

Short Note

**MORPHOLOGICAL CHARACTERIZATION OF
CAULIFLOWER VARIETIES/CULTIVARS USING DUS
CHARACTERS**

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Cauliflower is a cool season crop; it is more exacting in its climatic requirements than most other crops in this family. The plant is extremely sensitive to unfavourable conditions, such as unusually hot weather, drought or too low temperature, which often result in the formation of premature curds. It is monogenic species whose genomic constitution is C and chromosome number is $n=9$ belongs to Cruciferae family (Thamburaj and Singh, 2001). The variety attains acceptance when the farmers get genetically pure seed of high standard. For the purpose, each cultivar should be properly defined with suitable descriptors, so as to maintain its identity during seed production through field inspection and certification. In India, Protection of Plant Varieties and Farmer's Right Act, 2001 (PPV and FRA, 2001) envisages the registration and protection of new and notified/extant plant varieties based on the criteria of Distinctness, Uniformity and Stability (DUS) of morphological characteristics and increasing attention is being paid towards comprehensive plant genetic resources.

The characterizations of 15 varieties were done to use as reference material for protection of other varieties under PPV and FR Rules, 2003. Therefore, the database of cauliflower varieties generated may be useful for the selection of suitable varieties to be compared against the candidate varieties developed in India as and when required. This investigation may also be helpful to the researchers with respect to breeding of cauliflower varieties for particular traits. Moreover, farmers can also get benefit with regards to selection of suitable varieties of their interest.

The present investigation was carried out for successive three years during Rabi season of 2010 to 2012 to carry out characterization of already released cauliflower varieties at Research Farm, Indian Institute of Vegetable Research, Varanasi, India. The seed materials for the present investigation comprised of 15 varieties i.e Pusa Paushja, Pusa Sharad, Pusa Himjyoti, Pusa Shukti, Pusa Meghna, Pusa Deepali, Kashi Kunwari, Kashi Agahani, CCS-80, Pant Gobhi-3, Pusa Subhra,

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Pusa Snow Ball-1 PSBK-1, PSB-16 and PSBK-25. The field experiment was laid out in a randomized block design with three replications. Each plot consisted of four rows of 5m length with spacing of 50 cm between rows and 50 cm between plants and all the recommended agronomic practices were followed to raise the good crop. The observations were recorded on 10 plants in each replication at specific stages of crop growth period when the characters under study had full expression. Varieties were evaluated for 28 DUS qualitative and quantitative characters listed in National DUS test guidelines descriptors for cauliflower *viz*; seedling: anthocyanin colouration of hypocotyl, outer stem (stalk): length (up to insertion of first leaf) , leaf attributes *viz*; leaf: attitude, length, width, shape, lobe, colour, waxiness, torsion of tip profile of upper side of blade, puckering , crimping near main vein and degree of undulation of margin, curd characteristics *viz*; curd: initiation (days to 50% of the plants with curd initiation from sowing of seed), covering by inner leaves, polar diameter, equatorial diameter, shape in longitudinal section, doming, colour, knobbing, texture, compactness, anthocyanin colouration at maturity, maturity group, flower: colour, and stalk length (Anonymous, 2009).

The characterization of cauliflower varieties is presented in table-1 and frequency distribution of each descriptor of released varieties along with example varieties is depicted in table-2.

