ISSN 0258-7122
Bangladesh J. Agril. Res. 39(1): 1-12, March 2014

IDENTIFICATION OF MAINTAINER AND RESTORER LINES IN LOCAL AROMATIC RICE (*Oryza sativa*)

M. ALI[1], M. A. HOSSAIN[2], M. J. HASAN[3] AND M. E. KABIR[4]

Abstract

The availability of stable cytoplasmic male sterility and fertility restoring system is vital for commercial exploitation of heterosis in rice. The experiment was conducted to identify stable maintainers and restorers for three CMS lines having wild abortive type sterility inducing genes in local rice germplasm. One hundred and twenty nine test crosses were made by using 43 aromatic rice genotypes and three CMS lines. Pollen sterility and spikelet fertility of the raised F_1s were assessed in consecutive 2006-2007 Boro and 2007 T. Aman seasons. Pollen sterility was categorized as 100% sterility for complete sterile (CS), 91-99% as sterile (S), 71-90% as partial sterile (PS), 31-70% as partial fertile (PF), 21-30% as fertile (F), and 0-20% sterility as full fertile (FF). Pollen sterility of F_1s in Boro 2006-07 season ranged from 18.83 to 100%, while in T. Aman 2007 season, it ranged from 15.28 to 100%. Whereas spikelet fertility in Boro 2006-07 season ranged from 0.86 to 69.71% and in T. Aman 2007 season, it ranged from 1.97 to 82.91% with CMS line IR58025A. Out of 43 F_1s with IR58025A, two were found complete sterile (IR58025A/Kaliijira-9 and IR58025A/ Sorukamini-2) and three as full fertile (IR58025A/Agali, IR58025A/Benaful, and IR58025A/Khasa). With CMS line IR62829A, pollen sterility ranged from 2.77 to 100% in Boro 2006-07 season and 0.96 to 100% in T. Aman 2007 season. Spikelet fertility status of the same combinations ranged from 0 to 75.41% in Boro 2006-07 season and 1.76 to 88.36% in T. Aman season 2007. Six crosses were identified as complete sterile and seven as full fertile for the said combination. In case of IR68885A four crosses were found as complete sterile, and a single cross as full fertile. The local aromatic line, Kalijira-9 and Sorukamini were identified as maintainer for IR68885A which was common with IR58025A. The local aromatic line Benaful was identified as restorer for IR58025A and IR62829A.

Keywords: Pollen sterility, spikelet fertility, maintainer, restorer

Introduction

The use of cytoplasmic genetic male sterility system in developing hybrids in crops is possible only when effective maintainers and restorers are identified. The rice CMS lines introduced from China are unstable to use as such in developing hybrid rice in Bangladesh. Therefore, it is imperative to identify maintainers and

[1]Regional Director, Agriculture Information Service (AIS), Mymensingh 2200, [2]Senior Scientific Officer, Plant Breeding Division, Bangladesh Rice Research Institute (BRRI), Gazipur, [3]Principal Scientific Officer, Hybrid Rice Division, BRRI, Gazipur, [4]Scientific Officer, Plant Pathology Division, BRRI, Gazipur, Bangladesh.

restorers from local germplasm for development of component lines in a hybrid programme. Pollen or spikelet fertility or both have been used as an index to fix the restoration ability of the lines (Sutaryo, 1989). Identification of locally adapted maintainers and restorers which show complete sterility and consistently high degree of restoration of CMS lines would be of great value in commercial hybrid programme, if restoring ability is combined with high combining ability.

