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Study the Effect of Staggered Sowing of Hybrid Rice in New Alluvial Zone

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A B S T R A C T

Hybrid rice has been a successful and widely adopted technology that has increased rice production in China since early 80's of the last century. But in India inspite of development of several successful hybrids the technology has not been widely adopted and is cultivated in select regions only. West Bengal is the largest producer of rice. But hybrid rice is cultivated in a very limited area. There is urgent need to adopt the hybrid rice technology to enhance the production level to meet the ever increasing food demand. Hybrid rice seed yield of the popular hybrids is reported to be very low. So, there is need for refinement of hybrid rice seed production technology to enhance the production to a level of 2-2.5 t ha^{-1} from the present level 1-1.5 t ha^{-1}. On this back ground the present study was conducted to fine tune the seed production technology of the popular hybrid rice, KRH 2 with respect to the Gangetic New Alluvial Zone of West Bengal to determine the exact seeding interval of the parental lines and to standardize the dose of GA_3 in both kharif and boro seasons. The experimental materials included the parental lines of KRH 2 i.e. CMS line-IR-58025A and restorer line KMR 3. The experiment was conducted at the Teaching Farm, Monduri, Bidhan Chandra Krishi Vishwavidyalaya, Nadia, West Bengal during kharif 2012, boro 2012-13, kharif 2013 and boro 2013-14.

Introduction

West Bengal is the largest rice producing state in the country. At present, the cultivated area of rice is about 57 lakh hectare in West Bengal (Bordolui *et al.*, 2006). The demand for food is increasing day by day. On the other hand due to rapid urbanization and other infrastructure development, cultivated land of rice is decreasing (Bordolui *et al.*, 2016). To meet the increasing demand of food, hybrid rice is the only option, which can add 22-30% more yield over semi-dwarf variety.

The country witnessed an impressive growth in rice production in the post-independence era due to the adoption of semi dwarf high yielding varieties coupled with the adoption of intensive input based management practices (Bordolui *et al.*, 2018). Rice production was increased four times, productivity three times while the area increase was only one and half times during this period. In order to keep pace with the growing population, the estimated rice requirement by 2025 is about 130 m.t. plateuing trend in the yield of HYV's, declining and degrading natural resources like land and water and acute shortage of labor make the task of increasing rice production quite challenging. The current situation necessitates looking for some innovative technologies to boost rice production.

Encouraged by the success of hybrid rice technology in enhancing the rice production and productivity in China, the Indian Council of Agricultural Research (ICAR) initiated a national program for development and large scale adoption of hybrid rice in the country in December 1989. The project was implemented through a National Network comprising research, seed production and extension networks. The hybrid rice research network consisted of 11 research centers and many voluntary centers spread across the country. The seed production network consisted of public sector seed production agencies such as National Seed Corporation, State Farms Corporation of India and the State Seed Development Corporations in addition to many private sector seed companies. The extension network consisted of state departments of Agriculture, extension wings of the SAUs, Krishi Vigyan Kendras (Farm science centers) and the NGOs. Effective linkages were established within the different sub-components of the network. The entire project was co-ordinated and implemented by the Directorate of Rice Research (DRR), Hyderabad. The project initiated by the ICAR, was further strengthened by the technical backstopping from IRRI Philippines, FAO, the financial support from the UNDP, Mahyco Research Foundation, World Bank funded National Agricultural Technology Project (NATP) and IRRI/ADB Project on Hybrid Rice. The visionary approach of the policy makers, generous funding from the donors and effective implementation of the multi-disciplinary program in a mission mode by the project personnel, helped India to become the second country in the world after China to develop and commercialize hybrid rice.

Hybrid rice technology is likely to play a key role in increasing the rice production (Biradarpatil and Shekhargouda, 2006). More than 80 % of the total hybrid rice area is in eastern Indian states like Uttar Pradesh, Jharkhand, Bihar, Chhattisgarh, with some little area in states like Madhya Pradesh, Assam, Punjab and Haryana. As rice is a key source of livelihood in eastern India, a considerable increase in yield through this technology will have a major impact on household food and nutritional security, income generation, besides an economic impact in the region. The present status of hybrid rice in the country is the major challenge and the future outlook for this innovative technology. The main objective of the study to evaluate the effect of staggered sowing.

With the above consideration, the present investigation has been undertaken to observe fine tuning of hybrid specific and location specific seed production technology, microclimatic factors and potential selection of chemicals for higher seed set percentage in

A line during *kharif* season 2012, *boro* season 2012-13, *kharif* season 2013 and *boro* season 2013-14 at the Teaching Farm, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India.

Materials and Methods

The main field was prepared following standard agronomic practices and intercultural operations. During field preparation fertilizer was added 100:50:50 N: P: K kg ha^{-1}. While another dose of 50 kg N ha^{-1} was applied as top dressing at 45 DAT. The main land was leveled properly and accordingly the requirement for the study it was made in to small sized plots (4.5 m × 2.05 m). A spacing of R to R: 30cm, A to A: 15cm, R to A: 20 cm were maintained and planting row ratio (Patil, 2008) was maintained in the ratio of 2:8 i.e. Restorer line (KMR-3R): CMS line (IR-58025 A). Intercultural operations and irrigations were carefully done for proper growth and development of plants. For hybrid rice seed production synchronization of flowering between restorer line and CMS line is very important (Praveen, 2009). Here in this experiment restorer line was seeded in three days interval which was name as Restorer line (R1), Restorer line (R2), Restorer line (R3). Simultaneously five CMS lines (A1, A2, A3, A4 and A5) were seeded in differential gap with restorer line (R2). A1, A2, A3, A4 and A5were sown at 5, 7, 9, 11 and 13 days after R_2 soaking the seeds (Shaloie *et al.*, 2014). Experiment was laid out in RBD (Randomize Block Design) with two replications. The different seed quality parameters such as Panicle exertion rate (PER), Plant Height (cm), Days to 50 percent flowering, Effective tillers $plant^{-1}$, Panicle length (cm), Spikelet number $panicle^{-1}$, Number of fertile spikelet $panicle^{-1}$, Number of tillers $hill^{-1}$, out crossing rate Test weight (g) and Yield (t ha^{-1}) were recorded from individual plots.