The varieties were classified on the basis of seedling anthocyanin pigment of hypocotyls into two groups i.e. absent and present. Most of the varieties exhibited absent while, snowball group (Pusa Snowball-1, PSBK-1, PSB-16) expressed seedling anthocyanin colouration. Based on outer stem (stalk) length, cauliflower varieties were grouped as short, medium and long. Two varieties namely Pusa Sharad and Pusa Snow Ball-1 expressed medium and 13 varieties showed long stalk length while, none of the varieties depicted short outer stem (stalk) length. As per leaf attitude, three varieties i.e. Pusa Himjyoti, Pusa Snow Ball-1 and PSBK-25 expressed erect while, Pusa Meghna and Kashi Aghrahani showed horizontal and rest 10 varieties showed semi erect type. Leaf length of cauliflower varieties classified into three categories *viz*; short, medium and long. However, in the present study, only four varieties *i.e.* Pusa Meghna, Pusa Shukti, PSB-16 and Pusa Sharad had short leaf length, ten varieties showed medium leaf length and other varieties showed long leaf length. Considerable variation was also observed for leaf shape, variety like Pusa Meghna was of narrow elliptic leaf shape while, Pusa Paushja, Pusa Sharad, PSB-1, Pusa Himjyoti, Pant Gobhi-3, PSBK-25, Pusa Deepali and Kashi Agahani were of elliptic type and rest varieties *i.e.* Pusa Snow Ball K-1, Pusa Shukti, CCH-80, Pusa Subhra, PSB-16 and Kashi Kunwari had broad elliptic type leaf shape. On the basis of leaf lobe, the varieties were classified in two group *viz*; absent and present. Most of the varieties expressed leaf lobe except Pusa Paushja, Pusa Sharad, Pusa Himjyoti, Pusa Snow Ball-1 and Pusa Shukti.

The varieties were also classified on the basis of leaf colour in three groups *i.e.* light green, dark green and bluish. Most of the varieties were found to have light and dark green leaves except Pusa Paushja which showed as bluish leaf colour. Leaf waxiness was another trait with good variability. On the basis of this character, the varieties were categorized into four groups *i.e.* absent, light, medium and strong. Waxiness was absent in Pusa Meghna while, Pusa Paushja, CCS-80, Pant Gobhi-3, Pusa Subhra and PSB-16 exhibited medium waxiness. Varieties like Pusa Himjyoti, Pusa Snow Ball-1, Pusa Shukti, PSBK-1 and Pusa Meghna expressed light whereas; Pusa Paushja and PSBK-25 showed strong leaf waxiness. The trait leaf torsion of tip was categorized into four categories namely, absent, weak, medium and strong. Five varieties *i.e.* Pusa Snow Ball-1, Pusa Shukti, Pusa Meghna, Pusa Deepali and Kashi Kunwari depicted absent, while, 5 varieties expressed weak and rest varieties showed medium torsion of leaf tip. None of the varieties showed strong torsion of leaf tip. On the basis of leaf profile of upper side of blade character, the varieties were classified into three groups *i.e.* concave, flat and convex. Varieties like, Pusa Snow Ball-1, Pusa Shukti, Pusa Deepali, Kashi Kunwari and Kashi Agahani were of flat type leaf while, Pusa Paushja, Pusa Sharad, Pusa Himjyoti, CCS-80, Pant Gobhi-3 and PSBK-1 showed convex and rest varieties showed concave type leaf. Among the varieties, weak leaf puckering was absent in Pusa Himjyoti, Pusa Snow Ball-1, Pusa Meghna and Kashi Kunwari whereas, Pusa Paushja, Pusa Sharad, CCS-80, Pant Gobhi-3, Pusa Subhra, PSBK-1 and Kashi Agahani expressed medium and Pusa Shukti, PSBK-25 and Pusa Deepali showed strong leaf puckering characters. In the favour of leaf crimping near main vine, the varieties have been grouped into four categories, *viz;* seven varieties as weak, five as medium and 3 as strong whereas, none of the varieties had no leaf crimping near main vine. On the basis of curd initiation, cauliflower varieties can be classified into three categories *viz;* early (<75 days), medium (75-100 days), late (>100 days). There are three varieties with early curd initiation *e.g.* Pusa Meghna, Pusa Deepali and Kashi Kunwari while, 9 varieties *i.e.* Pusa Himjyoti, Kashi Agahani, Pusa Paushja, Pusa Sharad, Pusa Shukti, CCS-80, Pant Gobhi-3 and Pusa Subhra were in medium group and Pusa Snowball -1, PSBK-1, PSB-16 and PSBK-25 exhibited late curd initiations. Curd covering by inner leaves was another trait with good variability. On the basis of this character, the varieties were grouped into three types *viz;* not covered, partly covered, and covered. Four varieties (Kashi Kunwari, Pusa Himjyoti, Pusa Deepali and Pusa Meghna) were not covered, whereas, Kashi Agahani Pusa Paushja, Pusa Sharad, Pusa Shukti, CCS-80, Pant Gobhi-3 and Pusa Subhra exhibited partly covered and four (PSBK-1, PSB-16, PSBK-25 and Pusa Snow Ball-1) varieties covered by inner leaves. Based on polar diameter of curd, varieties were classified into 3 groups *viz;* small (<15 cm), medium (15-20cm) and large (>20cm). Proportionate distributions of varieties in small and medium group were observed. Only two varieties Pusa Shukti and PSBK-1 were in large group. Equatorial diameter of curd cauliflower varieties were grouped as small, medium and large, accordingly, 4 varieties as small, 9 as medium and 2

