ENHANCING HYBRID SEED AND ITS QUALITY PARAMETERS INTEGRATING THROUGH PLANTING RATIO AND SOWING TIME IN INDIAN MUSTARD (*Brassica juncia* L.) UNDER SODIC SOIL CONDITION

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ABSTRACT

The experiment was conducted during *Rabi* 2018-19 at Research Farm of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (Uttar Pradesh). The experimental material consisted of the parental lines viz., CMS (MJA5) and Restorer (MJR1) of Indian mustard (*Brassica juncea* L.) hybrid NRCHB 506. The CMS line (female) and restorer line (male) were sown at spacing of 45 cm × 10 cm with four different dates *viz.*, 10th October, 25th October, 10th November and 25th November following the planting ratio of 2:6, 2:8, 2:10 and 2:12, (R:A) respectively. The experimental site was characterized by 0.31 % organic carbon, 180 kg available N/ha, 11.80 kg available P_2O_5/ha, 180 kg available K_2O/ha, 8.8 pH and 0.96 dS/m electrical conductivity. The findings revealed that early sowing (10th October) and delaying after 25th October significantly reduced the most of the characters whereas increasing the planting ratio from 2:6 to 2:12 increased invariably the characters under study. The parental lines (CMS-MJA 5 and Restorer- MJR1) of Indian mustard hybrid NRCHB 506 sown on around third week of October at planting ratio of 2:12 was found to be the optimum for producing maximum hybrid seed (12.25 g / plant) owing to the best expression of flowering and seed contributing traits as well as seed quality parameters under sodic soil condition which could be exploited for its hybrid seed production.

Keywords: *Brassica juncia*, hybrid seed, planting ratio, seed vigour, sowing time.

INTRODUCTION

The rapeseed-mustard {*Brassica juncea* (L.) Czern and Coss} is one of the most important and ancient groups of oilseed crop. It is being cultivated in around 36.59 million hectares with a total production of 72.37 million tonnes and 1980 kg / ha productivity globally (drmr.res.in). India account about 19.8% and 9.80% of the total acreage and production, respectively of the world. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes about 26.24% in the total oilseeds production and ranks third after soyabean and groundnut by sharing 38.46% and 25.41%, respectively in the Indian oilseed production. The mustard cultivated in India is known as Indian mustard or Rai (*Brassica juncea*). It alone occupies about 85% of the total area under these crops. The species and cultivars of a *Brassica* genus are also cultivated as forage and feed crops in many parts of the world. They are generally grown as alternative feed crops. Production of

Brassica crops for forage production can be done on any kind of the soil. *Brassica* is high in dry matter digestibility *i.e.*, 85-95% in contrasts with good alfa-alfa, at 70%. Its leaves contain 18-25% crude protein, while the root contain about 10% crude protein. Due to their rich nutritional contains, these leaves and root crops have been commonly grown as nutritional fodder crops for sheep and cattle.

Soil salinity is a major issue that the world faced in the past and also presently. As per recent estimates nearly 953 million hectare area is affected by salinity in the world. In India, about 6.73 million hectare area is affected by salinity and sodicity. Gujarat is the top in the list with 2.22 million hectare area under sodic soil followed by Uttar Pradesh that has an area of 1.37 million hectare [8].

Development of hybrid in field crops led to its higher production as well as productivity. Use of male sterility system is one of the means to develop hybrids. Heterosis in *Brassica spp. i*s a well- known phenomenon [3, 4, 11]. Identification of fertility restorer is another pre-requisite. However, use of CMS lines for hybrid seed production depends upon the production potential of CMS lines in a specific heterotic cross combination. There is a need to develop seed production technology in this hybrid. Seed yield of rapeseed-mustard is mainly affected by prevailing temperature especially at flowering and seed setting [6]. It is important to choose the right time for sowing. Late sown early varieties produce less number of siliqua and early sown late varieties give more leafy growth and produce siliqua very late. Optimum time of sowing for rapeseed mustard seed production varies according to cultivar and climatic conditions [7, 10]. Information suggested in the literature is not suitable for every situation. Therefore, it is necessary to evaluate the effect of different sowing times on the plant growth, seed yield and quality. Standardization of optimum planting ratio is also essential to facilitate pollination and to accommodate more female plants in the seed production plots to maximize hybrid seed [11]. A number of cytoplasmic male sterility (CMS) systems are available in Indian mustard (*Brassica juncea* L.). However, no commercial hybrid is developed due to problems primarily associated with non-availability of appropriate fertility restoration system [3, 4, 10]. After successful introduction of fertility restorer gene from *Moricandia arvensis* and other sources, it now has become possible to exploit the hybrid vigour in this crop. The first hybrid in Indian mustard NRCHB506 developed and released for commercial cultivation is based on *Moricandia* CMS system (drmr.res.in). Development of a successful hybrid seed production technology in a crop, which is essential for the acceleration of hybrid technology to farmers precisely, depends on the understanding of its pollination, seed setting under varied agro-climatic conditions. The present investigation was therefore undertaken to optimize the sowing time and planting ratio in order to maximize the production of hybrid seed of newly developed promising hybrid NRCHB 506 in Indian mustard under sodic stress condition.

