Standardization of planting ratio for hybrid seed production in Indian mustard [*Brassica juncea* (L.) Czern. & Coss.]

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Abstract

A number of cytoplasmic male sterility (CMS) systems are available in Indian mustard. These systems are expected to play important roles in hybrid development with/without appropriate restorer systems in revolutionizing the edible oil market in future. The production of hybrid seed is an important aspect in extension of hybrid seed technology. The planting ratio is very crucial for making hybrid seed available to the farmers on a very competitive rate by optimizing the seed yield in Indian mustard. The results of the present study showed significant differences in seed yield per plot in different row positions. The first two rows nearest to the pollen parent rows had the highest seed yield and the central rows had the lower seed yields. The declining trend in seed yield towards the central rows was not observed in case of *Ogura* and *Moricandia* (chlorotic). The maximum seed yield of *Moricandia* (green) and *Ogura* was obtained in 8:2 (15.75q/ha) and 16:2 (16.32q/ha) planting ratios respectively. It is thus suggested to follow a planting ratio of 8:2 in *Moricandia* (green) and 12:2 or 16:2 in *Ogura* based CMS hybrid seed production. The usefulness of undertaking seed production in different planting ratios for promising CMS lines is also advocated.

Key words: planting ratio, hybrid seed production, Indian mustard, CMS lines

Introduction

A number of cytoplasmic male sterility (CMS) systems are available in Indian mustard (*Brassica juncea*). However, no commercial hybrids are yet recommended for cultivation due to problems mainly associated with fertility restoration. These systems are expected to play important roles in hybrid development with/without appropriate restorer systems in future. The production of hybrid seed is an important aspect in extension of hybrid seed technology. Standardization of planting ratio is one aspect for an economic hybrid seed production and it is more valid for a species that is predominantly self- pollinated. A higher frequency of male rows in a planting ratio gave higher hybrid seed set in Indian mustard (Banga *et. al*., 1993). It was in the order of 2:4>1:2>1:3>1:4 (M: F). A significant reduction in hybrid seed set was recorded when the male: female ratio was changed from 1:3 to 1:4. This was associated with higher number of pods with few or no seeds in general. The seed yield reported by the workers was too low (maximum of 417kg/ha with 1:3 planting ratio) to draw any valid practical conclusion on planting ratio in economic hybrid seed production. Therefore, with availability of more number of stable CMS lines in a similar nuclear background studies were made (i) to assess and select the promising CMS systems for hybrid seed production and (ii) to evaluate the effect of differential planting ratios on hybrid seed production of few promising CMS systems.

Materials and Methods

Experiment I

Seven CMS systems viz., *Oxyrrhina*, *Siifolia*, *Tournefortii*, *Ogura*, *Moricandia* (green), *Moricandia* (chlorotic) and *Erucoides* in Pusa Bold background (used as a maintainer variety, also a popular variety) were used for this study. All these CMS lines were grown in the field of Indian Agricultural Research Institute, New Delhi in *Rabi*, 2002 following a uniform planting ratio of 10:2 (CMS: pollen parent i.e., Pusa Bold) in a randomized block design with 4 replications each. The row-to-row and plant-to-plant distances were 45 and 15cms respectively with a row length of 5m. The rows were oriented against the prevailing wind direction. All recommended agronomic practices were followed to grow a normal crop.

The male fertile plants in the CMS lines were rogued out at the time of flowering. Number of plants harvested in each row was recorded. The seeds were threshed and weighed separately row-wise. The seed yield of a row located in a similar position from the pollen parent row were pooled to obtain seed yield per plot i.e., row position (1^{st}, 2^{nd}, …5^{th}) from the pollen parent row. The 1^{st} row is the nearest while the 5^{th} is the farthest (central position) from the pollen parent row. The seed yield was also estimated per hectare considering the net area for calculation. Analysis was done following usual statistical procedures.

Experiment II

Based on results obtained in Experiment I two best performing CMS lines viz., *Ogura*, *Moricandia* (green) were selected for further study under different row ratios. These were grown in three planting ratios i.e., 8:2; 12:2 and 16:2 (CMS: pollen parent) taking Pusa Bold as pollen parents in the field of Indian Agricultural Research Institute, New Delhi in *Rabi*, 2003.The experiment was laid out with 3 replications in 5m rows with row-to-row and plant-to-plant spacing as 45 and 15 cms respectively. The experimental layout was such that different planting ratios are in a block covering the three replications.

