An assay of CMS lines of Indian mustard [*Brassica juncea* (L.) Czern. & Coss.] for flowering and seed yield characters

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Abstract

The production of rapeseed mustard has undergone phenomenal change since last two decades. The requirement for oils and fats will be much higher in view of ever increasing population in future. The only practical option left is the vertical increase of yields. Hybrid technology has shown a promise in this regard. A number of diverse CMS systems were developed. Evaluation of available CMS sources for flowering and seed yield characters for development of seed production technology of the hybrids and for the breeders to exploit the heterosis would be essential. An experiment was conducted to evaluate the seven cytoplasmic male sterile (CMS) lines of *Brassica juncea* in Pusa Bold background along with the variety Pusa Bold for flowering and seed yield characters. The results revealed that that variety Pusa Bold was the earliest in flowering. Hence, problem of non-synchrony in flowering of CMS lines and Pusa Bold was not observed. Amongst the CMS lines *Erucoides* was the earliest in bud initiation and first flowering while *Moricandia* (chlorotic) was the last. This may be due to the differential interaction of the nuclear cytoplasm of these two lines in common nuclear background of Pusa Bold. The CMS lines and Pusa Bold were at par in flowering duration except *Moricandia* (chlorotic). No significant difference in termination of flowering was observed among all the CMS lines except *Moricandia* (chlorotic). The similar was true for flowering duration. The results also indicated that secondary branches had higher pod length, beak length and number of seeds per pod as compared to those in primary and tertiary branches. Among the CMS lines while *Ogura* had the longest pods, *Tournefortii* had the shortest. There was significant difference in number of branches among the CMS lines evaluated. Except *Oxyrrhina* all the lines had more number of branches than that of Pusa Bold. The seed yield per plant was the highest in *Moricandia* (green) followed by *Ogura*. It is thus suggested that the mustard hybrid based on *Moricandia* (green) and *Ogura* CMS backgrounds could be a productive proposition.

Key words: *Brassica juncea,* CMS lines, flowering, seed yield

Introduction

Rapeseed mustard is the second most important source of edible oil in India. The production of rapeseed mustard in India has undergone phenomenal change since last two decades. It has increased from 0.76 million tonnes in 1949-50 to 7.59 million tonnes in 2004-05 (Anonymous, 2005). This jump is mainly attributed to wide spread adoption of improved technologies as a result of Technology Mission on Oilseeds project. But the gap still stands at 1.5 million tonnes/annum in edible oils. The requirement for oils and fats will be much higher in view of ever increasing population in future. In next 20 years, an additional 17 million tonnes of rapeseed-mustard seed need to be produced. To produce this quantity, there is little scope of horizontal expansion. The only practical option left is the vertical increase of yields. Because the present day cultivars have reached a plateau in their production, so focus has now been shifted to F_1 hybrids of *Brassica* species. Singh and Mehta (1954) were the first to report heterosis in brown sarson. Subsequently many studies have estimated the 13 to 91% of heterosis in *B. juncea* for seed yield (Banga and Labana, 1984; Kumar *et a*l., 1990; Rai, 1995; Thakur and Bhateria, 1993; Baishakh *et a*l., 1994; Verma *et a*l., 1998). A number of cytoplasmic sources have been introgressed to *Brassica* species in order to develop stable male sterility systems with high female fertility (Parkash *et al*., 1997). Using these cytoplasmic male sterility (CMS) systems, F_1 hybrids have been developed but no hybrid cultivars have been widely commercialized so far in want of suitable fertility restoration (Singh *et.a*l., 2003). The basic requirement for developing commercial hybrids in crops like *Brassica* is the availability of promising hybrids (preferably with more than 20% standard heterosis), stable performing male sterile (A), maintainer (B), and fertility restoring (R) lines, good synchrony of flowering in seed and pollen parents and adequate seed setting on male sterile seed parents through natural cross pollination. Thus, evaluation of available CMS sources for flowering and seed yield characters for development of seed production technology of the hybrids becomes essential. Hence in the present study an attempt has been made to identify the best CMS line of *Brassica juncea* for flowering and seed yield attributes.

