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Short communication

Evaluation of cauliflower (*Brassica oleracea* var. *botrytis*) CMS (*Ogura*) lines for agronomic and floral traits

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ABSTRACT

In this study 7 *Ogura* based CMS lines were evaluated for important agronomic, flower and sex related traits. There was no significant difference among A and B lines for most of the vegetative traits. However, within the CMS lines significant differences were recorded for curd maturity, leaf number, leaf size and plant height. For most of the commercial traits like, curd weight, curd length, curd width, curd depth, total yield and harvest index no significant difference was found among male sterile A and fertile B maintainer lines except few genotypes. Normal ovary and functional nectaries in all the CMS lines indicated the potentiality of these lines for high seed set. These CMS lines with good agronomic and floral traits would be instrumental in developing indigenous F_1 hybrids in cauliflower after testing their combining ability.

Key words: Agronomic and floral traits, cauliflower, cytoplasmic male sterility, F_1 hybrids, *Ogura*.

Snowball or European summer cauliflower (Erfurt) is the main vegetable crop cultivated in Indian sub-continent during *rabi* season. In cauliflower, F_1 hybrids proved advantageous especially for uniform maturity, high early and total yield, better curd quality with respect to compactness and colour, resistance to insect-pests, diseases and unfavourable weather conditions (Kucera *et al*., 6). Two pollination control mechanisms, *viz*., self-incompatibility (SI) and cytoplasmic male sterility (CMS) are used for commercial hybrid seed production of cauliflower. So far, majority of cruciferous hybrids have been developed by means of SI (Watanabe and Hinata, 10). In snowball cauliflower, CMS system offers a viable alternative for F_1 hybrid seed production as SI system has several disadvantages and very week 'S' allele in this group. Transfer of alien sterile cytoplasm in the background of cauliflower alters agronomic, floral and seed set related traits. From the earlier preliminary studies, it was known that introgression of *Ogura* cytoplasm associated with several undesirable effects like, petaloid stamen, pinnate, silk-like and carpellate anther, splitted anther, dysfunction of pistil, closed flower, flower bud falling and no nectary development in cauliflower (He *et al*., 4; Sharma and Vinod, 9). Usefulness of CMS (~defective *Ogura* cytoplasm) based F_1 hybrids to harness heterosis for various commercial traits have been demonstrated by Hoser-Krause (5) in cauliflower, Chander Prakash and Verma (8) and Melo and Giordano (7) in cabbage. In this study, systematic efforts have been made to develop and evaluate superior CMS lines with good agronomic and floral traits so that they can be used successfully in development of indigenous F_1 hybrids in cauliflower.

In the past, we have successfully transferred sterile *Ogura* cytoplasm into the background of snowball cauliflower (var. Snowball-1 and Snowball-16) through protoplast fusion. However, these CMS lines were not suitable for commercial utilization because of associated undesirable traits, low female fertility and very poor seed set. Fifteen elite recurrent parental lines of snowball cauliflower were crossed with previously developed CMS lines and since 1998, F_1s were successively back crossed with all the recurrent parents in order to transfer sterile cytoplasm. Very high selection pressure was practiced to recover plants free from floral deformities and with high seed set. In each backcross generation 10 plants with desirable traits were selected from a population of 250 plants. In 2008, after seven generations of backcrossing (BC_7) few alloplasmic lines of recurrent parents with good agronomic and floral traits were selected. Seven CMS lines along with their maintainers were evaluated in RBD for various agronomic and floral traits during *rabi* season, 2010. Fourteen agronomic traits, *viz*. (i) days to 50% curd, (ii) days to 50% curd maturity, (iii) plant height (cm), (iv) number of leaves, (v) leaf length (cm), (vi) leaf width (cm), (vii) gross plant weight (kg), (viii) marketable curd weight (kg), (ix) net curd weight (kg), (x) curd length (cm), (xi) curd width (cm), (xii) Curd depth (cm), (xiii) net curd yield (t/ha) and (xiv) harvest index (%) were taken for the present study. Marketable curd weight was measured by taking weight of the curd

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along with other vegetative parts sold in market and is most important trait in determining productivity. Total yield was calculated by multiplying the marketable curd weight with plant population (44,000 plants/ ha). Five floral traits, *viz*. (i) petal colour, (ii) shape of style, (iii) type of ovary, (iv) presence of functional nectarines, and (v) presence of viable pollen grains were also recorded for the study. Pollen viability was estimated on the basis of staining pollen with 2% acetocarmine and viewing under light microscope at 10 × and 40 × magnifications. Data were recorded from five randomly selected plants from each replication (12 plants/ replication). In this way data were recorded from 3 replications in RBD design using COSTAT software. The CMS lines and their maintainers were compared with each other using Duncan's multiple test range based on their mean values.