Results and Discussion

Development of an efficient and economically viable hybrid rice seed production package is important to harvest the benefit of a heterotic combination but the major limiting factors is non synchronization of flowering between CMS and restorer lines, and low panicle exertion at the time of anthesis which causes low out crossing and ultimately low seed setting on the CMS line. Synchronization of flowering is most important factor, as the amount of seed setting depends on the pollen load during flowering. The phenological behavior of the parental lines varies from location to location and season to season. Thus, it is important to standardize to exact seeding difference between the parental lines for synchronization of flowering.

The CMS line used in the KRH 2 hybrid combinations i.e. IR-58025A suffer from poor panicle exertion. Since the line contains the wild abortive (WA) cytoplasm it shows improper panicle exertion and at least 25-35 % spikelets remain enclosed within the flag leaf and thus reduce the number of spikelets available for out crossing (Yuan and Virmani, 1988).

Synchronization of flowering and out crossing in hybrid rice depends on various climatic factors like temperature, sunlight and relative humidity. Thus, the present study on “Refinement of Technology for Hybrid Seed Production in Rice” was carried out to develop a situation specific package for this region in the leading hybrid KRH 2 during *kharif* season 2012, *boro* season 2012-13, *kharif* season 2013 and *boro* season 2013-14.

Result of staggered planting on different traits

Synchronization of flowering between restorer line and CMS line is very much important for an efficient hybrid rice seed production system. Under the present investigation an attempt was made to standardize the sowing window of restorer and CMS line for synchronization of flowering in both *kharif* and *boro* season in Gangetic New Alluvial Region of West Bengal. The restorer line was seeded at three days interval (R1, R2 and R3) and the CMS line was seeded at different interval from R2 viz., 5 days (A1), 7 days (A2), 9 days (A3), 11 days (A4) and 13 days (A5). Observations were recorded on panicle exertion and different yield attributing traits. The result is presented season wise (*Kharif* and *boro* season of 2012 and 2013) as well as on the basis of pooled data over the season in Table 1, 2, 3, 4, 5 and 6 respectively.

Length of exerted panicle (cm)

No significant difference was observed on length of exerted panicle among the different treatments in all the seasons as well as in the pooled data. However, maximum panicle exertion (18.2 cm) in *kharif* 2012was observed at 5 days interval (A1) from restorer line (R2) which was followed by11 days interval (A4) and 7 days interval (A2). Whereas, during *kharif* 2013 maximum exerted panicle length (18.4 cm) was recorded at 11 days interval (A4) which was followed by 9 days interval (A3) and 5 days interval (A1). Similarly, during *boro* season 2012-13, the highest magnitude for the character (19.4 cm) was recorded at 9 days interval (A3) which was followed by 11 days interval (A4) and during *boro* season 2013-14 the highest value (19.7 cm) was recorded at 7 days interval (A2) which was followed by 9 days interval (A3).

Length of panicle within leaf sheath (cm)

During *kharif* season 2012, highest magnitude of length of panicle within leaf sheath (4.8 cm) was observed at 11 days interval (A4) which was followed by 13 days (A5) as well as 9 days (A3) interval. Whereas, during *kharif* season 2013 maximum value (4.8 cm) was recorded at both 11 days (A4) as well as 13 days (A5) interval which was followed by 9 days interval (A3) though no significant difference was observed among the treatments for this character in both *kharif* season 2012 and *kharif* season 2013.

In *boro* 2012-13, maximum value for this character (5.2 cm) was observed at 5 days interval (A1) which was followed by 9 days interval (A3). In *boro* season 2013-14, however, highest magnitude (5.2 cm) was recorded at 5 days interval (A1) which was followed by 13 days interval (A5). In this case also no significant difference was noticed among the treatments.

Total length of panicle (cm)

No significant variation among the treatments was observed for this character in the season wise as well as in the pooled data except in *kharif* 2013.

However, seeding of CMS line at 11 days interval (A4) recorded highest panicle length in both *kharif* season 2012 and 2013 which was reflected in the mean table also (Table 3).

In case of *boro* season 2012-13, the highest magnitude (24.6 cm) was observed at 9 days interval (A3) which was followed by 11 days interval (A4) and in *boro* season 2013-14 the maximum panicle length (24.3 cm) was recorded at 7 days interval (A2).

Similar kind of observations was recorded from the mean values of *boro* seasons (Table 6). The highest value (24.0 cm) was at 5 days interval (A1), whereas, the lowest value (23.4 cm) was at 13 days interval (A5).

Panicle exertion rate (%)

Panicle exertion rate (PER) is an important parameter in hybrid rice seed production which is influenced by sowing frequency, restorer to CMS row ratio and many other factors (Ortuoste, R.M, 2016). However, under the present investigation no significant variation among the treatments was observed for this character in both the *kharif* seasons and in *boro* seasons of 2012-13. In *boro* 2013-14, however, the variation was significant. Highest panicle exertion rate (83.0 %) was noticed at 9 days interval (A3) which was followed by 7 days interval (80.8 %) and 11 days interval (80.1 %). Significantly lowest value was observed (78.4 %) at 5 days interval.