were observed as large equatorial diameter during experimentation. Dubey et al., (2003) reported high variability in curd size of cauliflower. Shape in longitudinal section of curd is another character with sufficient variability in cauliflower varieties. Circular shape was observed in Pusa Himjyoti, broad elliptic was observed in 11 varieties *viz*; Kashi Kunwari, Kashi Agahani, Pusa Paushja, Pusa Sharad, Pusa Shukti, CCS-80, Pant Gobhi-3, Pusa Subhra, PSBK-1, PSB-16 and PSBK-25, while, Pusa Snow Ball-1, Pusa Megna and Pusa Deepali were depicted as narrow elliptic. The character of curd doming was categorized as weak, medium and strong. In this respect variety Pusa Meghna showed weak and variety Pusa Paushja expressed have strong curd doming whereas, rest of other varieties were depicted as medium curd doming. Curd colour varied from white to creamy white in the varieties studied. Pusa Paushja, Pusa Sharad, PSBK-1 and PSBK-25 exhibited white colour whereas, rest of the varieties showed creamy white colour. Curd knobbing is important character categorized into three categories i.e. fine, medium and course. Most of the varieties showed medium knobbing except PSBK-1 which expressed fine curd knobbing. Among the 15 cauliflower varieties studied considerable variation was observed for all the characters except curd texture (Table-1) where all the varieties exhibited fine curd texture. On the basis of curd compactness, the varieties were classified into three groups *viz*; loose, medium and compact, seven varieties were found as medium type and 8 varieties of compact type. Similar findings were reported by Singh et al., (2005). Kumar et al. (2010) found significant differences among the genotypes in Indian cauliflower suggesting sufficient variability for yield and quality characters.

The trait anthocyanin colouration of curd at maturity was categorized into two categories namely, absent and present. Two varieties depicted as present and rest of 13 varieties showed absent in anthocyanin curd colouration. Curd maturity group is most important character which classified as early, mid early, mid late and late. Only one variety Pusa Deepali was found early, whereas, Kashi Kunwari, Pusa Meghna was expressed as mid early group, Pusa Paushja, Pusa Sharad, Pusa Himjyoti, Pusa Shukti, CCS-80, Pant Gobhi-3 and Pusa Subhra were exhibited as mid late group and all the snow ball group varieties were depicted as late group for maturity. Late group varieties *viz*; Pusa Snow Ball-1, PSB-16, PSBK-1, PSB-16 and PSBK-25 could not flower due to lack of chilling requirement in northern plane in India. Flower colour grouped as white, creamy white and yellow. Among the 11 flowered varieties, three varieties namely Pusa Himjyoti, Pusa Deepali and Pusa Meghna expressed creamy white, and rest of the other varieties showed yellow flower colour while, none of the variety was depicted as white colour. Similar grouping trends were reported by Singh et al., (2012) in cabbage. The trait flower stalk length was categorized into three categories namely short, medium and long. Out of these, two varieties was depicted as short stalk length and 9 varieties showed medium stalk length.

