Oryza Vol. 52 No.4, 2015 (251-254)

Pant CMS-3A: An improved cytoplasmic male sterile line for efficient rice hybrid seed production

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ABSTRACT

Three cytoplasmic male sterile (CMS) lines and their respective maintainer lines of rice were used in this experiment. The CMS lines included were the newly developed line 'Pant CMS 3A' along with the two existing CMS lines, IR58025A and Pusa 6A. These were planted in four rows of 6 meter length along with two rows of the respective maintainer lines by the side. The hybrid seed set under natural out crossing conditions was allowed without the application of GA_3 and supplementary pollination. Observations were recorded on plant height, tillers/plant, days to 50% flowering, panicle exsertion (%), out crossing rate (%) and total hybrid seed production. Pant CMS 3A showed significant advantage over the two widely used CMS lines, IR58025A and Pusa 6A with respect to all the important traits. The panicle exertion in CMS 3A was 96.7% compared to 72.3% in IR58025A and 71.2% in Pusa 6A. Similarly, the out crossing rate in CMS 3A was 31.8% compared to 8.7% in IR58025A and 16.3% in Pusa 6A; and the hybrid seed yield in CMS 3A was 1998 kg/ha compared to 1203 kg/ha for IR58025A and 1173 for Pusa 6A. These results indicate that by using the new Pant CMS 3 line, the yield of hybrid seed can be doubled and the use of GA_3 can be avoided.

Key words: *Hybrid rice, cytoplasmic male sterility, panicle exertion, out crossing, GA_3*

Hybrid rice cultivation is gaining world wide popularity. Research on hybrid rice in China was initiated in 1964 (Yuan, 1966). The genetic tools like cytoplasmic male sterile line (A-line), maintainer lines (B-line) and restorer (R-line) which are essential for breeding hybrid rice varieties were developed in 1973 (Yuan and Virmani, 1988) and the hybrid seed production techniques was developed by 1975. The first hybrid rice variety was released in 1976 for commercial cultivation and 0.14 million hectare area was transplanted. Since then, the area planted to hybrid rice has steadily increased over time particularly in China where more than 60% area is under hybrid rice. The development and identification of CMS lines with desirable characteristics like better panicle exertion and higher out crossing have played an important role in the popularization of hybrid rice in China.

Convinced with the success of hybrid rice technology in China, India also launched a hybrid rice breeding project in 1989. The first set of rice hybrids were released in 1994. Presently, more than 70 rice hybrids have been developed and released from public and private sectors. At present, the hybrid rice being grown in approximately 2.5-3.0 million hectares in India. Area under hybrid rice will further increase after heterotic hybrids suitable for high productivity areas of Punjab, Haryana, coastal region of Andhra Pradesh and shallow low land area are identified and an effective transfer of technology is taken up vigorously in the target states (Viraktamat, 2010). The private sector has played a pivotal role along with the public sector seed corporations to popularize the hybrid rice among the farmers.

Hybrid rice production technology is highly skill oriented and requires utmost care and precaution at various stages of the seed production. Many operations like flag leaf clipping, supplementary pollination and application of gibberelic acid are practiced in order to

enhance the seed availability from seed parent. Use of gibberelic acid (GA_3) at proper stage with proper dose enhances the seed set on seed parent (Virmani, 2005), but the use of GA_3 also enhances the seed cost that farmers or seed producers has to bear. The cost of one gram of GA_3 in the local market varies between Rs. 120-130 depending upon the purity and company. One hectare area under hybrid rice requires around 60-90 grams of GA3, small quantity of ethyl alcohol and labour for spray which raise the total expenditure on seed production by about Rs. 8000-9000/- per hectare. This is the routine expenditure on seed production which has to be incurred every season of the rice hybrid seed production (Virmani, 1996). This paper reports the development of an improved line, 'CMS 3A' which shows full panicle exertion and much higher hybrid seed set without the application of GA3 and supplementary pollination reducing the cost of hybrid seeds production substantially.

MATERIALS AND METHODS

With a view to improve the seed set of CMS lines in rice, a conversion programme in the background of an improved rice variety, 'NAT 990-99' was initiated at G.B. Pant University in 2003 by using the widely used CMS line 'IR58025A' as a non-recurrent parent. Progenies in each backcross generation were checked for pollen sterility and morphological traits. In BC_6 generation progeny with desired morphological traits, complete sterile plants were selected and allowed to cross pollinate with the maintainer line NAT 990-99 in isolation, to get the genetically pure seed of cytoplasmic male sterile line. The conversion procedure was followed as in the development of Pant CMS 2A (Nautiyal *et al.,* 2011). Briefly this method involved with the selection of sterile plants with full panicle exertion in BC_2 generations for crossing with the recurrent parent. This procedure was followed up to BC_6 generations and at last new cytoplasmic genetic male sterile line with full exerted panicles were obtained.

The newly developed CMS line Pant CMS 3A was planted along with other CMS lines i.e. IR58025A and Pusa 6A, in four rows of 6 meter length. Two rows of respective maintainer lines were also planted alongside (Fig.1). The distance between the rows of CMS lines was kept 15 cm and between CMS and maintainer line 20 cm and between maintainer lines 30 cm, respectively. The seed set under natural conditions was allowed without GA_3 application and supplementary pollination. Observations were recorded on plant height, tillers/plant, days to 50% flowering, panicle exertion (%), out crossing rate (%) and total hybrid seed production. The experiment was conducted

Fig. 1. Testing of CMS lines (the middle 4 rows) along with the two rows of maintainer line) at G.B. pant University Seed Production farm

in the rainy seasons of 2010 and repeated in 2011.