Materials and Methods

Materials and Method Seven cytoplasmic male sterile (CMS) lines viz.; *Moricandia* (chlorotic), *Moricandia* (green), *Tournefortii*, *Erucoides*, *Ogura*, *Siifolia* and *Oxyrrhina* of *B. juncea* in Pusa Bold background and a maintainer variety, Pusa Bold were collected from the Division of Genetics and National Research Center on Plant Biotechnology (NRCPB), Indian Agricultural Research Institute (IARI), New Delhi for their evaluation. Studies were undertaken at the field and laboratories of Division of Seed Science and Technology of IARI, New Delhi during winter seasons of the year 2000-01 and 2001-02. The

seven CMS lines were sown with Pusa Bold as the pollen parent during 2000-01 in two dates of sowings i.e. 24 October and 18 November. Based upon the observations during the year 2000-01 the sowing was done on 25 October only in the year 2001-02. The field experiments were laid out with three replications in a randomized block design for both the years and sowing dates. The planting ratio of 4:2 (A:B) was kept in each plot with row-to-row and plant-to-plant spacing of 45 cm and 15 cm, respectively in the year 2000-01 and in the year 2001-02 the planting ratio of 4:2 (A:B) was kept in each plot with row-to-row and plant-to-plant spacing of 75 cm and 15 cm, respectively. The crop was grown under conditions ensuring normal growth of plants. Days to bud initiation, first flowering, termination of flowering and flowering duration (days) were recorded on plot basis and for yield attributing characters namely; number of branches per plant, number of seeds per pod in primary, secondary and tertiary branches, pod length, beak length, 1000- seed weight were recorded on 5 random plants of each genotype. The actual seed yield (g)/plant and per plot were recorded in each replication for each genotype while seed yield per hectare was estimated for each genotype. The data for both the years were analysed following usual statistical procedure.

Results

Flowering time and duration

The data on days to bud initiation, first flowering, termination of flowering and flowering duration is presented in Table 1. The results showed that Pusa Bold was the earliest in flowering. Among the CMS lines *Erucoides* was the earliest in bud initiation and first flowering while *Moricandia* (chlorotic) was the latest. The CMS lines and Pusa Bold were at par in flowering except *Moricandia* (chlorotic). No significant difference in termination of flowering was noticed in the CMS lines except *Moricandia* (chlorotic) and the similar was true for flowering duration. Since all the CMS lines were in a common background, so their flowering behavior was similar. Pant and Singh (2001) reported no significant differences for days to flowering among the 25 genotypes of Indian mustard. Introgression of diverse CMS systems into a similar nuclear background did not change the flowering behaviour. In other words the CMS gene does not determine the flowering characters. It was also observed that the duration of flowering decreased about 10 days in the late sowing (18th November) in the first year of planting across the genotypes.

Table 1. Flowering characteristics in Pusa Bold and CMS lines of *Brassica juncea*.

Line	Days to bud initiation			Days to first flowering			Days to termination of flowering			Flowering duration		
	Y1D1	Y1D2	Y2D1	Y1D1	Y1D2	Y2D1	Y1D1	Y1D2	Y2D1	Y1D1	Y1D2	Y2D1
Pusa Bold	51.0	51.5	41.0	62.7	63.2	47.0	108.0	97.0	85.0	45.3	33.8	38.0
Oxyrrhina	52.8	53.6	45.0	64.3	68.5	55.0	107.0	98.7	96.0	42.7	30.2	41.0
Siifolia	51.8	52.5	46.0	63.3	68.9	60.0	106.7	99.2	95.0	43.4	30.3	35.0
Erucoides	51.1	51.6	44.0	63.1	65.4	54.0	107.1	97.5	99.0	44.0	32.1	45.0
Ogura	52.2	52.4	47.0	63.2	67.1	55.0	108.1	97.9	99.0	44.9	30.8	44.0
Tournefortii	53.2	52.7	48.0	65.5	65.0	66.1	110.8	93.8	99.1	45.3	28.8	33.0
Moricandia (Chlorotic)	64.9	66.8	55.0	83.5	71.0	76.3	116.7	112.2	113.0	33.2	41.2	36.7
Moricandia (Green)	53.8	56.2	45.0	64.0	68.0	54.0	108.5	101.5	101.0	44.5	33.5	47.0
Mean	53.9	54.7	46.4	66.2	67.1	58.4	109.1	99.7	97.4	42.9	32.6	40.0
C.D. (P=0.05)	4.5	2.3	1	6.1	3.6	5	NS	5.9	5	8.6	5.2	7

Y1D1: Year 1 (2000-01) Sowing 1 (October 24, 2000) Y1D2: Year 1 (2000-01) Sowing 2 (November 18, 2000)
Y2D1: Year 2 (2001-02) Sowing 1 (October 25, 2001)

Seed yield and yield component characteristics

The results obtained on siliquae characters viz.; pod length, beak length and number of seeds per pod (Table 2) indicated that secondary branches had higher pod length (46.54 mm), beak length (7.59 mm) and number of seeds per pod (14.49) as compared to those in primary (44.71,7.04,13.29) and tertiary branches (45.96,7.17, 13.75) respectively. Among the CMS lines *Ogura* had the longest pods (51.56) while *Tournefortii* had the shortest (39.67). Beak length was the longest (8.67) in Pusa Bold and shortest (6.67) in *Tournefortii* and *Moricandia* (chlorotic). Maximum seeds per pod (15.33) were recorded *Ogura* and *Moricandia* (green) as compared to that in Pusa Bold (11.89). This could be a reason for higher seed yield in these two CMS lines.