It is concluded that the DUS descriptors can be effectively used for identification and grouping of varieties and satisfying the DUS criteria for these morphological descriptors could be registered under PPV and FR Act. Pre-breeding

or genetic enhancement needs emphasis for transfer or introgression of genes and gene combinations from unadapted source into more usable breeding material. There are indications that novel and useful traits can be successfully combined from related varieties. Further, these varieties can be used in varietal improvement programme depending upon the desired characteristics. However, registration of candidate varieties only considered under DUS testing as per the legal frame work and till now, morphological characterizations are being considered as per PPV and FR Act for notified vegetable crops.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the PPV&FR Authority, New Delhi for financially support, assistance through PVP legislation and DUS testing project.

REFERENCES

- Anonymous. 2009. PPV and FR Authority specific DUS test guidelines for nine crop species – *Brassica oleracea* (Botrytis L.). *Plant Variety Journal of India*, 3 (11):217-229
- Dubey, R.K., Singh, B.P. and Ram, H.H. 2003. Genetic variability, heritability and genetic advance for quantitative characters in Indian cauliflower (*Brassica Oleracia* var. Botrytis L.). *Vegetable Science*, 30(1): 81-82
- Kumar, M. Mahesh, S.R. Sharma, Kalia, P. and Saha, P. 2010. Genetic variability and character association for quantitative and quality traits in early maturing Indian cauliflowers. *Indian Journal of Horticulture*, 67:218-223
- PPV and FR, 2001. Protection of Plant Varieties and Farmer's Right Act (No. 53 of 2001) Dept. of Agriculture and Cooperation, Ministry of Agriculture, Govt of India, Krishi Bhavan, New Delhi
- Singh, B., Chaubey, T., Upadhyay, D.K., Jha, A. and Pandey, S.D. 2012. Morphological characterization for DUS testing of cabbage (*Brassica oleracea* var. capitata L.) genotypes. *Progressive Horticulture*, 44 (1): 170-173
- Singh, B., Singh, A.K., Pandey, S and Rai, M. 2005. Effect of curd cutting techniques at different curd stage on seed production in Indian cauliflower (*Brassica Oleracia* var. Botrytis L.). *Vegetable Science*, 32(1): 80-81
- Tamburaj, T. And Singh, N. 2001. Textbook of Vegetables, Tuber crops and Spices, ICAR (Pub.) New Delhi

Table 1: Description of morphological DUS descriptors for fifteen cauliflower varieties/ cultivars.

S. No.	Descriptor	Varieties/Cultivars															Remarks
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	Seedling: anthocyanin colouration of hypocotyl	1	1	1	9	1	1	1	1	9	1	9	1	1	1	1	1:absent, 9:present
2	Outer stem (stalk): length (up to insertion of first leaf)	7	5	7	5	7	7	7	7	7	7	7	7	7	7	7	3:short, 5: medium,7: long
3	Leaf : attitude	3	3	1	1	3	3	3	3	3	3	1	5	3	3	5	1:erect, 3: semi erect,5: horizontal
4	Leaf: length	5	3	5	3	5	5	5	5	7	3	5	3	5	5	5	3:short, 5: medium,7: long
5	Leaf: width	5	5	3	3	7	5	5	5	5	3	5	5	5	3	5	3:narrow, 5:medium, 7:broad
6	Leaf: shape	5	5	5	5	7	7	5	7	7	7	5	3	5	7	5	3:narrow elliptic, 5:elliptic,7:broad elliptic
7	Leaf: lobe	9	9	9	9	9	9	1	1	1	1	1	1	1	1	1	1:absent, 9:present
8	Leaf: colour	2	2	1	1	2	2	2	1	2	2	2	1	1	1	2	1:light green, 2:dark green,3: bluish
9	Leaf: waxiness	7	3	2	2	2	3	3	3	2	3	7	1	2	3	3	1:absent, 2:light,3:medium,7:strong
10	Leaf: torsion of tip	3	5	3	1	1	5	3	3	5	5	5	1	1	1	3	1:absent, 3:weak,5:medium,7:strong
11	Leaf: profile of upper side of blade	3	3	3	2	2	3	3	1	3	1	1	1	2	2	2	1:concave, 2:flat, 3:convex
12	Leaf: puckering	5	5	3	3	7	5	5	5	5	1	7	3	7	3	5	1:absent, 3:weak,5:medium,7:strong
13	Leaf: crimping near main vein	5	5	3	3	7	5	5	3	7	3	7	3	5	3	3	1:absent, 3:weak,5:medium,7:strong
14	Leaf: degree of undulation of margin	3	5	3	1	7	5	5	5	5	3	7	5	3	3	3	1:absent, 3:weak,5:medium,7:strong
15	Curd initiation (days to 50% of the plants with curd initiation from sowing of seed)	5	5	5	7	5	5	5	5	7	7	7	3	3	3	5	3:early, 5:medium, 7:late