Number of fertile spikelet panicle^{-1}

Statistically significant difference was observed among the treatments for this attribute in all the seasons. In *kharif*, 2012, maximum number of fertile spikelet (34.3) was observed at13 days interval which was followed by 11 days interval (32.1), whereas, minimum number of fertile spikelet per panicle was recorded at 5 days interval (10.0). Similar trend was also noticed in *khrif* 2013, where maximum number of fertile spikelet per panicle (36.6) was noticed at 13 days interval which was followed by 11 days interval (30.6), 9 days interval (24.2), and 7 days interval (16.2).

From the mean of two *kharif* seasons, it may be opined that 13 days gap of A line from R2 was most effective in getting maximum number of fertile spikelet per panicle, whereas, reduction is gap lead to significant reduction in fertile spikelet number leading to low hybrid seed yield.

In *boro* seasons also the treatments recorded statistically significant difference for this character. In *boro* 2012-13, maximum number of fertile spikelet per panicle (49.8) was observed at 13 days interval which was followed by 11 days interval (39.3), 9 days interval (32.7), and 7 days interval (26.3). In *boro* season 2013-14 also, maximum number (36.6) was observed at13 days interval.

Based on the mean data of *boro* seasons, it may be concluded that 13 days interval was most effective for getting maximum number of fertile spikelet per panicle (50.2).

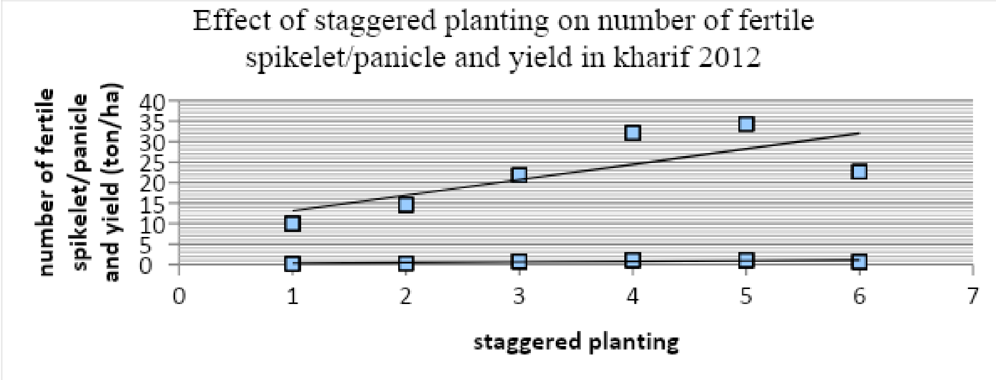
Number of sterile spikelet panicle^{-1}

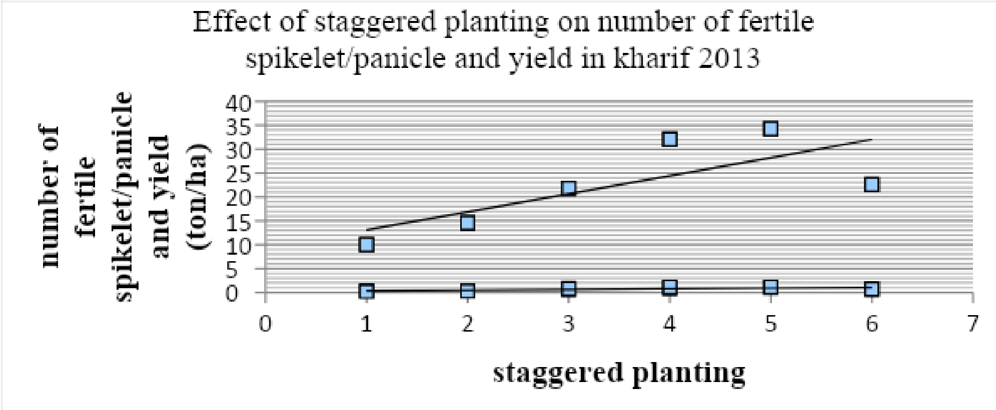
Low spikelet sterility in F_1 is desirable for getting higher seed yield in rice. Under the present investigation, however, high spikelet sterility was noticed in most cases. The trait recorded non-significant variation in all the seasons. In *Kharif*, 2012, however, highest value (180.8) was recorded at 13 days interval (A5) which was followed by 7 days (A2), and lowest value was noticed at 9 days interval (A3) (168.8). Whereas, during *kharif* season 2013, highest value (196.5) was at 13 days interval (A5) which was followed by 7 days (178.9), 9 days interval (169.5), 11 days interval (153.9) and 5 days interval (140.0).

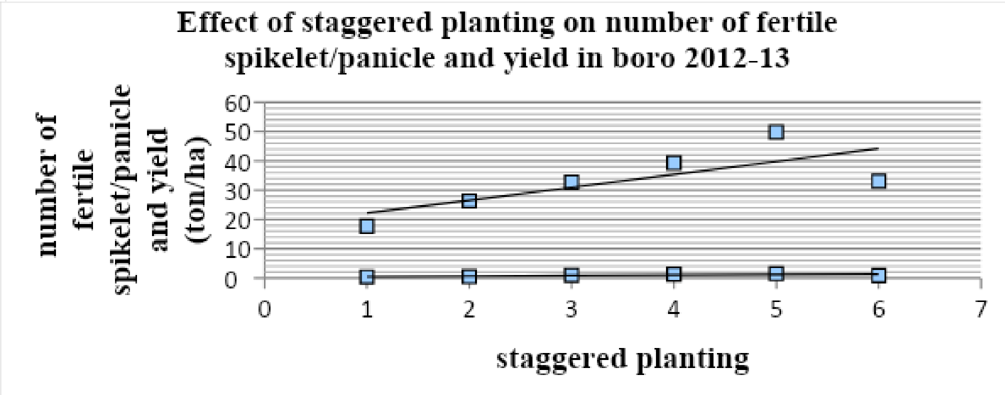
During *boro* season 2012-13, maximum number (171.3) was, however, observed at 7 days interval (A2) which was followed by 11 days (162.7) and in case of *boro* season 2013-14, highest value (196.5) was recorded at 13 days interval. Lowest spikelet sterility (124.7) was noticed in A5 (13 days interval)

