenty six cauliflower genotypes in pooled over years for days to curd initiation, days to marketable curd maturity, stalk length, leaves/plant, leaf length, leaf width plant height, plant frame and curd depth.

Genotypes	Days to curd initiation	Days to marketable curd maturity	Stalk length (cm)	Leaves/ plant	Leaf length (cm)	Leaf width (cm)	Plant height (cm)	Plant frame (cm)	Curd depth (cm)
DPCa CMS 1	67.67	103.98	4.00	15.72	35.81[1]	16.97[3]	47.60[1]	47.37[3]	9.67[2]
DPCa CMS 2	63.17	100.13	3.64	15.41	33.02[5]	14.72	45.50[4]	44.63	8.78
DPCa CMS 3	62.83	98.07	3.64	14.82	35.59[2]	17.24[2]	46.45[2]	53.99[1]	8.67
DPCaf 8	63.83	100.06	3.58	15.66	33.46[3]	15.20	41.86	45.49	8.70
DPCaf 10	62.83	90.77[1]	3.76	15.21	31.63	16.35[4]	38.74	47.29[4]	8.32
DPCaf 1	62.17	96.19	3.88	17.43[3]	31.97	14.56	40.77	45.21	8.78
DPCaf 2	60.33[1]	97.17	3.66	17.39[4]	32.00	14.26	42.84	43.65	8.76
DPCaf W3	65.00	105.53	3.73	15.51	27.37	13.50	36.80	42.46	8.68
DPCaf US	83.83	112.33	3.15[2]	15.78	30.21	15.07	40.49	42.88	9.71[1]
DPCaf S5-1	63.50	100.91	4.08	15.23	30.96	17.48[1]	39.65	46.48[5]	8.22
DPCaY 1	79.83	121.33	3.46	14.61	31.92	16.11[5]	40.56	42.37	8.90[5]
DPCaY 7	63.17	93.32[4]	3.62	15.81	30.80	14.56	39.91	44.43	8.42
DPCaf 9	62.83	95.40	3.70	15.86	30.09	15.64	39.29	43.67	8.36
DPCaf 12	62.33	94.69[5]	3.49	17.12[5]	28.97	14.48	35.62	39.80	8.68
DPCaf 13	63.50	97.74	3.38[5]	15.41	30.71	15.82	40.38	46.20	8.68
DPCaf 18	63.00	102.44	3.45	15.72	31.22	15.18	40.66	43.06	8.40
DPCaf 24	63.00	107.77	3.32[4]	16.31	28.91	15.56	37.96	41.00	8.12
DPCaf 29	61.33[2]	95.58	3.47	18.91[1]	32.13	13.42	37.66	41.64	8.76
DPCaf 30	61.67[5]	92.56[3]	3.29[3]	17.63[2]	32.74	14.21	39.31	43.73	9.00
DPCaf 35	61.33[3]	91.80[2]	3.75	16.54	26.99	12.99	35.39	36.26	8.65
Pusa Paushja	61.50[4]	96.04	3.49	14.37	29.85	14.74	42.11	46.10	7.76
Pusa Himjyoti	79.00	106.23	3.74	14.51	33.27[4]	14.38	46.10[3]	48.77[2]	8.73
Pusa Snowball KT-25	83.67	123.54	3.49	15.47	31.83	15.68	42.46	37.53	8.75
Pusa Snowball-1	82.50	123.97	3.14[1]	14.19	32.67	14.60	39.97	38.16	8.53
Pusa Snowball K-1	83.50	122.22	3.45	15.99	32.68	15.11	42.17	40.20	9.03[4]
Palam Uphar	66.17	101.54	3.40	15.56	31.31	15.87	43.39[5]	46.41	9.04[3]
Range	60.33 - 83.83	90.77 - 123.97	3.14 - 4.08	14.19 - 18.91	26.99 - 35.81	12.99 - 17.48	35.39 - 47.60	36.26 - 53.99	7.76 - 9.71
Mean	67.44	102.73	3.57	15.85	31.47	15.14	40.91	43.80	8.70
CV(%)	3.09	6.34	7.53	6.50	6.70	8.55	7.66	7.13	4.04
SE(m) ±	1.20	3.76	0.15	0.59	1.22	0.74	1.81	1.80	0.12
CD at $p \leq 0.05$	2.39	7.47	0.31	1.18	2.42	1.48	3.59	3.58	0.40