In developing CMS lines it is important that the developed lines possessed good agronomic traits and are similar to their respective fertile maintainer lines for their use in hybrids breeding programme. Under this study, 7 CMS lines along with their maintainers were compared for 7 vegetative traits and presented in Table 1. For days to 50% curd initiation it was found that majority of the CMS (A) lines (5) were similar to their respective maintainer (B) lines. However, the lines Ogu14A and Ogu33A had significant difference with their maintainer lines 14B and 33B, respectively. Similarly, 6 among 7 CMS lines had no difference for curd maturity and only 1 CMS line (Ogu16A) differ significantly for this trait when compared with their maintainer lines. Thus, it appeared that in majority of the cases there was no difference in maturity traits among male sterile CMS and male fertile maintainer lines. Dey *et al*. (2) also reported that backcrossing is effective in developing superior CMS lines in cauliflower. For plant height none of the 7 CMS lines differ from their fertile maintainer lines. Only one CMS line, Ogu17A had significantly lower (18.7) number of leaves per plant as compared to its maintainer line 17B (21.4). Two CMS lines, Ogu14A and Ogu33A had significantly larger leaves (both leaf length and leaf width) as compared to their respective maintainers. Rest 5 CMS lines and their respective maintainers possessed similar leaf size. Dey *et al*. (3) also reported similar result for these vegetative traits in cauliflower. The traits associated with curd yield and yield related components are determining factor in developing CMS lines for their use in development of F_1 hybrids. There was significant difference between most of the CMS lines for curd maturity, plant height, leaf number and leaf size indicating high genetic diversity for these traits among the CMS lines. Thus, these CMS lines had significantly divergent genetic base for these traits and can be used for development of highly heterotic F_1 hybrids although genetic diversity in snowball cauliflower is very low (Astarini *et al*., 1).

Table 1. Comparison of CMS (A) and maintainer (B) lines and among 7 CMS lines for various vegetative traits.

Line	Days to 50% curd initiation	Days to 50% curd maturity	Plant height (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)	Gross plant wt. (kg)
Ogu12A	115.2 cd	127.7 cd	38.2 cde	15.9 de	37.4 cd	17.4 ef	1.2 ef
12B	111.4 de	123.1 d	33.5ef	15.5 def	38.2 cd	18.7 de	1.4 de
Ogu13A	107.3 e	121.2 d	49.7 a	20.4 ab	49.3 ab	25.2 a	2.1 a
13B	110.2 de	123.8 d	50.3 a	19.9 ab	50.6 a	22.5 abc	2.0 a
Ogu14A	124.7 ab	136.3 ab	32.8 f	15.6 ef	36.1 d	17.8 def	1.2 ef
14B	118.2 c	131.3 bc	36.1 def	14.2 ef	29.4 e	13.7 g	1.1 f
Ogu15A	95.3 f	107.7 e	25.6 g	13.3 f	29.3 e	14.3 g	1.0 f
15B	93.6 fg	107.3 e	25.3 g	15.0 ef	31.3 e	15.3 fg	1.0 f
Ogu16A	118.3 bc	132.3 bc	40.7 bcd	19.3 abc	38.4 cd	20.6 bcd	1.1 f
16B	126.3 bc	139.6 a	36.6 cdef	17.3 cd	35.4 d	18.3 def	1.2 f
Ogu17A	89.6 fg	103 e	35.3 ef	18.7 bc	36.3 cd	17.6 def	1.7 bc
17B	92.1 fg	104.6 e	37.3 cdef	21.4 a	37.1 cd	18.6 de	1.9 ab
Ogu33A	88.4 g	100.8 ef	43.7 b	19.2 bc	46.7 b	23.3 ab	1.6 cd
33B	82.3 h	94.7 f	41.2 bc	19.9 ab	39.9 c	19.6 cde	1.6 cd
CD at 5%	5.71	6.46	4.35	2.01	3.27	2.72	0.2

*Same letters in the column mean non significant difference at $p<0.05$, according to Duncan's multiple range test

Gross plant weight has very high positive correlation with total economic yield in cauliflower. Hence, there was no difference in any of the CMS lines with their respective CMS lines however, most of the CMS lines differ from each other (Table 2). Except 2 CMS line (Ogu17A and Ogu33A), all the lines had similar marketable curd weight when compared with their maintainers (B lines). Net curd weight was similar in all CMS lines as compared to their respective maintainer. Curd shape is important in determining yield and compactness of the curd. For curd length only one CMS line, Ogu13A differed significantly from its maintainer line. In case of curd width, all the CMS lines were similar to their maintainer line. Again, only one CMS line, Ogu14A differed significantly from its maintainer for curd depth. Likewise, total yield was similar in 5 CMS lines as compared to their respective fertile maintainers and only 2 CMS lines (Ogu17A and Ogu33A) differed significantly for curd yield with respect to their maintainers. Considerable variation was observed among CMS lines for yield and yield related components. Dey *et al*. (2) had also reported that proper selection in successive backcrossing was effective in developing CMS lines with commercial traits similar to respective recurrent parent.