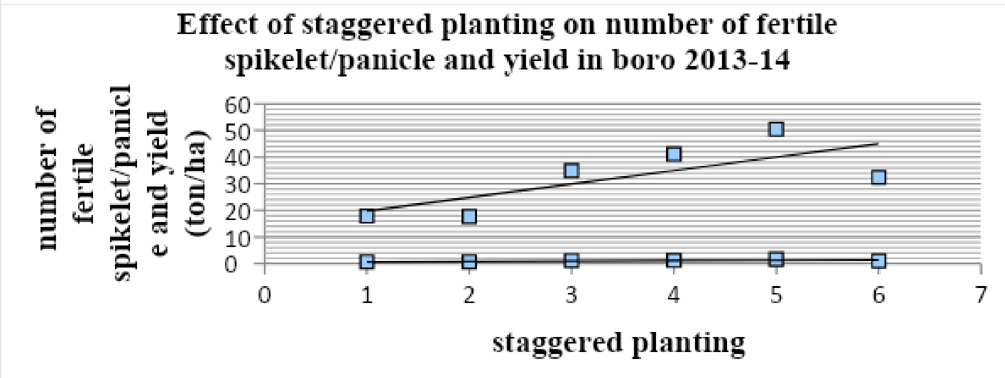
Total number of spikelet panicle^{-1}

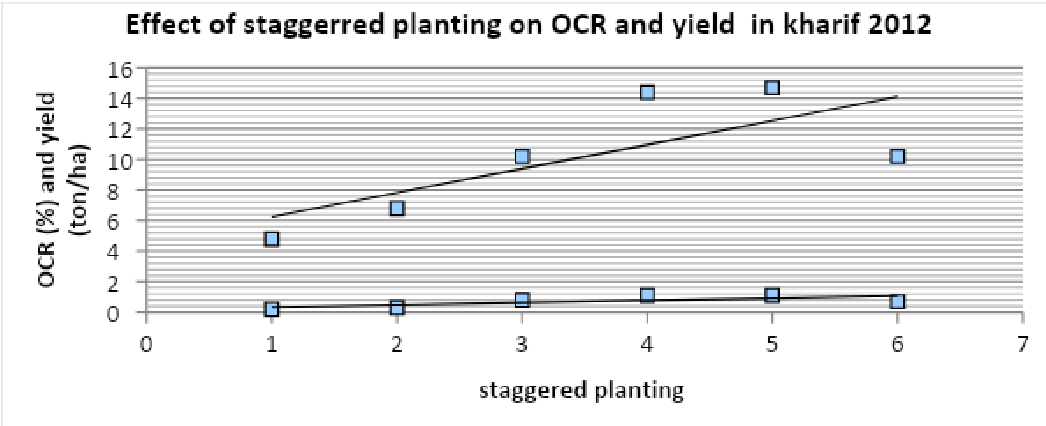
Maximum number of spikelet panicle^{-1} was recorded in case of 13 days interval in both the *kharif* seasons and lowest value was noticed at 5 days interval. No significant difference in the data in *kharif* season 2012 was noticed. Whereas, statistically significant difference among the treatments was noticed in *kharif* season 2013.

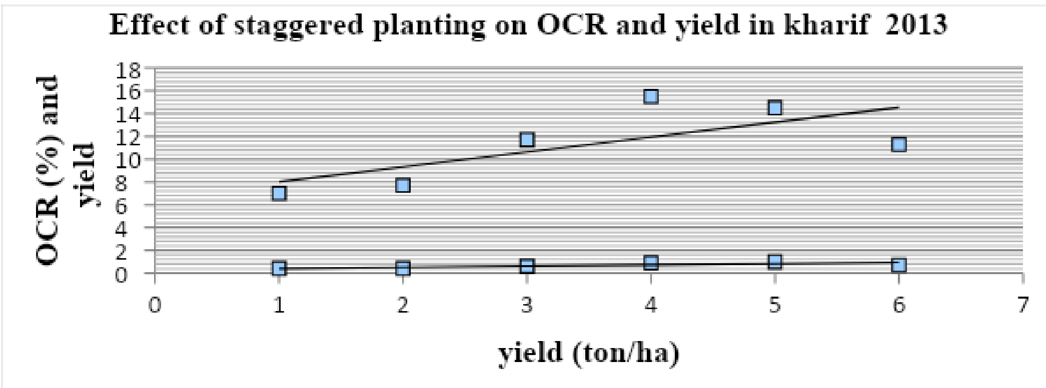

Effect of staggered planting on number of fertile spikelet/panicle and yield in kharif 2012
number of fertile spikelet/panicle and yield (ton/ha)
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7
staggered planting