*Superscript (1, 2, 3, 4 and 5) indicated top ranking five genotypes.

one third of 'N' along with full dose of 'P_2O_5' and half dose of 'K_2O' were applied and the remaining dose of nitrogen was provided in two equal splits, each applied with an interval of one month after transplanting through top dressing while the remaining half of potassium was applied along with second dose of nitrogen during curd initiation stage. Immediately after transplanting the irrigation was given and it was followed by 10-15 days interval as per requirement. Observations were recorded for marketable curd yield per hectare (q/ha) along with its related traits viz., days to curd initiation, days to marketable curd maturity, stalk length (cm), leaves/plant, leaf length (cm), leaf width (cm), plant height (cm), plant frame (cm), curd depth (cm), curd diameter (cm), curd angle (^{0}), curd size index (cm^2), curd solidity (g/cm), gross plant weight (g), net curd weight (g), marketable curds (%) and total soluble solids (^{0}Brix).

RESULTS AND DISCUSSION

The mean performance of 26 genotypes of cauliflower for various traits has been presented in Tables 2–3, Figs. 1-2. The perusal of mean values of different genotypes showed wide variation in the performance with respect to marketable curd weight and its contributing

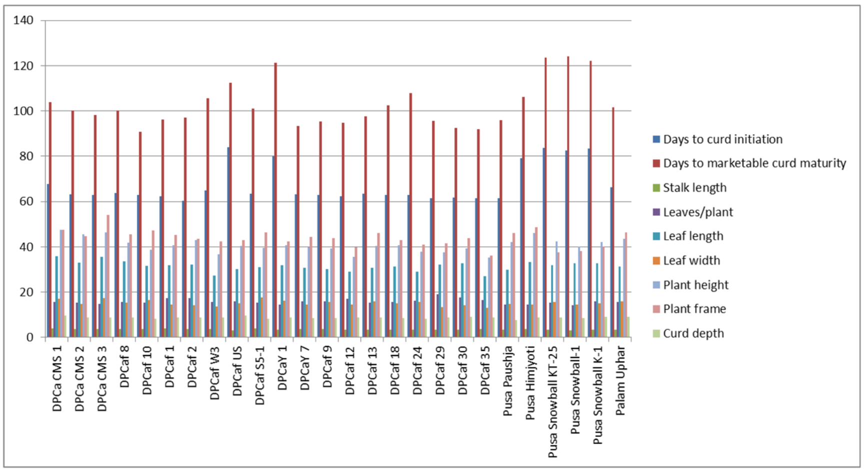

Fig. 1. Graphical representation of mean values of twenty six cauliflower genotypes in pooled over years for days to curd initiation, days to marketable curd maturity, stalk length (cm), leaves/plant, leaf length (cm), leaf width (cm), plant height (cm), plant frame (cm) and curd depth (cm).

traits. This indicates great extent of genetic diversity among genotypes which would provide immense opportunities for genetic improvement of cauliflower.

Earliness is one of the most desirable traits in vegetable crops as early maturing genotypes fetch higher prices in the market because of their availability early in the season. Days to curd initiation and marketable curd maturity are the indicators to identify early maturing genotypes. Days to curd initiation for different genotypes ranged from 60.33 (DPCaf 2) - 83.83 (DPCaf US) with population mean of 67.44 (Table 2, Fig. 1). A perusal of the data for days to curd initiation revealed that majority of the genotypes belong to mid late maturity group since 19 genotypes showed either early or at par days to curd initiation to standard check Palam Uphar in pooled years. The genotypes DPCaf 2, DPCaf 29, DPCaf 35, Pusa Paushja, DPCaf 30, DPCaf 1, DPCaf 12, DPCa CMS 3, DPCaf 10, DPCaf 9, DPCaf 18, DPCaf 24, DPCa CMS 2, DPCaY 7, DPCaf S5-1 and DPCaf 13 significantly took less number of days to curd initiation as compared to the standard check Palam Uphar. On the other hand, DPCaf 8, DPCaf W3 and DPCa CMS 1 were at par for days to curd initiation to that of Palam Uphar. Further, critical evaluation of the data showed that DPCaf US (84 days) and DPCaY 1 (80 days) were late in curd initiation at par with late maturing recommended varieties namely, Pusa Snowball-1 (83 days), Pusa Snowball K-1 (84 days) and Pusa Snowball KT-25 (84 days). Kumar *et al.* (2011), Santhosha *et al*. (2014), Chittora and Singh (2015) and Kumar *et al.* (2018) have also reported variation for days to curd initiation.