S. No.	Descriptor	Varieties/Cultivars															Remarks
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
16	Curd: covering by inner leaves	5	5	3	7	5	5	5	5	7	7	7	3	3	3	5	3: not covered, 5: partly covered, 7: covered
17	Curd: polar diameter	5	5	3	3	7	5	5	5	7	5	5	3	3	5	5	3: small, 5: medium, 7: large
18	Curd: equatorial diameter	5	5	3	3	7	5	5	5	7	5	5	3	3	5	5	3: small, 5: medium, 7: large
19	Curd: shape in longitudinal section	3	3	1	5	3	3	3	3	3	3	3	5	5	3	3	1: circular, 3: broad elliptic, 5: narrow elliptic
20	Curd: doming	7	5	5	5	5	5	5	5	5	5	5	3	5	5	5	3: weak, 5: medium, 7: strong
21	Curd: colour	1	1	2	2	2	2	2	2	1	2	1	2	2	2	2	1: white, 2: creamy white, 3: orange
22	Curd: knobbing	5	5	5	5	5	5	5	5	3	5	5	5	5	5	5	3: fine, 5: medium, 7: coarse
23	Curd: texture	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3: fine, 7: coarse
24	Curd: compactness	7	7	5	7	5	5	5	7	7	5	7	5	5	7	7	3: loose, 5: medium, 7: compact
25	Curd: anthocyanin colouration at maturity	1	1	1	9	1	1	1	1	9	1	1	1	1	1	1	1: absent, 9: present
26	Curd: maturity group	7	7	7	9	7	7	7	7	9	7	9	5	3	5	7	3: early, 5: mid early, 7: mid late, 9: late
27	Flower: colour	3	3	2	-	3	3	3	3	-	-	-	2	2	3	3	1: white, 2: creamy white, 3: yellow
28	Flower: stalk length	5	3	5	-	5	5	5	5	-	-	-	5	3	5	5	3: short, 5: medium, 7: long

Varieties/cultivars: 1: Pusa Paushja, 2: Pusa Sharad, 3: Pusa Himjyoti, 4: Pusa Snow Ball-1, 5: Pusa Shukti, 6: CCS-80, 7: Pant Gobhi-3, 8: Pusa Subhra, 9: PSBK-1, 10: PSB-16, 11: PSBK-25, 12: Pusa Meghna, 13: Pusa Deepali, 14: Kashi Kunwari, 15: Kashi Agahani

Note: (-) is Pusa Snow Ball-1, PSBK-1, PSB-16 and PSBK-25 are snowball group. Temperate region is suitable for this group flowering.

Table 2: Frequency distribution and example varieties of some important attributes of 15 varieties/ cultivars of cauliflower