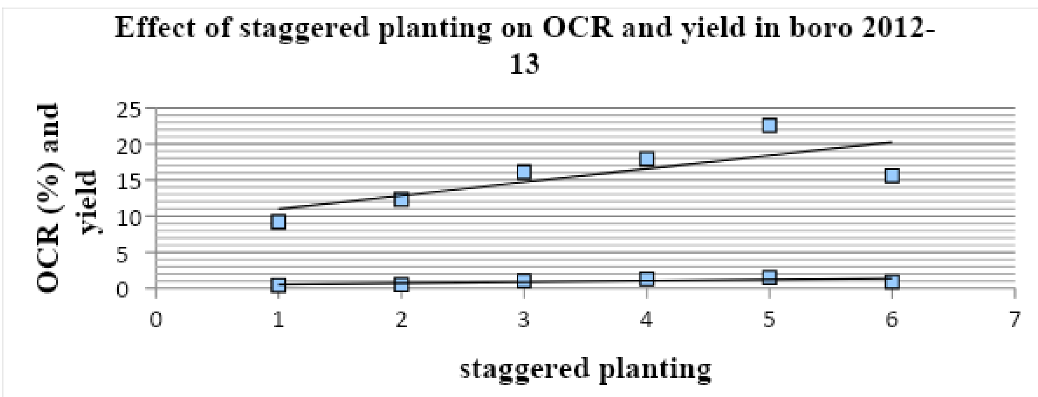

Effect of staggered planting on number of fertile spikelet/panicle and yield in kharif 2013
number of fertile spikelet/panicle and yield (ton/ha)
40
35
30
25
20
15
10
5
0
0 1 2 3 4 5 6 7
staggered planting


Effect of staggered planting on number of fertile spikelet/panicle and yield in boro 2012-13
number of fertile spikelet/panicle and yield (ton/ha)
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7
staggered planting


Effect of staggered planting on number of fertile spikelet/panicle and yield in boro 2013-14
number of fertile spikelet/panicl e and yield (ton/ha)
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7
staggered planting


Effect of staggerred planting on OCR and yield in kharif 2012
OCR (%) and yield (ton/ha)
0 2 4 6 8 10 12 14 16
0 1 2 3 4 5 6 7
staggered planting


Effect of staggered planting on OCR and yield in kharif 2013
OCR (%) and yield
0 2 4 6 8 10 12 14 16 18
0 1 2 3 4 5 6 7
yield (ton/ha)


Effect of staggered planting on OCR and yield in boro 2012-13
OCR (%) and yield
0 5 10 15 20 25
0 1 2 3 4 5 6 7
staggered planting

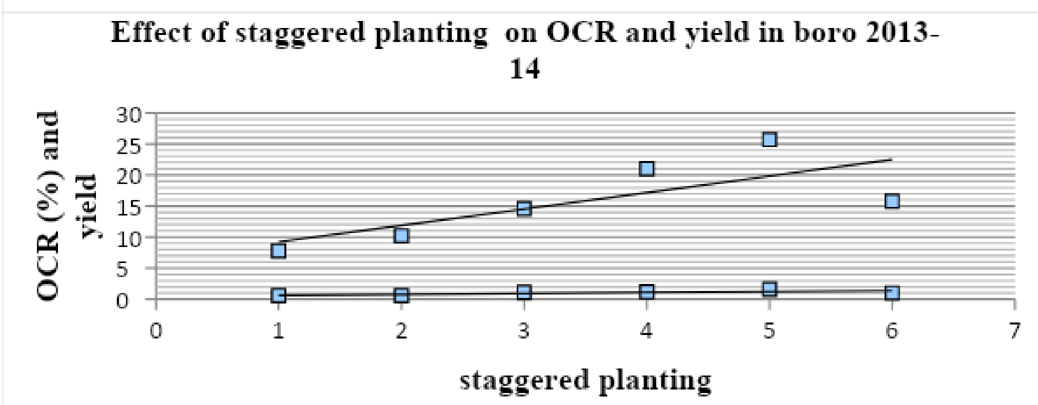

Effect of staggered planting on OCR and yield in boro 2013-14
OCR (%) and yield
0 5 10 15 20 25 30
0 1 2 3 4 5 6 7
staggered planting

Table.1 Effect of staggered planting on different traits in *kharif*, 2012

Time of Staggered sowing	Length of exerted panicle (cm)	length of panicle within leaf sheath (cm)	Total length of panicle (cm)	PER (%)	No of fertile spikelet panicle^{-1}	No of sterile spikelet panicle^{-1}	No of spikelet within leaf sheath panicle^{-1}	Total no of spikelet panicle^{-1}	No of exerted spikelet panicle^{-1}	OCR (%)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Test weight (g)	Yield (t ha^{-1})
A1	18.2	4.3	22.5	80.8	10.0d	172.4	26.2	208.6	182.4	4.8	9.1d	4.8b	19.5	0.2c
A2	17.9	4.6	22.5	79.5	14.6cd	180.2	19.4	214.2	194.7	6.8	10.0b	5.2b	19.5	0.3c
A3	17.7	4.7	22.4	79.0	21.8bc	168.8	25.7	216.2	190.5	10.2	10.0b	9.2a	19.5	0.8b
A4	18.0	4.8	22.8	79.1	32.1ab	172.8	18.2	223.1	204.8	14.4	11.1a	9.0a	19.5	1.1a
A5	17.8	4.7	22.4	79.2	34.3a	180.8	17.4	232.5	215.0	14.7	9.7c	8.5a	19.5	1.1a
Mean	17.9	4.6	22.5	79.5	22.6	175.0	21.4	218.9	197.5	10.2	10.0	7.3	19.5	0.7
SEm (±)	**0.8**	**0.29**	**0.7**	**1.6**	**4.14**	**9.2**	**3.5**	**12.09**	**9.4**	**1.70**	**0.09**	**0.66**	**NA**	**0.08**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**0.014**	**NS**	**NS**	**NS**	**NS**	**4.7**	**0.24**	**1.84**	**NA**	**0.22**
CV (%)	**4.6**	**6.32**	**2.9**	**1.9**	**18.36**	**5.25**	**16.2**	**5.5**	**4.7**	**16.7**	**0.7**	**9.09**	**NA**	**11.21**