The genotypes showed variation for days to marketable curd maturity ranging from 90.77 (DPCaf 10) - 123.97 (Pusa Snowball-1) with average of 102.73 days (Table 2, Fig. 1). The genotypes namely, DPCaf 35, DPCaf 30, DPCaf 10 and DPCaY 7 significantly took less number of days to marketable curd maturity as compared to standard check Palam Uphar. The critical evaluation of data over the years indicated that majority of the genotypes i.e. 16 showed marketable curd maturity at par with mid-late check Palam Uphar. However, DPCaf US significantly mature early for curd harvesting in the pooled years with an advantage of 7-11 days than DPCaY 1 and about three weeks over late maturing Snowball check varieties. The differences in the days to curd harvesting over the years signify the importance of G × E interaction. Kumar *et al.* (2011), Santhosha *et al.* (2014), Chittora and Singh (2015) and Kumar *et al*. (2018) also observed significant difference for days to marketable curd maturity.

Shorter stalk length is most desirable as it is able to with hold higher weight of the curd and thereby minimizes lodging losses. The minimum stalk length was observed for Pusa Snowball-1 (3.14 cm) as compared to population mean of 3.57 cm (Table 2, Fig. 1). In addition, seven genotypes had also stalk length statistically parallel to the top ranking captioned genotypes. These genotypes include DPCaf US, DPCaf 30, DPCaf 24, DPCaf 13, Palam Uphar, DPCaf 18 and Pusa Snowball K-1. However, the genotypes showed variable performance for stalk length during respective years which revealed that this trait is influenced by environmental variations. Sharma *et al.* (2006), Santhosha *et al.* (2014), Chittora and Singh (2015), Kumar *et al.* (2017) and Chatterjee *et al.* (2018) also observed sufficient variations for stalk length in different genotypes.

The leaf plays a pivot role in photosynthetic activity and is an important character which contributes directly towards the curd weight. The number of leaves ranged from 14.19 (Pusa Snowball-1) - 18.91 (DPCaf 29) with population mean of 15.85 (Table 2, Fig. 1). The top ranked genotypes DPCaf 29 (18.91) along with DPCaf 30 (17.63), DPCaf 1 (17.43), DPCaf 2 (17.39) and DPCaf 12 (17.12) had significantly more number of leaves than that of Palam Uphar (15.56). Majority of the genotypes revealed statistically same number of leaves as that of Palam Uphar. Santhosha *et al.* (2014), Vanlalneihi *et al.* (2017) and Kumar *et al.* (2018) also reported significant differences for leaves/plant in cauliflower genotypes. Leaf length ranged from 26.99 cm (DPCaf 35) - 35.81 cm (DPCa CMS 1) with population mean of 31.47 cm (Table 2, Fig. 1). The data revealed that two genotypes i.e. DPCa CMS 1 (35.81 cm) and DPCa CMS 3 (35.59 cm) significantly surpassed the standard check Palam Uphar (31.31 cm) while DPCa CMS 1 was at par with DPCa CMS 3 and DPCaf 8 for leaf length. Only two genotypes namely, DPCaf W3 and DPCaf 35 had significantly lesser leaf length than that of Palam Uphar. Earlier workers viz., Dhatt and Garg (2008) and Vanlalneihi *et al.* (2017) reported a wide range of variations for leaf length in their respective breeding materials. Leaf width ranged from 12.99 cm (DPCaf 35) - 17.48 cm (DPCaf S5-1) with the population mean of 15.14 cm (Table 2, Fig. 1). Only single genotype 'DPCaf S5-1' (17.48 cm) was significantly superior than the Palam Uphar (15.87 cm) while DPCa CMS 3 (17.24 cm), DPCa CMS 1 (16.97 cm), DPCaf 10 (16.35cm) and DPCaY 1 (16.11 cm) were at par with the top ranked genotype DPCaf S5-1 (17.48 cm). Dhatt and Garg (2008) and Vanlalneihi *et al*. (2017) also observed variable leaf width in their breeding materials.