RESULTS AND DISCUSSION

Major differences were observed among the three lines with respect to all the studied traits (Tables 1,2,3). Plant height of Pant CMS 3B was higher with 111.66cm followed by Pant CMS 3A (104.6cm) and IR58025A (86.66cm) pooled over the years 2011 and 2012. Higher estimate of average tiller number was recorded from Pant CMS 3A while a relatively low number of tillers were observed in IR58025B *(*14.66 tillers). Comparatively a maximum out crossing rate of 32.08 and 31.58 percent was observed in Pant CMS 3A in the two years (Fig. 2) followed by Pusa 6A with 18.14 percent and 19.17 percent and IR58025A with 13.33 percent and 15.46 percent. The panicle exertion in Pant CMS 3A was 96.83 percent and 96.50 percent respectively, whereas IR58025A showed 72.16 percent and 72.4 percent and Pusa 6A showed 71.4 and 71.23 percent panicle exertion during 2011 and 2012 (Table 2). Days to 50% flowering was found minimum in Pusa 6A *i.e.* 93.00 and 95.16 days followed by IR58025A (97.16 and 96.16 days) and maximum were found in Pant CMS 3A (110.50 and 103.66 days).

Table 1. Morphological traits of different CMS lines

CMS Line	Plant height (cm)			Days to 50% flowering			No. Of tillers/plant		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
IR58025A	86.0	87.33	86.66	97.16	96.16	96.66	16.50	13.56	15.03
IR58025B	89.0	91.43	90.21	94.83	95.70	95.26	13.33	15.93	14.63
Pusa 6A	98.93	99.43	99.18	97.00	97.53	97.26	19.06	17.46	18.26
Pusa 6B	100.06	100.86	100.46	93.00	95.16	94.08	20.26	20.50	20.38
Pant CMS 3A	105.00	104.33	104.66	110.50	103.66	107.08	24.66	24.06	24.36
Pant CMS 3B	111.33	112.00	111.66	105.50	106.33	105.91	22.80	23.30	23.05
CD (P<0.05)	2.13	4.05	-	2.51	1.35	-	1.40	1.03	-
CV	1.19	2.24	-	1.38	0.74	-	3.98	2.82	-

Fig.2. The CMS line, Pant CMS 3A with high seed set

Table 2. Out crossing rate and Panicle exertion in different CMS lines

CMS Line	Out crossing (%)			Panicle exsertion (%)		
	2011	2012	Mean	2011	2012	Mean
IR58025A	13.33	15.46	8.70	72.16	72.4	72.28
IR58025B	88.16	89.92	89.04	Complete	Complete	-
Pusa 6A	18.14	19.17	16.36	71.06	71.4	71.23
Pusa 6B	91.64	91.99	91.81	Complete	Complete	-
Pant CMS 3A	32.08	31.58	31.83	96.83	96.5	96.66
Pant CMS 3B	95.06	94.25	94.65	Complete	Complete	-
CD (P<0.05)	3.06	1.43	-	-	-	-
CV	2.99	1.38	-	-	-	-

Table 3. Panicle length, Filled grains and Total number of grains in different CMS lines

CMS Line	Panicle length (cm)			Filled grain			Total grains			Yield (kg/ha)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
IR58025A	20.66	21.66	21.16	23.36	27.30	25.33	174.33	175.96	175.14	1231	1176	1203
IR58025B	21.46	21.90	21.68	147.16	154.20	150.68	168.16	171.46	169.81	2616	2693	2654
Pusa 6A	24.73	24.93	24.83	24.72	28.90	26.81	136.40	142.00	139.2	1153	1193	1173
Pusa 6B	25.63	26.56	26.09	137.83	155.16	146.49	150.40	168.66	159.53	2393	2483	2438
Pant CMS 3A	29.13	30.66	29.89	109.20	110.50	109.85	340.26	349.83	345.04	1953	2043	1998
Pant CMS 3B	31.43	32.60	32.01	305.43	303.83	304.63	321.40	322.33	321.86	4633	4833	4833
CD (P<0.05)	1.22	0.95	-	7.13	4.07	-	4.77	1.96	-	192	165	-
CV	2.63	1.98	-	3.14	1.72	-	1.22	0.48	-	454	379	-

A long panicle was in Pant CMS 3B (31.43cm and 32.60 cm) followed by Pant CMS 3A with 29.13 cm and 30.66 cm. A maximum of 305 filled grains was recorded in Pant CMS 3B followed by IR58025B. Similarly, the total numbers of grains per panicle was found maximum in Pant CMS 3A while 139, a less number of grains were found in Pusa 6A. The mean hybrid seed yield in CMS 3A was 1998 kg/ha compared to 1203 kg/ha for IR58025A and 1173 for Pusa 6A (Table 3).

The results from this study indicate substantial and significant advantage of Pant CMS 3A line over the other two with respect to panicle exsertion, hybrid seed set and total hybrid seed yield without application of GA3 or supplementary manual pollination (Table2,3). The hybrid seed yield from Pant CMS 3A is about 2000 kg/ha compared to 11-12 q/ha obtained from the popular CMS lines being used in India. Thus, if Pant CMS 3A is used in the hybrid seed production, use of GA_3 can be avoided and the cost of hybrid rice seed production will be drastically reduced making hybrid production more economically viable to the seed producers and seed growers.

Further seed yield can be improved in Pant CMS 3A by timely supplementary pollination. The grains of Pant CMS 3A are long slender (> 10mm). Pant CMS 3A line is being tried with prominent restorers to find out the heterotic combinations. The Pant CMS 3A line is being maintained at G. B. Pant University of Agriculture & Technology, Pantnagar.

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