Table.2 Effect of staggered planting on different traits in *kharif*, 2013

Time of Staggered sowing	Length of exerted panicle (cm)	length of panicle within leaf sheath (cm)	Total length of panicle (cm)	PER (%)	No of fertile spikelet panicle^{-1}	No of sterile spikelet panicle^{-1}	No of spikelet within leaf sheath panicle^{-1}	Total no of spikelet panicle^{-1}	No of exerted spikelet panicle^{-1}	OCR (%)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Test weight (g)	Yield (t ha^{-1})
A1	17.6	4.7	22.3b	79.3	11.1c	140.0	14.0	165.1	151.0	7.0	5.7	4.4	19.7	0.4
A2	17.5	3.9	21.4c	81.9	16.2c	178.9	18.6	213.6	195.1	7.7	10.7	6.8	19.7	0.4
A3	18.2	4.6	22.8a	79.8	24.2b	169.5	13.2	206.9	193.7	11.7	11.6	6.6	19.7	0.6
A4	18.4	4.8	23.1a	79.3	30.6ab	153.9	12.6	197.2	184.6	15.5	15.2	7.6	19.7	0.9
A5	17.4	4.8	22.2b	78.5	36.6a	196.8	16.7	250.0	233.4	14.5	12.7	7.1	19.7	1.0
Mean	17.8	4.6	22.3	79.7	23.7	167.8	15.0	206.5	191.5	11.3	11.1	6.5	19.7	0.7
SEm (±)	**0.37**	**0.44**	**0.19**	**1.84**	**2.51**	**12.93**	**2.49**	**13.09**	**15.04**	**0.80**	**4.86**	**2.44**	**NA**	**0.30**
LSD (0.05)	**NS**	**NS**	**0.53**	**NS**	**6.98**	**NS**	**NS**	**36.34**	**41.75**	**2.22**	**NS**	**NS**	**NA**	**NS**
CV (%)	**2.09**	**9.61**	**0.86**	**2.35**	**10.59**	**7.70**	**16.57**	**6.34**	**7.85**	**7.10**	**43.69**	**33.5**	**NA**	**44.65**

A1, A2, A3, A4 and A5: CMS (A) line seeds were soaked for seeding 5, 7, 9, 11 and 13 days respectively later than middle Restorer (R2) line seeds.

Table.3 Effect of staggered planting on different traits (pooled *kharif* seasons)

Time of Staggered sowing	Length of exerted panicle (cm)	length of panicle within leaf sheath (cm)	Total length of panicle (cm)	PER (%)	No of fertile spikelet panicle^{-1}	No of sterile spikelet panicle^{-1}	No of spikelet within leaf sheath panicle^{-1}	Total no of spikelet panicle^{-1}	No of exerted spikelet panicle^{-1}	OCR (%)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Test weight (g)	Yield (t ha^{-1})
A1	17.9	4.50	22.4	80.1	10.6	156.2	20.1	186.9	166.7	5.90	7.40	4.60	19.6	0.30
A2	17.7	4.25	22.0	80.7	15.4	179.6	19.0	213.9	194.9	7.25	10.4	6.00	19.6	0.35
A3	18.0	4.65	22.6	79.4	23.0	169.2	19.5	211.6	192.1	11.0	10.8	7.90	19.6	0.70
A4	18.2	4.80	23.0	79.2	31.4	163.4	15.4	210.2	194.7	15.0	13.2	8.30	19.6	1.00
A5	17.6	4.75	22.3	78.9	35.5	188.8	17.1	241.3	224.2	14.6	11.2	7.80	19.6	1.05
Mean	17.9	4.59	22.4	79.6	23.2	171.4	18.2	212.7	194.5	10.7	10.6	6.92	19.6	0.68
SEm(±)	**0.32**	**0.19**	**0.24**	**0.86**	**1.17**	**5.61**	**1.51**	**6.30**	**6.26**	**0.66**	**1.72**	**0.90**	**NA**	**0.11**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**5.58**	**18.29**	**NS**	**20.55**	**20.42**	**2.16**	**NS**	**NS**	**NA**	**0.36**
CV (%)	**3.59**	**8.11**	**2.16**	**2.17**	**14.8**	**6.54**	**16.56**	**5.92**	**6.44**	**12.38**	**32.62**	**24.50**	**NA**	**32.09**

Table.4 Effect of staggered planting on different traits in *boro*, 2012-13

Time of Staggered sowing	Length of exerted panicle (cm)	length of panicle within leaf sheath (cm)	Total length of panicle (cm)	PER (%)	No of fertile spikelet panicle^{-1}	No of sterile spikelet panicle^{-1}	No of spikelet within leaf sheath panicle^{-1}	Total no of spikelet panicle^{-1}	No of exerted spikelet panicle^{-1}	OCR (%)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Test weight (g)	Yield (t ha^{-1})
A1	18.6	5.2	23.8	78.2	17.7d	151.9	23.0	192.6	169.6	9.2c	10.0	5.7bc	18.8	0.4c
A2	18.4	4.7	23.1	79.8	26.3cd	171.3	16.4	213.9	197.5	12.3bc	9.20	5.1c	18.8	0.5c
A3	19.4	5.2	24.6	78.7	32.7bc	155.5	15.7	203.8	188.2	16.1b	10.2	8.5a	18.8	1.0b
A4	18.9	5.2	24.0	78.5	39.3b	162.7	20.7	222.6	201.9	17.9ab	11.1	8.9a	18.8	1.3ab
A5	18.6	5.2	23.7	78.3	49.8a	154.2	14.7	218.6	203.9	22.6a	10.5	8.0ab	18.8	1.5a
Mean	18.8	5.1	23.8	78.7	33.1	159.1	18.1	210.3	192.2	15.6	10.2	7.2	18.8	0.9
SEm(±)	**1.52**	**0.28**	**1.43**	**2.02**	**3.22**	**15.48**	**3.64**	**11.43**	**14.39**	**2.20**	**0.71**	**0.87**	**NA**	**0.23**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**8.93**	**NS**	**NS**	**NS**	**NS**	**6.09**	**NS**	**2.42**	**NA**	**0.35**
CV (%)	**8.09**	**5.5**	**5.98**	**2.56**	**9.71**	**9.73**	**20.10**	**5.44**	**7.48**	**14.07**	**7.02**	**12.12**	**NA**	**13.23**