Plant height ranged from 35.39 cm (DPCaf 35) - 47.60 cm (DPCa CMS 1) (Table 2, Fig. 1). Data construed that maximum plant height was recorded for DPCa CMS 1 (47.60 cm) which was significantly better than Palam Uphar (43.39 cm) but at par with DPCa CMS 3 (46.45 cm), Pusa Himjyoti (46.10 cm) and DPCa CMS 2 (45.50 cm). In cauliflower, selection of genotypes with optimum plant growth is most desirable as too long or too small plants results in poor curd size. Therefore, it would be imperative to identify genotypes which produce better marketable curds with an optimum plant height and plant frame which was quite evident with the performance of genotype DPCaf W3 who ranked 24th position at for plant height while at second position for marketable curd weight. Vanlalneihi *et al.* (2017) and Shree *et al.* (2019) also recorded variable plant height in their germplasm. Plant frame ranged from 36.26 cm (DPCaf 35) - 53.99 cm (DPCa CMS 3) with population mean of 43.80 cm (Table 2, Fig. 1). DPCa CMS 3 (60.43 cm, 53.99 cm) revealed significantly more plant frame as compared to the standard check Palm Uphar (47.27 cm, 46.41 cm) while 15 genotypes had plant frame similar to that of Palm Uphar. Similar findings have also observed by Dhatt and Garg (2008) and Kumar *et al.* (2017) for this trait. Significant differences were recorded for curd depth that ranged from 7.76 cm (Pusa Paushja) - 9.71 cm (DPCaf US) with population mean of 8.70 cm (Table 2, Fig. 1). The highest curd depth was recorded in DPCaf US (9.71 cm) in pooled years which significantly surpassed Palam Uphar for curd depth (9.04 cm). The variations in the curd depth of genotypes over the years indicated that environmental variations significantly influence this trait though DPCaf US and DPCa CMS 1 were least influenced by the environment as they were placed in top two positions and 15 genotypes showed statistically similar curd depth. Sharma *et al.* (2006), Santhosha *et al.* (2014) and Kumar *et al.* (2018) have also observed significant variations for curd depth in cauliflower genotypes. A wide variation for curd diameter was recorded ranging from 11.80 cm (DPCaY

1) - 13.89 cm (DPCaf US) (Table 2, Fig. 1). Highest curd diameter was observed in DPCaf US (13.89 cm) followed by DPCa CMS 1 (13.85 cm) and DPCaf 30 (13.60 cm), at par with Palam Uphar (13.38 cm). In addition, nine genotypes also showed statistically same curd diameter as that of Palam Uphar namely, DPCa CMS 3 (13.11 cm), Pusa Snowball KT-25 (13.07 cm), DPCaf 18 (13.06 cm), DPCaf 12 (12.98 cm), Pusa Himjyoti (12.96 cm), DPCaf 13 (12.91 cm), DPCaf 29 (12.89 cm), DPCaf W3 (12.89 cm) and DPCa CMS 2 (12.83 cm). Significant differences for curd diameter have also been reported by Sharma *et al.* (2006), Santhosha *et al.* (2014), Chittora and Singh (2015) and Kumar *et al.* (2018).

Curd angle is the measure of curd compactness. Generally compact curds are preferred by the consumers in the market on account of better turgidity besides enhanced shelf life. DPCaf US (106.45^0) had the maximum curd angle at par with eight other genotypes viz., DPCaf W3 (106.45^0), DPCa CMS 1 (105.34^0), Pusa Himjyoti (104.22^0), Pusa Snowball K-1 (103.69^0), Pusa Snowball KT-25 (103.33^0), Pusa Snowball-1 (103.28^0), DPCaf 30 (102.78^0) and DPCaf S5-1 (102.73^0) indicating semi compact curds (Table 3, Fig. 2). In general, majority of the genotypes showed curd angle at par with recommended variety Palam Uphar in pooled over years. Kumar *et al.* (2018) and Shree *et al.* (2019) also reported significant differences in their respective breeding material for curd angle. A wide range of variation was recorded for curd size index ranging from 94.76 (Pusa Paushija) - 135.18 (DPCaf US) (Table 3, Fig. 2). The genotype DPCaf US (135.18 cm^2) and DPCa CMS 1 (134.02 cm^2) significantly performed better for this trait and seven genotypes namely, DPCaf 30 (122.54 cm^2), Pusa Snowball KT-25 (144.16 cm^2), DPCa CMS 3 (113.78 cm^2), Pusa Himjyoti (113.27 cm^2), DPCaf 29 (112.92 cm^2), DPCaf 12 (112.79 cm^2) and DPCa CMS 2 (112.71 cm^2) revealed curd size index at par with Palam Uphar. Santhosha *et al.* (2014) and Chatterjee *et al.* (2018) have also observed significant differences for curd size index.