MATERIALS AND METHODS

The seed materials of the parental lines of hybrid NRCHB 506 were obtained from the Division of Seed Science and Technology, Indian Agriculture Research Institute, New Delhi. The female and male parents were MJA5 (A) and MJR1 (R), respectively. The MJA5 is a cytoplasmic male sterile (CMS) and MJR1 is the restorer. The field experiment was conducted at the Research Farm of Genetics and Plant Breeding, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (Uttar Pradesh) during *Rabi* 2018-19. Geographically, the farm is located

between 24.47^0 and 26.56^0 N latitude, 82.12^0 and 83.98^0 E longitudes and at an altitude of 113m above from mean sea level in the gangetic plains of eastern Uttar Pradesh. This area falls in sub-tropical climate zone. The female (A) and male (R) seeds were sown in plots with sufficient soil moisture at four different dates *i e.* 1) 10th October, 2) 25th October and 3) 10th November and 4) 25th November following a planting ratio (R: A) of 2:6, 2:8, 2:10 and 2:12, respectively. The spacing between rows and plants were maintained as 45cm and 10cm, respectively. The experiment was laid out in Factorial Randomized Block Design with four replications. Fertilizers NPK @ 40:40:40 kg/ha and Sulfur @ 30 kg/ha were applied in field prior to seed sowing. Forty kg N was top dressed in two equal splits at vegetative and pre-flowering stages. Two irrigations were applied at vegetative and pre-flowering stages.

Fifteen plants were randomly selected from each replication for recording the plant height (cm), number of primary branches / plant, number of secondary branches / plant, number of total branches / plant, number of siliqua on main raceme, number of siliqua on primary branches, number of siliqua on secondary branches and number of total siliqua /plant. The days to 50 per cent flowering were recorded from the date of sowing to date on which 50 per cent of each plot flowered. Number of seeds / siliqua was counted from twenty five randomly selected siliquae in each of the fifteen tagged plants and thereafter average was taken. Length of siliqua (cm) was measured from twenty five randomly selected siliqua from each of main raceme, primary branches and secondary branches and averaged. Besides, twenty five random siliqua, treatment and replication wise were selected and counted the number of seed well developed in there. The percentage of seed set was calculated as total number of seed fully developed over the number of seeds to be developed / siliqua and expressed in percentage. Further, 1000 seed (moisture content, 8%) from the produce of each selected plant were randomly counted and weighed in gram with the help of electronic balance. Seed yield per plant was recorded in gram by weighing the total seed obtained after threshing of each plant separately**.**

One hundred random seed were kept thrice in two layers of moist blotter paper in Petri dish. The sample was kept in seed germinator maintained at 20 ± 1^0 C. The germination percentage was calculated as below:

$$\text{Germination}(\%) = \frac{\text{Number of seed germinated}}{\text{Total number of seed}} \text{x}100$$

Twenty seedlings were randomly taken from each replication on eighth day and root length was measured in centimetre and averaged. Similarly, **t**wenty random seedlings used for the measurement of root length, were also used for the measurement of their shoot length. The shoot length was measured from the tip of the primary leaf to the base of the hypocotyls and mean shoot length was expressed in centimetre (cm).The randomly selected twenty seedlings used to measure root length and shoot length earlier were used to measure seedling length in centimeter and finally averaged. Vigor index was calculated by the multiplication of germination percentage with that of seedling length on the day of final count as per the method prescribed by Abdul- Baki and Anderson [1]. The experimental data were subjected to statistical analysis by applying the technique of Analysis of Variance (ANOVA) prescribed for "Randomized Block Design (Factorial)" to test the significance of the overall differences among the treatments. By the 'F' value in the analysis of variance table was drawn at 5 per cent probability level. When 'F' value in the analysis of variance table was found to be significant, the critical difference (CD) was computed to test the significance of the difference between two treatments [5].