A1, A2, A3, A4 and A5: CMS (A) line seeds were soaked for seeding 5, 7, 9, 11 and 13 days respectively later than middle Restorer (R2) line seeds.

Table.5 Effect of staggered planting on different traits in *boro*, 2013-14

Time of Staggered sowing	Length of exerted panicle (cm)	length of panicle within leaf sheath (cm)	Total length of panicle (cm)	PER (%)	No of fertile spikelet panicle^{-1}	No of sterile spikelet panicle^{-1}	No of spikelet within leaf sheath panicle^{-1}	Total no of spikelet panicle^{-1}	No of exerted spikelet panicle^{-1}	OCR (%)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Test weight (g)	Yield (t ha^{-1})
A1	18.9	5.2	24.1	78.4b	17.9d	152.6	11.9	182.3	170.5	7.8e	12.2b	8.5	19.3	0.6d
A2	19.7	4.7	24.3	80.8ab	17.7d	138.6	11.3	167.6	156.3	10.2d	10.3c	9.1	19.3	0.6d
A3	19.1	3.9	23.0	83.0a	34.9c	177.1	15.0	226.9	212.0	14.6c	15.6a	8.4	19.3	1.1c
A4	18.8	4.7	23.5	80.1b	41.1b	137.4	10.7	189.1	178.5	21.0b	10.1c	7.8	19.3	1.2b
A5	18.2	4.9	23.0	78.9b	50.5a	124.7	10.2	185.3	175.1	25.7a	13.1b	8.0	19.3	1.6a
Mean	18.9	4.7	23.6	80.2	32.4	146.1	11.8	190.2	178.5	15.8	12.2	8.3	19.3	1.0
SEm(±)	**1.48**	**0.34**	**1.77**	**0.91**	**2.22**	**13.8**	**2.59**	**13.14**	**15.43**	**0.61**	**0.61**	**0.34**	**NA**	**0.03**
LSD (0.05)	**NS**	**NS**	**NS**	**2.53**	**6.16**	**NS**	**NS**	**NS**	**NS**	**1.69**	**1.69**	**NS**	**NA**	**0.08**
CV (%)	**7.84**	**7.4**	**7.51**	**1.14**	**6.85**	**9.49**	**21.97**	**6.91**	**8.65**	**3.85**	**4.99**	**4.03**	**NA**	**2.71**

Table.6 Effect of staggered planting on different traits (pooled *boro* seasons)

Time of Staggered sowing	Length of exerted panicle (cm)	length of panicle within leaf sheath (cm)	Total length of panicle (cm)	PER (%)	No of fertile spikelet panicle^{-1}	No of sterile spikelet panicle^{-1}	No of spikelet within leaf sheath panicle^{-1}	Total no of spikelet panicle^{-1}	No of exerted spikelet panicle^{-1}	OCR (%)	No of tillers hill^{-1}	No of effective tillers hill^{-1}	Test weight (g)	Yield (t ha^{-1})
A1	18.8	5.20	24.0	78.3	17.8	152.3	17.5	187.5	170.1	8.50	11.1	7.10	19.1	0.50
A2	19.1	4.70	23.7	80.3	22.0	155.0	13.9	190.8	176.9	11.3	9.75	7.10	19.1	0.55
A3	19.3	4.55	23.8	80.9	33.8	166.3	15.4	215.4	200.1	15.4	12.9	8.45	19.1	1.05
A4	18.9	4.95	23.8	79.3	40.2	150.1	15.7	205.9	190.2	19.5	10.6	8.35	19.1	1.25
A5	18.4	5.05	23.4	78.6	50.2	139.5	12.5	202.0	189.5	24.2	11.8	8.00	19.1	1.55
Mean	18.9	4.89	23.7	79.5	32.8	152.6	15.0	200.3	185.4	15.7	11.2	7.80	19.1	0.98
SEm(±)	**0.75**	**0.16**	**0.80**	**0.78**	**1.38**	**7.34**	**1.58**	**6.16**	**7.46**	**0.81**	**1.21**	**0.33**	**NA**	**0.05**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**4.50**	**NS**	**NS**	**28.4**	**NS**	**2.63**	**1.53**	**1.52**	**NA**	**0.15**
CV (%)	**7.96**	**6.47**	**6.78**	**1.97**	**8.43**	**9.63**	**21.13**	**6.15**	**8.05**	**10.25**	**5.93**	**8.51**	**NA**	**9.22**

A1, A2, A3, A4 and A5: CMS (A) line seeds were soaked for seeding 5, 7, 9, 11 and 13 days respectively later than middle Restorer (R2) line seeds.

From the mean of *kharif* seasons, it was revealed that 13 days interval recorded maximum number of spikelet.