The CMS lines differed significantly for the yield character (Table 3) viz. number of branches per plant, 1000-seed weight, seed yield per plant, seed yield per plot and thus the seed yield per hectare. There was significant difference in the number of branches among the lines evaluated. Except the CMS line, *Oxyrrhina* all the lines had more number of branches than that of Pusa Bold in both the years. The average test weight was highest (7.7 g) in case of *Moricandia* (green) while it was lowest (5.0 g) in *Tournefortii*. The seed yield per plant and per plot were highest in *Moricandia* (green) followed by *Ogura;* however, per hectare yield was highest in Pusa Bold. Similar results for the entire yield contributing characters were obtained in both the years for all genotypes. In second year the yield advantage over the first year in all the lines was observed.

Table 2. Evaluation of Pusa bold and CMS lines of *Brassica juncea* for Pod length, beak length and seeds per pod.

LINE/Branches	Pod length (mm)				Beak length (mm)				Number of seeds per pod			
	PRI.	SEC.	TER.	Mean	PRI.	SEC.	TER	Mean	PRI.	SEC.	TER.	Mean
Pusa bold	46.33	48.00	43.00	45.78	8.33	9.67	8.00	8.67	12.33	12.33	11.00	11.89
Oxyrrhina	38.33	44.67	42.33	41.78	7.00	7.00	5.67	6.56	13.33	14.00	13.67	13.67
Siifolia	49.67	49.67	49.00	49.44	7.33	8.00	8.00	7.78	11.67	13.33	13.67	12.89
Erucoides	48.00	45.67	49.33	47.67	7.00	8.00	9.00	8.00	13.33	14.00	13.67	13.67
Ogura	53.67	51.33	49.67	51.56	7.00	7.33	6.67	7.00	14.67	16.67	14.67	15.33
Tournifortii	34.00	43.00	42.00	39.67	6.33	7.00	6.67	6.67	13.00	15.00	12.67	13.56
Mori (Chl)	43.67	45.67	44.33	44.56	6.67	7.33	6.00	6.67	14.67	16.67	14.67	15.33
Mori (Gr)	44.00	44.33	48.00	45.44	6.67	6.33	7.33	6.78	13.33	16.33	16.00	15.22
Mean	44.71	46.54	45.96		7.04	7.59	7.17		13.29	14.79	13.75	
CD (P=0.05)		Line: 2.17 Branches: 1.19 Line×Branches: 3.75				Line: 0.85 Branches: 0.46 Line×Branches: 1.47				Line: 1.14 Branches: 0. 62 Line×Branches: 1.97		

Table 3. Evaluations of CMS lines of *Brassica juncea* yield characteristics (Normal Sowing time).

Var./ Line	No. of branches per plant		1000-Seed weight (g)		Seed yield per plant (g)		Seed yield per plot (g)		Seed yield per hectare (kg)	
YEAR	**2000-01**	**2001-02**	**2000-01**	**2001-02**	**2000-01**	**2001-02**	**2000-01**	**2001-02**	**2001-02**	**2000-01**
Pusa Bold	94.0	82.0	7.4	7.5	50.3	54.9	1279.0	2496.0	2842.2	3327.9
Oxyrrhina	91.0	58.0	7.4	7.4	33.3	72.2	1869.0	4208.0	2076.6	2805.1
Siifolia	125.0	94.0	7.4	7.5	51.3	79.1	1776.0	3472.0	1973.3	2314.4
Erucoides	95.0	98.0	6.3	6.5	38.7	48.6	1773.0	3713.0	1970.0	2475.1
Ogura	97.0	89.0	7.4	7.5	56.0	92.1	2658.0	4628.0	2953.3	3085.0
Tournefortii	109.0	128.0	5.0	5.0	35.0	48.3	1063.0	1846.0	1181.1	1230.5
***Moricandia* (Green)**	95.0	94.0	7.6	7.8	60.7	96.4	2884.0	4528.0	3204.4	3018.4
***Moricandia* (Chlorotic)**	112.0	93.0	5.7	5.9	51.7	54.5	1402.0	1558.0	1557.8	1038.6
Mean	102.6	92.0	6.8	6.9	47.1	68.3	1838.0	3306.1	2219.8	2411.9
C D (P=0.05)	2.4	3.4	0.2	0.2	1.8	3.4	112.3	193.2	112.3	193.2