The maximum curd solidity was observed for the genotype DPCaf W3 with value of 66.90 g/cm (Table 3, Fig. 2). Besides, DPCaf US (52.66 g/cm), DPCa CMS 3 (49.02 g/cm), DPCa CMS 1 (49.02 g/cm), DPCaf S5-1 (48.08 g/cm), DPCaf 30 (46.54 g/cm) and Pusa Snowball K-1 (45.89 g/cm) along with top ranked genotype DPCaf W3 significantly out-performed Palam Uphar for curd solidity. A critical evaluation of the data showed that eleven genotypes namely, Pusa Himjyoti, Pusa Snowball KT-25, Pusa Snowball-1, DPCaf 2, DPCaf 13, DPCaf 1, DPCaf 24, DPCaf 12, DPCaf 10, DPCaf 18 and DPCaf 29 had curd solidity statistically same as Palam Uphar. Sharma *et al.* (2018) and Chatterjee *et al.* (2018) have also observed variation in mean performance of genotypes for curd solidity. In cauliflower plants with more foliage though result in high gross plant weight but plants with excessive foliage may result in reduced curd size. Therefore, it is imperative to identify genotypes with optimum foliage so as to achieve maximum economic yield i.e., marketable curd yield. The gross plant weight of different genotypes varied from 700.44 g in DPCaf 9 to 1342.99 g in DPCa CMS 1 (Table 3, Fig. 2). Highest gross plant weight was recorded in DPCaCMS 1 (1342.99 g) followed by DPCaf W3 (1149.72 g), DPCaf 30 (1122.59 g) and DPCaf US (1104.20 g) which was significantly higher than that of Palam Uphar. Also, three genotypes namely, DPCaf S5-1 (1045.48 g), DPCaf 1 (1029.76 g) and DPCaf 2 (996.39 g) had gross plant weight statistically comparable with Palam Uphar. Earlier research workers namely, Sharma *et al.* (2006), Santhosha *et al.* (2014), Chittora and Singh (2015), Kumar *et al.* (2018) and Chatterjee *et al*. (2018) also observed a wide range of variation among genotypes for gross plant weight in their respective breeding material. Net curd weight signifies the overall performance of variety/genotype as consumers prefer better curd size than plant parts retained to provide jacket/protection to the curds. The net curd weight ranged from 242.80 g in DPCaf 9 to 579.87 g in DPCaf W3 (Table 3, Fig. 2). Besides, DPCaf US (511.15 g) and DPCa CMS 1 (474.71 g) also significantly produced high net curd weight than the best performing recommended variety Pusa Snowball K-1 (413.73 g) in pooled over years, respectively. A comparison of net curd weight of individual genotypes revealed that DPCaf W3 significantly outperformed all the genotypes. Further analysis of mean performance indicated that DPCa CMS 3 (424.45 g), DPCaf 30 (418.79 g), DPCaf S5-1 (396.17 g), Pusa Himjyoti (394.40 g) and Palam Uphar (383.71 g) also produced

Table 3. Mean values of twenty six cauliflower genotypes in pooled over years for curd diameter, curd angle, curd size index, curd solidity, gross plant weight, net curd weight, marketable curds, total soluble solids and marketable curd yield per hectare.