Plant descriptors	Range in expression	No. of varieties	Example varieties
Seedling: anthocyanin colouration of hypocotyl	absent	12	Pusa Deepali, Kashi Agahani
	present	3	PSBK-1, PSBK-25, Pusa Snowball-1
Leaf : attitude	erect	3	PSBK-25, Pusa Snowball-1
	semi-erect	10	Pusa Paushja, Pusa Sharad, Pusa Himjyoti
	horizontal	2	Pusa Meghna
Leaf: length	short (<35 cm)	4	Pusa Meghna, Pusa Shukti, PSB-16
	medium (35-50 cm)	10	Pusa Sharad, Kashi Agahani, CCS-80
	large (>50 cm)	1	PSBK-1
Leaf: width	narrow (<15 cm)	4	Pusa Himjyoti, Kashi Kunwari
	medium (15-25 cm)	10	Kashi Agahani, Pusa Deepali, , PSBK-25
	broad (>25 cm)	1	Pusa Shukti
Leaf: shape	narrow elliptic	1	Pusa Meghna
	elliptic	8	Pusa Paushja, Pusa Sharad, PSB-1, Pusa Himjyoti
	broad elliptic	6	Pusa Snow Ball-1, Pusa Shukti
Leaf: profile of upper side of blade	concave	4	Pusa Meghna, PSB-16
	flat	5	Pusa Shukti, Kashi Kunwari, Pusa Deepali
	convex	6	Pusa Paushja, Pusa Sharad, Pusa Himjyoti
Leaf: puckering	absent	1	PSB-16
	weak	4	Kashi Kunwari, Pusa Meghna, Pusa Himjyoti
Leaf: crimping near main vein	medium	7	Kashi Agahani Pusa Paushja, Pusa Sharad,
	strong	3	Pusa Deepali, Pusa Shukti
	absent	0	Nil
	weak	7	Kashi Kunwari, Pusa Meghna
Curd initiation (days to 50% of the plants with curd initiation from sowing of seed)	medium	5	Pusa Paushja, Pusa Sharad, Pusa Deepali
	strong	3	Pusa Shukti, PSBK-25, PSBK-1
	early (<75 days)	2	Pusa Meghna, Pusa Deepali
	medium (75-100)	9	Kashi Kunwari, , Pusa Himjyoti, Kashi Agahani Pusa Paushja, Pusa Sharad, Pusa Shukti
	late (>100)	4	Pusa Snowball -1, PSBK-1, PSB-16, PSBK-25
Curd: covering by inner	not covered	4	Kashi Kunwari, Pusa Himjyoti, Pusa

Plant descriptors	Range in expression	No. of varieties	Example varieties
leaves	partly covered	7	Deepali, Pusa Meghna Kashi Agahani Pusa Paushja, Pusa Sharad, Pusa Shukti
	covered	4	PSBK-1, PSB-16, PSBK-25, Pusa Snow Ball-1
Curd: polar diameter	small (<15 cm)	4	Pusa Himjyoti, Pusa Deepali, Pusa Meghna
	medium (15-20 cm)	9	Kashi Agahani Pusa Paushja, Pusa Sharad
	large (>20cm)	2	Pusa Shukti, PSBK-1
Curd: equatorial diameter	small (<15 cm)	4	Pusa Himjyoti, Pusa Deepali, Pusa Meghna
	medium (15-20 cm)	9	Kashi Agahani Pusa Paushja, Pusa Sharad
	large (>20cm)	2	Pusa Shukti, PSBK-1
Curd: shape in longitudinal section	circular	1	Pusa Himjyoti
	broad elliptic	11	Kashi Kunwari, Kashi Agahani Pusa Paushja, Pusa Sharad, PSBK-25
	narrow elliptic	3	Pusa Deepali, Pusa Meghna PSB-1
Curd: doming	weak	1	Pusa Meghna
	medium	13	Kashi Kunwari, Kashi Agahani, PSBK-25, Pusa Sharad, Pusa Himjyoti
	strong	1	Pusa Paushja
Curd: compactness	loose	0	Nil
	medium	7	Pusa Himjyoti, Pusa Deepali, Pusa Meghna,
	compact	8	PSBK-25, Pusa Sharad, Pusa Paushja, Pusa Shukti
Curd: maturity group	early	1	Pusa Deepali
	mid-early	2	Kashi Kunwari, Pusa Meghna
	mid-late	9	Pusa Paushja, Pusa Shukti ,Pusa Sharad, Kashi Agahani
	late	3	PSBK-25, PSB-1, Pusa Snowball -1
Flower: colour	white	0	Nil
	creamy white	3	Pusa Himjyoti, Pusa Deepali, Pusa Meghna
	yellow	8	Pusa Sharad, Kashi Agahani, Pusa Himjyoti, Kashi Kunwari