RESULTS AND DISCUSSION

The days to 50% flowering significantly decreased in female line at 25th November (49.38) of sowing in comparison to those of earlier sowing viz., 10th October, 25th October and 10th November (Table 1). In case of male parent, days to 50% flowering did not show any significant variation among the dates of sowing, though the highest value (51.50 days) was in second date of sowing (Table 1). In all the sowings, the male parent flowered 5–6 days earlier to the female parent indicating no limitation of non-synchrony of flowering of parental lines for hybrid seed production in this particular hybrid. In case of male parent, plant height differed among the four dates of sowing with the highest height (174.20 cm) at first date of sowing very closely followed by second date of sowing (173.24 cm) where as in case of female line, the highest plant height (155.64 cm) was recorded at second date of sowing (Table 1). Number of primary branches / plant, number of secondary branches / plant, number of total branches / plant of male line were exhibited as 6.25, 18.42 and 24.67, respectively at first date of sowing, 7.25, 20.47 and 27.21, respectively at second date of sowing) and 7.00, 14.13 and 21.09, respectively at third date of sowing, which showed significantly higher as compared to those with the fourth date of sowing. In case of female parent, the highest number of primary branches / plant (7.17), number of secondary branches / plant (16.56) and number of total branches / plant (25.10) were appeared at second date of sowing (Table 1). Number of siliqua on main raceme, number of siliqua on primary branches, number of siliqua on secondary branches, number of total siliqua /plant, length of siliqua (cm), number of seed / siliqua of male line were noted as 43.58, 157.67, 171.83, 411.08, 4.91 and 13.25, respectively at first date of sowing, 48.67, 165.87, 176.56, 392.17, 4.64 and 12.91, respectively at second date of sowing and 38.00, 135.20, 125.14, 292.17, 4.45 and 12.15, respectively at third date of sowing significantly higher as compared to those for at the fourth date of sowing, but no significant difference in these traits was seen between first and second dates of sowing. Whereas number of siliquae on main raceme, primary branches, secondary branches, and total number of branches / plant showed significant differences at all the four dates of sowing. Length of siliqua at first date of sowing (4.91cm) and second date of sowing (4.64cm) was higher as compared to third and fourth dates of sowing. In CMS line, the number of siliqua on main raceme, number of siliqua on primary branches, number of siliqua on secondary branches, number of total siliqua / plant, length of siliqua (cm), number of seed /siliqua at first date of sowing (42.25, 135.33, 157.25, 334.83, 4.93 and 7.74, respectively) and second date of sowing (39.68, 128.69, 125.54, 289.13, 4.64 and 7.17, respectively) showed significantly higher as compared to third and fourth date of sowing (Table 2). The seed set (%) of female and male line and seed yield / plant (g) of hybrid at first date of sowing (58.83, 95.08 and 9.37, respectively), second date of sowing (55.17, 97.17 and 9.41, respectively) and third date of sowing (50.29, 96.85 and 6.59, respectively) appeared significantly higher in comparison to those at the fourth date of sowing (Table 3). Seed yield / plant extremely reduced at the fourth date of sowing. Panda *et al*. [7] observed that delay in sowing beyond 16 October reduced 1000-seed weight. This may be due to other factors of hybrid seed production such as pollinator abundance scarcity which can lead to poor seed setting resulting in lower yield [2], but no effect on seed weight. Khushu and Singh [6] reported that seed yield decreased with delay in sowing after third week of October.