It is important to develop CMS lines with functional nectaries, normal ovaries and straight style for good seed setting capacity and their use in hybrid seed production. Petal colour was yellow in 6 CMS lines and it was white in the line Ogu33A (Table 3). Similar petal colour in A and B lines indicated high responsiveness of this trait to selection. Similar to their respective maintainer lines, style was straight in Ogu14A, Ogu15A and Ogu33A. In line Ogu13A, the style was straight to slightly curved although its maintainer, 13B had straight style indicating effect of Ogura cytoplasm in this genotype. In the rest 3 CMS lines and their respective maintainers the style was straight to slightly curved. The ovary was normal in all the CMS lines and there was good development of functional nectarines indicating potentiality of these lines for development of hybrid seeds. Ogura cytoplasm confers complete male sterility in all the CMS lines which was evident by absence of viable pollen grains. Similar style shape, ovary and nectary development in A and B lines indicates high responsiveness of these lines to selection. In our earlier study we also observed similar result (Dey *et al*., 3). These CMS lines with complete sterility and good vegetative, commercial and floral traits would be highly useful in developing indigenous F_1 hybrids in cauliflower as they have enough variability among themselves and good floral traits.

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Table 2. Comparison of CMS (A) and maintainer (B) lines and among 7 CMS lines for various commercial traits.

Line	Marketable curd wt. (kg)	Net curd wt. (kg)	Curd length (cm)	Curd width (cm)	Curd depth (cm)	Total yield (t/ha)	Harvest index (%)
Ogu12A	0.73 cd	0.45 de	9.8 def	11.4 c	7.1 bcde	32.1 cd	59.8 ab
12B	0.71 cde	0.48 d	10.1 def	11.8 c	7.3 bcde	31.4 cde	50.7 ab
Ogu13A	1.28 a	0.79 ab	10.9 bcd	13.7 a	7.6 abc	56.5 a	60.4 ab
13B	1.24 a	0.89 ab	12.2 a	13.9 a	7.9 ab	54.7 a	63.3 ab
Ogu14A	0.72 cd	0.55 cd	11.6 ab	13.7 a	5.9 f	31.8 cd	58.8 ab
14B	0.60 def	0.52 cd	10.7 bcde	12.8 abc	4.9 g	26.5 def	52.3 ab
Ogu15A	0.51 f	0.34 f	9.3 ef	11.9 bc	6.6 def	22.3 f	50.4 ab
15B	0.54 f	0.37 ef	10.2 def	12.1 abc	6.5 ef	23.9 f	54.1 ab
Ogu16A	0.65 def	0.36 ef	9.6 ef	12.1 abc	7.3 bcde	28.4 def	56.4 ab
16B	0.56 ef	0.34 f	9.2 f	11.3 c	6.8 cdef	24.6 ef	47.8 b
Ogu17A	1.00 b	0.75 b	10.9 bcde	12.9 abc	7.9 ab	44.1 b	57.9 ab
17B	1.27 a	0.85 ab	11.8 abc	13.6 ab	8.4 a	55.9 a	65.8 a
Ogu33A	1.03 b	0.63 c	10.2 cdef	13.7 a	7.5 abcd	45.2 b	62.2 ab
33B	0.82 c	0.53 cd	9.6 def	12.2 abc	6.9 cde	36.1 c	50.7 ab
CD (5%)	0.14	0.10	1.2	1.5	0.9	6.3	13.9

*Same letter in the columns mean no significant difference at $p<0.05$, according to Duncan's multiple range test

Table 3. Floral characteristics of the 7 CMS lines (A) and their respective maintainers (B) lines.

Line	Petal colour	Shape of style	Type of ovary	Presence of functional nectarines	Presence of viable pollen grains
Ogu12A	Yellow	Straight to slightly curved	Normal	Present	Absent
12B	Yellow	Straight to slightly curved	Normal	Present	Present
Ogu13A	Light yellow	Straight to slightly curved	Normal	Present	Absent
13B	Light yellow	straight	Normal	Present	Present
Ogu14A	Dark yellow	Straight	Normal	Present	Absent
14B	Dark yellow	Straight	Normal	Present	Present
Ogu15A	Yellow	Straight	Normal	Present	Absent
15B	Yellow	Straight	Normal	Present	Present
Ogu16A	Yellow	Straight to slightly curved	Normal	Present	Absent
16B	Yellow	Straight to slightly curved	Normal	Present	Present
Ogu17A	Light yellow	Straight to slightly curved	Normal	Present	Absent
17B	Light yellow	Straight to slightly curved	Normal	Present	Present
Ogu33A	white	Straight	Normal	Present	Absent
33B	white	Straight	Normal	Present	Present

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