Genotypes	Curd diameter (cm)	Curd angle (^{0})	Curd size index (cm^2)	Curd solidity (g/cm)	Gross plant weight (g)	Net curd weight (g)	Marketable curds (%)	Total soluble solids (^{0}Brix)	Marketable curd yield per hectare (qt/ha)
DPCa CMS 1	13.85[2]	105.34[3]	134.02[2]	49.02[4]	1342.99[1]	474.71[3]	89.72	9.71	342.12[2]
DPCa CMS 2	12.83	98.00	112.71	38.14	805.32	335.00	85.00	8.58	208.44
DPCa CMS 3	13.11[5]	100.17	113.78	49.02[3]	978.99	424.45[4]	91.66	9.66	265.82
DPCaf 8	12.55	95.61	109.38	34.89	830.73	304.44	93.05	9.55	231.67
DPCaf 10	12.40	99.78	103.28	40.28	791.93	335.08	93.89[5]	10.05[1]	217.93
DPCaf 1	12.70	99.95	111.73	40.86	1029.76	359.90	93.05	9.27	281.32[5]
DPCaf 2	12.23	98.28	107.25	42.44	996.39	372.79	89.72	9.31	263.80
DPCaf W3	12.89	106.45[2]	112.02	66.90[1]	1149.72[2]	579.87[1]	93.05	9.86[4]	346.55[1]
DPCaf US	13.89[1]	106.45[1]	135.18[1]	52.66[2]	1104.20[4]	511.15[2]	93.05	9.73	329.97[3]
DPCaf S5-1	12.10	102.73	99.84	48.08[5]	1045.48[5]	396.17	87.50	9.22	267.66
DPCaY 1	11.80	99.84	105.12	33.85	963.14	298.94	74.44	9.54	206.36
DPCaY 7	12.61	96.28	106.27	38.39	780.16	323.85	80.56	9.86[3]	176.03
DPCaf 9	11.92	98.64	99.80	28.92	700.44	242.80	85.00	9.16	180.65
DPCaf 12	12.98	102.39	112.79	40.42	843.97	351.67	98.61[1]	9.38	273.10
DPCaf 13	12.91	97.67	112.20	41.26	915.25	357.54	91.11	9.56	246.45
DPCaf 18	13.06	99.14	109.73	40.22	892.27	337.43	95.83[2]	9.52	252.44
DPCaf 24	11.92	100.14	96.71	40.73	887.64	328.74	84.87	8.80	216.21
DPCaf 29	12.89	100.17	112.92	38.81	894.34	338.21	93.89[4]	9.16	250.21
DPCaf 30	13.60[3]	102.78	122.54[3]	46.54	1122.59[3]	418.79[5]	95.28[3]	9.16	317.56[4]
DPCaf 35	12.37	99.92	107.12	31.11	732.06	267.89	85.83	9.31	189.90
Pusa Paushja	12.21	97.89	94.76	34.97	781.00	272.10	87.78	9.93[2]	192.31
Pusa Himjyoti	12.96	104.22[4]	113.27	45.26	882.89	394.40	80.56	8.65	222.28
Pusa Snowball KT-25	13.07	103.33	114.16[5]	42.86	948.47	375.18	80.56	8.96	213.72
Pusa Snowball-1	12.29	103.28	104.87	42.69	903.84	363.96	85.22	8.55	211.14
Pusa Snowball K-1	12.24	103.69[5]	110.62	45.89	984.49	413.73	73.05	8.06	215.24
Palam Uphar	13.38[4]	102.11	121.25[4]	42.25	1045.44	383.71	89.72	9.81[5]	268.39
Range	11.80-13.89	95.61 - 106.45	94.76 - 135.18	28.92 – 66.90	700.44 - 1342.99	242.80-579.87	73.05 - 98.61	8.06 - 10.05	176.03-346.55
Mean	12.72	100.93	110.90	42.17	936.67	367.79	88.15	9.32	245.66
CV(%)	3.87	3.23	6.91	7.31	5.20	7.40	8.39	3.71	10.86
SE (m) ±	0.28	1.88	4.42	1.78	28.11	15.72	4.27	0.20	15.40
CD at $p \leq 0.05$	0.56	3.74	8.78	3.53	55.80	31.20	8.47	0.40	30.58

*Superscript (1, 2, 3, 4 and 5) indicated top ranking five genotypes.

net curd weight statistically at par with best check Pusa Snowball K-1 (413.73 g). The earlier researchers have also reported a wide range of variations for net curd weight in their breeding materials viz., Kumar *et al.* (2018) and Shree *et al.* (2019).