The germination (%), root length (cm), shoot length (cm), seedling length (cm) and vigour index of hybrid at first date of sowing (88.13, 8.19, 5.60, 13.96 and 1230.73, respectively), second date of sowing (94.94, 8.41, 5.68, 14.26 and 1353.94, respectively) and third date of sowing (89.75, 8.23, 5.60, 14.00 and 1257.14, respectively) showed significantly higher as compared to those with the fourth date of sowing. The highest 1000-seed weight of female (6.20 g) and male (5.82g) were obtained at second date of sowing. Further, there was significant difference in test weight of hybrid seed at dates of sowing was recorded (Tables 4 & 5). In present study, flowering was hampered with increase in temperature and decrease in RH during flowering period especially when the sowing is delayed beyond October. Seed yield contributing traits also followed the same pattern as the environmental conditions were altered for the entire crop growth period by changing the sowing date. Based on the findings from our study we can recommend third week of October is the optimum time for sowing of parental lines for higher hybrid seed yield of Indian mustard hybrid NRCHB 506. This phenomenon is strongly supported by a number of researchers but most of the studies were conducted on varieties [6, 7, 9].

Table 1. Effect of date of sowing and planting ratio on flowering and seed yield contributing traits in parental lines of Indian mustard hybrid NRCHB 506.

Parameter	Days to 50 % flowering		Plant height (cm)		Number of primary branch/plant		Number of secondary branch/ plant		Number of total branch/ plant	
	CMS	Restorer	CMS	Restorer	CMS	Restorer	CMS	Restorer	CMS	Restorer
Date of sowing										
10 October	57.63	51.00	152.93	174.20	6.75	6.25	16.08	18.42	22.75	24.67
25 October	60.81	51.50	155.64	173.24	7.17	7.25	16.56	20.47	25.10	27.21
10 November	51.13	47.06	144.61	163.52	6.46	7.00	13.75	14.13	20.53	21.09
25 November	49.38	43.38	144.13	160.66	6.37	6.56	13.37	14.79	20.30	19.89
Planting ratio										
2:6	54.13	48.06	146.77	164.38	5.83	6.15	14.00	15.08	19.96	20.75
2:8	54.75	48.25	149.70	168.91	6.61	6.44	15.31	16.74	21.90	22.99
2:10	54.50	4850	149.94	168.84	6.96	7.19	15.14	17.44	22.49	24.41
2:12	54.56	49.13	150.89	169.49	7.34	7.29	15.32	18.54	24.33	24.70
CD (5%)	1.98	1.29	1.39	1.24	0.57	0.70	0.97	1.14	1.39	1.33

Table 2. Effect of date of sowing and planting ratio on seed yield contributing traits in parental lines of Indian mustard hybrid NRCHB 506.

Parameter	No. of siliqua on main raceme		No. of siliqua on primary branch		No. of siliqua on secondary branch		No. of total siliqua / plant		No. of seed/ siliqua		Siliqua length (cm)	
	C MS	Restorer	CMS	Restorer	CMS	Restorer	CMS	Restorer	C MS	Restorer	C MS	Restorer
Date of sowing												

10 October	42.25	43.58	135.33	157.67	157.25	171.83	334.83	411.08	7.74	13.25	4.93	4.91
25 October	39.68	48.67	128.69	165.87	125.54	176.56	289.13	392.17	7.17	12.91	4.64	4.64
10 November	32.30	38.00	106.27	135.20	104.40	125.14	245.35	292.17	6.21	12.15	4.45	4.45
25 November	29.02	34.79	100.58	134.81	92.52	104.81	223.85	271.92	5.45	12.26	3.91	3.91
Planting ratio												
2:6	33.92	38.67	109.33	142.04	116.71	138.33	261.21	327.50	6.02	11.67	4.42	4.44
2:8	35.58	41.27	117.60	149.53	119.74	143.90	274.56	340.84	6.67	12.65	4.52	4.48
2:10	36.70	42.13	121.13	149.91	120.91	146.65	278.28	346.01	6.80	12.97	4.50	4.53
2:12	37.06	42.98	122.81	152.06	122.36	149.48	279.11	352.99	6.95	13.29	4.48	4.45
CD (5%)	**1.10**	**1.21**	**2.30**	**1.62**	**1.91**	**1.49**	**4.94**	**17.42**	**0.64**	**0.65**	**0.19**	**0.20**

Table 3. Effect of date of sowing and planting ratio on seed set and seed yield in parental lines of Indian mustard hybrid NRCHB 506.