Discussion

Higher mean temperature (> 17 °C) at vegetative stage (Fig.1) reduced the number of days to bud initiation and flowering drastically (46.4 days) as compared to lower temperatures (≤15 °C) before bud initiation and flowering (53.9 days). The decrease in duration of flowering by 10 days in the late sowing might due to high temperature. Siedenschnur (1973) also reported that under higher daily temperature conditions the flowering period becomes shorter in winter rape. Similar nature of flowering behaviour was expected since all the CMS lines were in a common varietal background, however, the differences in flower behaviour of *Moricandia* (chlorotic) might be attributed to chlorosis (light yellow color) of the young leaves resulting in delayed plant growth and consequently late flowering.

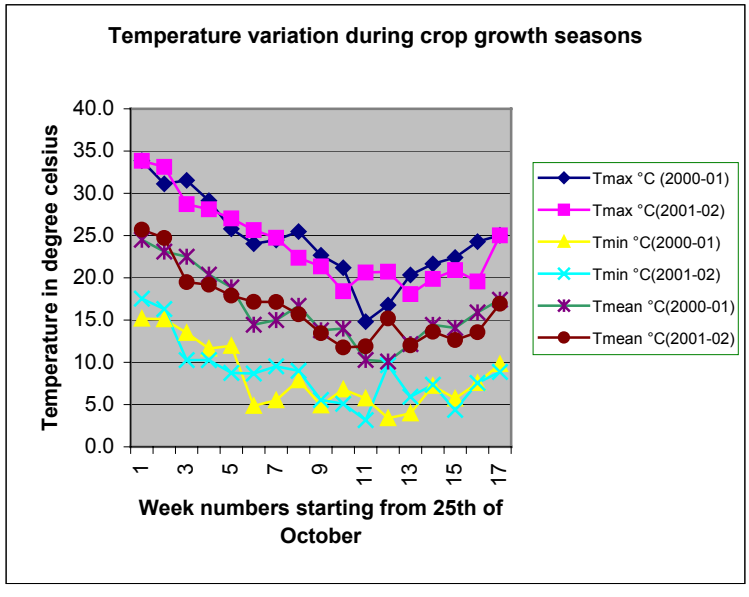

Figure 1. Temperature variation during crop growth seasons in 2000-01 and 2001-02.

Singh *et a*l. (2003) evaluated performance of different cytoplasmic male sterility (CMS) systems and observed that the plant height, seeds per siliquae, seed weight, oil and protein contents, days to flower, days to maturity, seed yield, biological yield and harvest index and found that all the CMS lines within the CMS systems were similar under similar type of growing conditions. Tyagi *et a*l. (1996) also observed that early sowing resulted in early flowering, a longer seed filling period, a longer reproductive phase and ultimately a higher seed yield per hectare. Days taken to maturity were reduced in delayed sowings. Hence, it is suggested that for taking up the hybrid seed production the CMS and restorer/maintainer lines should be timely sown.

There was a significant difference in the number of branches among the lines evaluated. Except *Oxyrrhina* all the lines had more number of branches than that of Pusa Bold. The yield advantages in second year over the first year among all the lines were mainly due to the wider spacing during the year. It is also evident that mid October sowing is suitable for seed production of the CMS lines as compared to the mid November sowing. Among the CMS lines *Ogura* had the longest pods, while *Tournefortii* had the smallest. Beak length was the longest in Pusa Bold and smallest in *Tournefortii* and *Moricandia* (chlorotic). Interestingly more seeds per pod were recorded *Ogura*, *Moricandia* (green) as compared to that in Pusa Bold. This could be a reason for higher seed yield in these two CMS lines. Chen *et al*. (1995) reported that the seed yield/single plant under natural pollination was 7.2 g, 16.6% higher than for normal plants. In economic traits, the CMS lines were almost equal to the maintainer lines and standard varieties. A hybrid of *B. napus* based on tour CMS (PGSH-51) has been released in India and has given 18% more yield than check variety (Downey and Chopra, 1996). Hybrids (Mankar, 2000) and line composites can be developed even without fertility restorer genotype (Singh *et a*l., 2003). Hence, it is recommended that the mustard hybrid and line composites based on *Moricandia* (green) and *Ogura* CMS backgrounds could be the promising options.

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