There is a serious issue of curd formation in the open pollinated varieties of cauliflower. The variety which forms maximum desirable marketable curds is the most suitable. Therefore, marketable curds (%) directly contribute to the total yield and should be taken into account for identification of suitable variety/genotype. The per cent marketable curds ranged from 73.05% in Pusa Snowball K-1 to 98.61% in DPCaf 12 (Table 3, Fig. 2). Ten genotypes namely, DPCaf 18, DPCaf 30, DPCaf 29, DPCaf 10, DPCaf US, DPCaf W3, DPCaf 1, DPCaf 8, DPCa CMS 3 and DPCaf 13 showed at par performance for this trait with top ranked genotype DPCa 12. Sharma *et al.* (2006) have also reported significant differences for marketable curds (%). The total soluble solids ranged from 8.06 0Brix (Pusa Snowball K-1) - 10.05 ^{0}Brix (DPCaf 10) (Table 3, Fig. 2). The highest total soluble solids were recorded in DPCaf 10 (10.05 ^{0}Brix). Seven genotypes namely, Pusa Paushja, DPCaY 7, DPCaf W3, Palam Uphar, DPCaf US, DPCa CMS 1

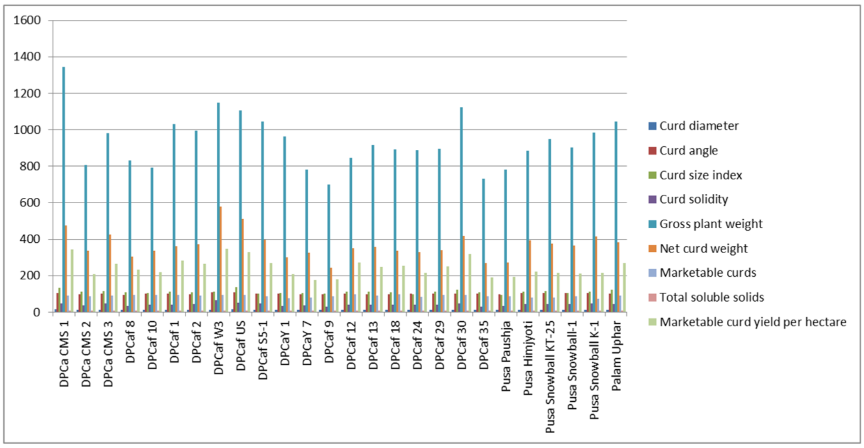

Fig. 2. Graphical representation of mean values of twenty six cauliflower genotypes in pooled over years for curd diameter (cm), curd angle (^{0}), curd size index (cm^2), curd solidity (g/cm), gross plant weight (g), net curd weight (g), marketable curds (%), total soluble solids (^{0}Brix) and marketable curd yield per hectare (qt/ha).

and DPCa CMS 3 had similar performance as that of DPCaf 10. Sharma *et al.* (2018) have also observed variations in mean performance for total soluble solids in their breeding material. A genotype should not be considered beneficial until it surpasses the existing commercial cultivar with respect to the yield. Hence, marketable curd yield per hectare provides a good scope to compare the yielding ability of any genotype to that of standard commercial variety. The marketable curd yield per hectare ranged from 176.03 q/ha (DPCaY 7) – 346.55 q/ha (DPCaf W3) (Table 3, Fig. 2). DPCaf W3 (346.55 qt/ha), DPCa CMS 1 (342.12 q/ha), DPCaf US (329.97 q/ha) and DPCaf 30 (317.57 q/ha) were the top ranked genotypes who significantly surpassed Palam Uphar (268.39 q/ha) with an increase of 29.12, 27.47, 22.94 and 18.32% respectively. Kumar *et al.* (2011) have also observed a wide range of variations for marketable curd yield per hectare in their breeding material.

CONCLUSION

Based on the mean performance of different genotypes, it can be concluded that the superior/desirable performing genotype namely, DPCaf US, DPCa CMS 1, DPCaf W3 and DPCaf 30 for marketable curd yield may be attributed for their better performance for related traits namely, curd depth, curd diameter, leaf length, leaf width, leaves/plant, optimum plant frame, curd compactness, curd solidity, gross plant weight and net curd weight. It is quite apparent from the results that curd depth, curd diameter, curd compactness and curd size index have direct bearing on the marketable curd yield.

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