Parameter	Seed set (%)		Seed yield / plant (g)
	CMS	Restorer	Hybrid
Date of sowing			
10 October	58.83	95.08	9.37
25 October	55.17	97.17	9.41
10 November	50.29	96.85	6.59
25 November	46.16	94.75	7.05
Planting ratio			
2:6	51.67	95.83	7.92
2:8	53.39	96.91	7.74
2:10	52.89	97.95	8.47
2:12	52.50	98.58	8.81
CD (5%)	1.42	1.34	1.23

Table 4. Effect of date of sowing and planting ratio on germination, vigour index and 1000- seed weight of hybrid seed in Indian mustard NRCHB 506.

Parameter	Germination (%)			Vigour Index			1000 seed weight (g)	
	CMS	Restorer	Hybrid	CMS	Restorer	Hybrid	CMS	Restorer
Date of sowing								
10 October	86.06	88.44	88.13	1193.83	1258.84	1230.73	5.60	5.81
25 October	88.88	94.38	94.94	1231.38	1330.56	1353.94	6.20	5.82
10 November	88.13	88.13	89.75	1206.92	1213.58	1257.14	5.38	5.39
25 November	79.69	80.13	80.94	1067.01	1061.74	1112.74	5.25	5.22
Planting ratio								
2:6	83.94	86.69	86.81	1120.62	1171.71	1181.72	5.52	5.41
2:8	84.81	87.25	87.88	1150.84	1200.01	1218.01	5.64	5.68

2:10	86.25	87.88	88.75	1184.98	1219.26	1253.74	5.54	5.54
2:12	87.75	89.25	90.31	1242.71	1273.73	1301.08	5.74	5.62
CD (5%)	**1.21**	**1.15**	**1.14**	**25.40**	**24.28**	**27.68**	**0.13**	**0.15**

Table 5. Effect of date of sowing and planting ratio on seedling length, root length and shoot length of hybrid seed in Indian mustard NRCHB 506.

Parameter	Seedling length (cm)			Root length (cm)			Shoot length (cm)		
	CMS	Restorer	Hybrid	CMS	Restorer	Hybrid	CMS	Restorer	Hybrid
Date of sowing									
10 October	13.87	14.23	13.96	8.25	8.53	8.19	5.38	5.54	5.60
25 October	13.84	14.09	14.26	8.18	8.29	8.41	5.46	5.66	5.68
10 November	13.69	13.77	14.00	8.06	8.04	8.23	5.43	5.59	5.60
25 November	13.39	13.25	13.74	7.90	7.74	8.01	5.29	5.38	5.56
Planting ratio									
2:6	13.34	13.50	13.60	7.92	7.95	7.99	5.23	5.38	5.43
2:8	13.56	13.74	13.86	8.01	8.08	8.13	5.33	5.50	5.56
2:10	13.73	13.86	14.11	8.13	8.15	8.28	5.44	5.60	5.68
2:12	14.15	14.25	14.39	8.33	8.41	8.44	5.57	5.69	5.78
CD (5%)	**0.19**	**0.21**	**0.22**	**0.17**	**0.15**	**0.17**	**0.14**	**0.13**	**0.15**

There was no significant difference in days to 50% flowering of the male parent (48.6 to 49.13) and of female (54.56 to 55.13) among planting ratios but the slight increasement in flowering duration was noticed as increasing the planting ratio. Further, an increasing trend over planting ratio was invariably recorded for seed yield and its contributing yield (plant height, number of primary branches / plant, number of secondary branches / plant, number of total branches / plant number of siliquae on main raceme, number of siliquae on primary branches, number of siliquae on secondary branches, number of total siliquae / plant, number of seed/ siliqua and seed set) as well as seed quality parameters (germination, root length, soot length, seedling length and vigour index) as the planting ratio increased (Tables 1,2,3,4 and 5). Thus, the planting ratio as increased from 2:6 to 2:12 was found to increase the hybrid seed production indicating the suitability of both the lines under such agro-climatic condition. These findings are strongly in support to Yadav *et al*. [11].

CONCLUSION

Keeping present findings in view, it is concluded that the hybrid seed production of Indian mustard NRCHB 506 could be maximized by sowing around third week of October at 2:12 planting ratio of male and female even under sodic soil condition.

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