For *boro* season 2012-13, maximum number was recorded at11 days interval (222.6) which was followed by 13 days interval (218.6). Lowest value was found at 5 days interval (192.6). Statistically no significant difference was noticed for total number of spikelet per panicle. In *boro* season 2013-14, maximum number was recorded at 9 days interval (226.9) which was followed by 11 days (189.1) and 13 days (185.3).

Out crossing rate (%)

Significant difference in OCR (out crossing rate) was noticed among the treatments. Maximum out crossing percentage was observed in case of 13 days interval (14.7%) which was followed by 11 days interval (14.4 %), and lowest out crossing rate was recorded at 5 days interval in both *kharif* season 2012 and *kharif* season 2013.

From the mean of *kharif* seasons, it may be opined that 11 days interval had maximum out crossing rate.

In *boro* season 2012-13, maximum percentage was obtained in 13 days interval (22.6 %) which was followed by 11 days interval (17.9 %), and lowest value was observed at 5 days interval (9.2%). Similar kind of result was in *boro* season 2012-13 also. From mean of *boro* seasons it was noticed that maximum percentage of out crossing rate was at 13 days interval (24.2 %) which was followed by 11 days interval (19.5 %) and 9 days (15.4 %).

Number of tillers hill^{-1}

Highest number of tillers hill^{-1} in A line was recorded at 11 days interval (11.1) which was followed by 9 days interval (10.0) and 7 days interval (9.7) in *kharif* season 2012.

In *kharif* season 2013, no significant difference among the staggered sowing was observed. The highest value, however, was noted at 11 days interval (15.2) which was followed by 13 days interval (12.7) and 9 days interval (11.6) respectively.

From mean of *kharif* seasons, it was observed that maximum number of tillers per hill was at 11 days interval (13.2) which was followed by 13 days interval (11.2) and 9 days interval (10.3) whereas minimum number was at 5 day interval (7.40).

In *boro* season 2012-13, number of tillers per hill ranged from 11.1 in A2 (9.20). Though, no significant difference was observed in number of tillers per hill among the staggered sowing of CMS lines.

In case of *boro* season 2013-14, highest value was obtained at 9 days interval (15.6) which was followed by 13 days interval (A5) (13.1), 5 days interval (A1) (12.2). From mean of *boro* seasons, it was observed that maximum mean number of tillers per hill was recorded at 9 days interval (12.9) which was followed by 13 days interval (A5) (11.8), 5 days interval (A1) (11.1) and minimum mean number was recorded at 7 days interval (A1) (9.75) though the recorded magnitudes had significant difference among the treatments.

Number of effective tillers hill^{-1}

In *kharif* season 2012, highest value for number of effective tillers hill^{-1} was recorded in case of 9 days interval (A3) (9.2) which was followed by 11 days interval (A4) (9.0),13 days interval (A5) (8.5) and lowest magnitude was observed at 5 days interval (A1) (4.8). Significant difference was observed for this character *kharif*, 2012.

Maximum number of effective tillers hill^{-1} was recorded at 11 days interval (A4) (7.6) which was followed by 13 days interval (A5) (7.1), 7 days interval (A2) (6.8) and minimum number was observed at 5 days interval (A1) (4.4) during *kharif* 2013. Though all the treatments were statistically insignificant.

In case of pool of *kharif* seasons, maximum mean number of tillers per hill was noted at 11 days (A4) (8.30) which was followed by 9 days interval (A3) (7.90), 13 days interval (A5) (7.80) and minimum mean number was at 5 days interval (A1) (4.60) from the restorer line.

During *boro* 2012-13, maximum number was recorded at 11 days interval(A4) (8.9) which was followed by 9 days interval(A3) (8.5), 13 days interval(A5) (8.0) though significance difference was observed for number of effective tillers per hill among the treatments during *boro* season 2012.

Whereas during *boro* season 2013-14, maximum number was recorded at 7 days interval (A2) (9.1) which was followed by 5 days (A1) (8.5) and 9 days (A3) (8.4) interval. For the character however, no significant difference was observed.

From the mean value of two *boro* seasons, i.e. *boro* 2012-13 and *boro* 2013-14, maximum mean number of tillers per hill was noticed at staggered planting of 9 days interval (A3) (8.45) which was followed by 11 days interval (A4) (8.35) and 13 days interval (A5) (8.00).

Test weight (g)

No significant difference among the treatments was observed for the test weight indicating that the staggered planting did not have any influence of seed filling on the CMS line.

Seed yield (t ha^{-1})

In *kharif* season 2012, maximum yield (1.1 t ha^{-1}) was obtained both at 11 days (A4) and 13 days (A5) interval and minimum yield ha^{-1} was recorded at 5 days interval (0.2 t ha^{-1}). Similarly, in *kharif* season 2013, highest seed yield per ha was observed at 13 days interval (1.0 t ha^{-1}) and lowest yield was obtained at 5 days interval (0.4 t ha^{-1}). Significant difference among the treatments observed for yield at both the *kharif* seasons i.e. *kharif* season 2012 and *kharif* season 2013.

From the mean of the two *kharif* seasons it, was revealed that 13 days interval recorded maximum yield (1.05 t ha^{-1}) which was followed by 11 days (1.00 t ha^{-1}). Minimum seed yield was recorded at days interval (0.30 t ha^{-1}).

During *boro* 2012-13 also maximum seed yield (1.2 t ha^{-1}) was observed at 13 days interval. This was followed by 11 days interval. Similarly in *boro* 2013-14 maximum yield (1.6 t ha^{-1}) was noticed at 13 days interval. Statistically significant difference in yield data was noticed at both the *boro* seasons. Thus, from the mean of two *boro* seasons, it was concluded that 13 days interval effective between the parental lines was most effective in getting higher seed yield.

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