The two CMS lines also were planted in separate blocks. It was done to restrict the honeybee movement to some extent within a planting ratio. The distance between two replications kept was 5 m to avoid pollen dispersal through winds to a greater extent.

CMS Lines	Replication I	Replication II	Replication III
	2:8	2:8	2:8
Moricandia	2:12	2:12	2:12
	2:16	2:16	2:16
	2:16	2:16	2:16
Ogura	2:12	2:12	2:12
	2:8	2:8	2:8

Data on seed yield were collected row-wise as in previous year (Experiment I) and analysed following standard statistical procedures.

Results

Experiment I

The mean number of plants per plot i.e., two rows of 5 m length in the different row positions over CMS lines had been similar. There was no significant difference in the plant stand among the CMS lines except in *Tournefortii*. *Moricandia* (green) (73.53) had the highest mean plant population per plot and *Tournefortii* had the lowest (55.15) (Table 1). The low plant stand in *Tournefortii* was because of low seedling emergence.

There was a significant difference in seed yield per plot in different row positions. The 1st two rows nearest to the pollen parent rows had the highest seed yield (609 gm) and the central rows located in 4th and 5th had the lower seed yield (i.e., 531 and 541 gm respectively) across the CMS lines (Table 2). The CMS lines also showed significant difference for seed yield per plot. *Ogura* and *Moricandia* (green) produced 883 and 852 g seeds respectively on the whole plot basis (Table 2).

The row wise seed yield data indicated that in general female rows just beside the male row had the highest seed yield and it reduced gradually towards the central row positions (4th and 5th row from the pollen parent row) (Table 2). However, the declining trend in seed yield towards the central rows was not observed in case of *Ogura* and *Moricandia* (chlorotic). This may be attributed to the attractiveness /preference of flowers of *Ogura* by honeybees. The similar seed yield among different row positions in case of *Moricandia* (chlorotic) could be due to its late flowering compared to that of other CMS lines for which honeybee population foraged on it was maximum. This indicated that there is a need of undertaking seed production in different planting ratios for CMS lines. *Ogura* and *Moricandia* (green) yielded to the extent of 1958 kg and 1893 kg/ha. *Tournefortii* was the lowest (376 kg/ha) yielder among the CMS lines (Table 3). This may be attributed to the floral and pod deformity in this CMS line.

Experiment II

Based on the results of the Experiment I, the two higher yielding CMS lines namely *Ogura* and *Moricandia* (green) were identified. These were grown in three planting ratios i.e., 8:2, 12:2 and 16:2 for standardization of hybrid seed production. The results indicated a non –significant difference in seed yield among different row ratios. However, maximum seed yield of *Moricandia* (green) and *Ogura* obtained was 15.75q/ha in 8:2 and 16.32q/ha in 16:2 planting ratios respectively. This validated our earlier observations of non-significant differences in seed yield among the row positions for *Ogura*.

Seed yield per row in two CMS lines planted in 3 planting ratios indicated that the seed parent rows of *Moricandia* farther from the pollen parent rows had a decline in seed yield as compared to that of rows nearer to the pollen parent (Fig. 1). However, in case of *Ogura*, there was an inconsistency in seed yield decline among the rows in relation to their position from the pollen parent in all the planting ratios. This indicated a possibility of undertaking seed production in a wider planting ratio in *Ogura* without considerable yield reduction in this CMS line.

Discussion

In *B. juncea* outcrossing ranging from 7.6 to 18.1 % has been demonstrated (Williams, 1978). Though *B. juncea* is a predominantly self- pollinated species in nature, role of winds and insects cannot be ignored. It was reported that air-borne pollen can move up to 35 m from the pollen source maximum being up to 5 m (Singhal *et. al*., 2005). This was reflected by the percent seed bearing pods, seeds per pod and seed yield. It was found that beyond 2nd row i.e., 1.35 m distance from the pollen source no pods set leading to no seed production. It is to be noted that distance between rows was 90cms between the pollen parent and seed parent rows and 45cms among the seed parent rows.

The experiment conducted with 5:1 (Female: Male) planting ratio showed a decline in percent seed set, seeds per siliquae and seed yield per row in the seed parent rows farther from the pollen parent rows both under wind pollination and open pollination (Singhal *et. a*l*.,* 2005). Therefore, our results validated that of their study.

Foraging by honeybees play the most crucial role in pollination. The differences in the bee activity between the parental lines is obvious because of the fact that the seed parent lines are devoid of pollens which is present in pollen parent. This possibly restricted their movement to the pollen parent rows and to the seed parent rows nearer to the pollen parent to a greater extent. The differential movement of honeybees from pollen parent row to the different seed parent rows was also observed in sunflower by the author (unpublished data). Singh *et. al.* (2002) reported higher population of honeybees upto 4th and 5th seed parent rows from the male rows in 8:1 planting ratio indicating role of distances from the male row in honeybees foraging activity. Similar results were reported in sunflower (Drane *et.a*l*.,* Satyanarayana and Seetharam, 1982; DeGrandi-Hoffman and

Martin, 1993) and in cotton (DeGrandi-Hoffman and Morales, 1989). However, Skinner (1987) did not observe differences in honeybees number as a function of distance from pollen parent.

A higher female: male planting ratio did not show any significant adverse effect on the average seed yield per row obtained in different planting ratio and in case of Ogura. In case of Moricandia (green) a narrow planting ratio i.e., 8:2 gave higher seed yield as compared to that in other two planting ratios i.e., 12:2 and 16:2 although higher number of seed parent plants are available in the later planting ratios. Therefore, it can be concluded that planting ratio must be standardized for different CMS lines for seed production.

A decision on the planting ratio to be followed depends also on the existing natural bee population available at a given location, the area under the crop including other competing crops. Supplementing with additional bees through keeping beehives, the planting ratios could be modified.

The limitation of conducting the experiment is lack of control on the pollinator as such. Their behaviour to forage on the desired attractive flowers with more nectar content could be possible factor to influence them. However, with the limitations in field it was indicated that the distance between the pollen parent and seed parent had a role to determine the planting ratios. The role of wind cannot be ignored at least up to the 3rd row i.e., 135 cms from the pollen parent row. It is thus suggested to follow a planting ratio of 8:2 in *Moricandia* (green) and 12:2 or 16:2 in *Ogura* based CMS hybrid seed production.

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Table 1. Number of plants / plot in CMS lines of mustard

CMS lines	Row positions					Mean
	1	2	3	4	5	
Oxyrrhina	69.75	66.25	68.25	66.00	66.00	67.25
Siifolia	73.75	70.25	68.75	62.75	70.50	69.20
Erucoides	73.25	72.60	67.00	67.75	68.75	69.75
Ogura	69.75	65.25	68.50	67.00	65.25	67.15
Tournefortii	53.00	53.50	52.50	60.75	56.00	55.15
Mori.Green	69.25	74.00	74.25	76.25	74.00	73.53
Mori.Chlo.	63.00	63.75	58.25	64.00	56.50	61.10
Mean	67.39	66.43	65.36	66.36	65.29	66.16

C.D.(P=0.05) : genotype = 6.47; row position =2.23 ; genotype×row position 14.76;
Plot size = 2 rows of 5m length

Table 2. Seed yield (gm/plot)* of CMS lines of mustard

CMS lines	Row positions					Mean
	1	2	3	4	5	
Oxyrrhina	691	558	561	556	556	585
Siifolia	590	528	573	453	484	525
Erucoides	705	666	610	586	605	635
Ogura	884	928	841	848	914	883
Tournefortii	214	193	179	139	120	169
Mori.Green	878	903	846	810	822	852
Mori.Chlo.	299	276	278	323	310	297
Mean	609	579	555	531	545	

CD (P=0.05) : genotype =39.07; row position=33.02; genotype×row position= 87.37;
Plot size: 4.5 sq m

Table 3. Seed yield (kg/ha) of CMS lines of mustard.

CMS lines	Row positions					Mean
	1	2	3	4	5	
Oxyrrhina	1536	1240	1247	1236	1236	1300
Siifolia	1311	1173	1273	1007	1076	1167
Erucoides	1567	1480	1356	1302	1344	1411
Ogura	1964	2062	1870	1884	2031	1958
Tournifortii	476	429	398	309	267	376
Mori.Green	1991	2007	1880	1800	1827	1893
Mori.Chlo.	664	613	618	718	689	660
Mean	1353	1287	1231	1180	1209	1253

C.D.(P=0.05): genotype = 87; row position = 73; genotype×row position = 193

Table 4. Seed yield of CMS lines in different planting ratios

Planting ratio	Seed yield			
	Ogura		*Moricandia* (green)	
	g/plot *	kg/ha	g/plot*	kg/ha
8:2	415	1475	429	1575
12:2	427	1628	389	1496
16:2	411	1632	371	1462
Mean	418	1578	396	1511
CD (0.05)		NS		

* Plot size-2.25 sq.m

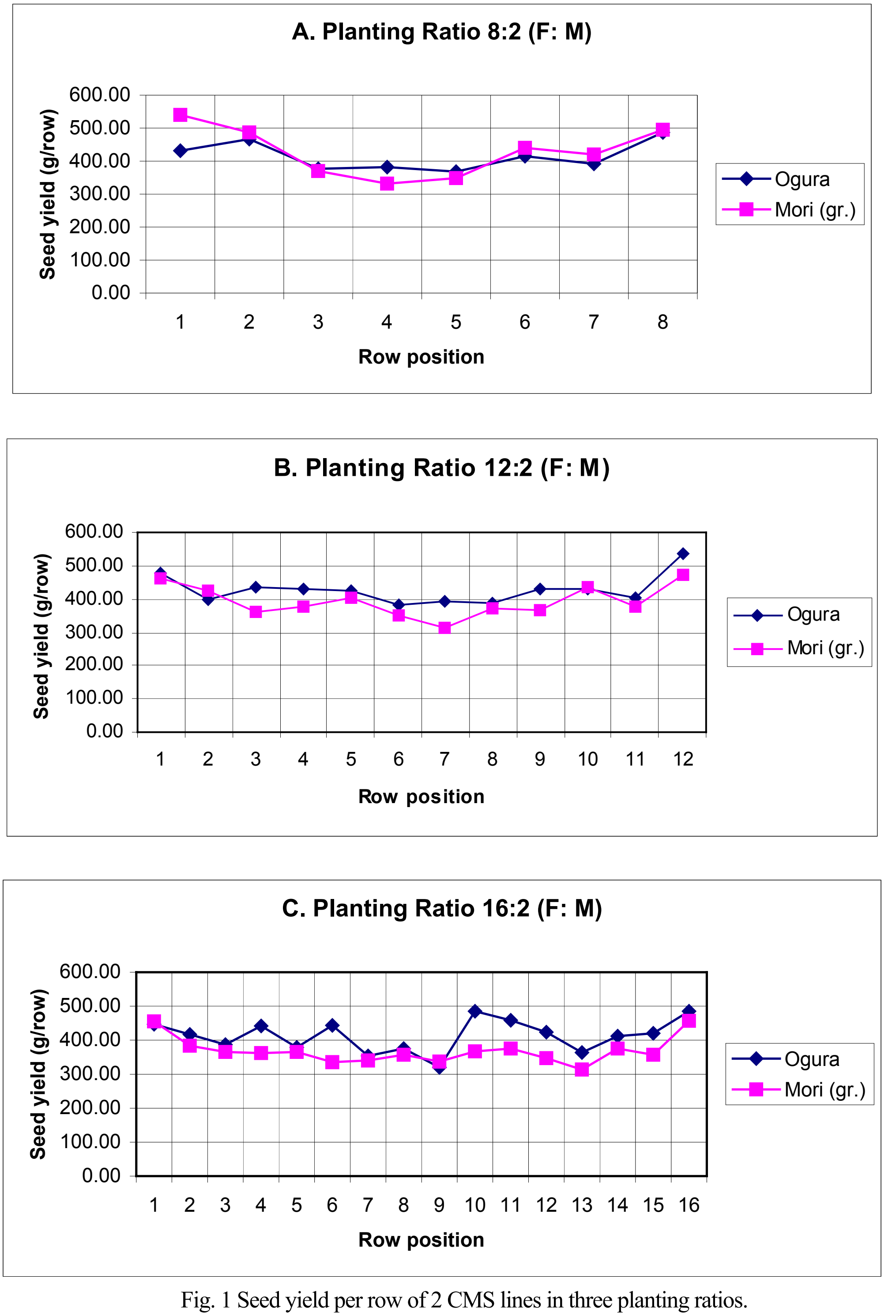

Fig. 1 Seed yield per row of 2 CMS lines in three planting ratios.