Use of male sterility system would be appropriate approach for commercial exploitation of heterosis in rice. CMS system is controlled by the interaction of cytoplasm with nuclear genes (Kaul, 1997). Development of a hybrid in rice using CMS requires identification of a male sterile line (A-line), a maintainer line (B-line), and a restorer line (R-line). Main characteristics of these lines are A-line is male sterile, which is used as female line in commercial hybrid production plot. B-line is isogenic line of A-line, which is needed to maintain A-line. B-line is considered as key line without that A-line could not be maintained. R-line is a male fertile line used as pollen parent in commercial seed production plot. Test cross programmes help identify maintainers as well as restorers. Maintainer lines used for conversion into new CMS lines and restorer lines are subsequently used as male parent in hybrid development programme. CMS lines introduced from elsewhere may not be well adapted to a given target area. Successful use of hybrid vigour in rice largely depends on the availability of locally developed cytoplasmic genetic male sterile (CMS) and restorer lines (Kumar *et al.*, 1996). Julfiquar *et al.* (2002) evaluated Chinese CMS lines V20A and Zhen Shan97A along with their maintainer for adaptability and performance, but these were not adapted under Bangladesh condition due to high susceptibility to diseases and insects.

Moreover, breeders need wide range of CMS lines to produce desired hybrids. Therefore, it is necessary to transfer available CMS system into local elite breeding lines. So, use of local CMS line would be helpful to alleviate this problem and to develop adaptable, heterotic hybrids. Kumar *et al.* (1996) identified two effective maintainers for WA cytoplasmic source and successfully converted into local lines through backcrossing. Ali and Khan (1996) successfully transferred CMS genes from IR58025A and IR62829A into Basmati line 47456 in Pakistan. A little work on identifying CMS in local aromatic rice varieties is done so far in Bangladesh. Roy (2006) identified 10 maintainers and four restorers of five exotic CMS lines, while working with 33 local aromatic genotypes of Bangladesh. But it is not complete in searching maintainer and restorer lines from local aromatic rice germplasm against different exotic cyto-sources.

So, the present investigation was undertaken to identify more maintainer and restorer lines from local aromatic rice germplasm against exotic cyto-sources.

Materials and Method

The experiment was conducted at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during T. Aman season 2006, Boro season 2006-07, and T. Aman season 2007. Forty one local aromatic rice genotypes and two aromatic rice varieties collected from BRRI gene bank along with three CMS lines from Genetics and Plant Breeding Department, BSMRAU were transplanted in three staggered plantings with 7 days interval between local aromatic germplasm and CMS lines for synchronization of flowering. In T. Aman 2006 season, 25 days old single seedlings were transplanted in main field with three separate blocks for all entries. The plots were 3.5 meter in length containing five rows. The plant spacing was 20 cm between rows and 15 cm between plants of the same row. Adequate soil fertility was ensured by applying Urea-TSP-MP-Gypsum-$ZnSO_4$@ 150:100:70:60:10 kg/ha, respectively. Total TSP, MP, gypsum, and $ZnSO_4$ were applied during final land preparation. The urea was applied in three installments, at 15, 30, and 45 days after transplanting (DAT). Necessary intercultural operations were carried out during cropping period for proper growth and development of the plants.

For facilitating hybridization at flowering stage, several plants of CMS lines were transferred to pots previously filled with soil. Clipping of CMS panicles was done in the evening and hand pollination was carried out in the following morning by dusting pollen from 43 selected local aromatic rice genotypes. Necessary measures were taken to avoid undesirable pollination. The clipped and crossed panicles were tagged and bagged properly with white and brown papers, respectively. Bagging after pollination continued for 3-4 days to avoid unwanted pollination. After maturity, sufficient spikelets of 129 crosses were collected from panicles. Properly dried cool seeds were kept in store for further study. All F_1s along with their pollen parents were grown during both Boro and T. Aman season of 2006-07 in 1m plot of 30 plants per entry for testing pollen viability. Pollen parents of the F_1s were local Bangladeshi photo sensitive genotypes and do not flower in Boro season. Dark treatment was imposed on them for 20 days at late vegetative stage from 05 pm to 08 am for flower induction. No dark treatment was needed during T. Aman season. Randomly selected about 20 spikelets were collected from just emerged panicle of F_1 plant in a vial containing 70% ethanol for pollen viability test. At laboratory, one drop of 1% Iodine Potassium Iodide (IKI) stain was put on a glass slide. All anthers of 5-6 spikelets were then taken out with the help of forceps and placed on stain of the glass slide. Anthers were crushed gently by using needle to release pollen grains. After removing debris, a cover slip was placed on crushed grains and pollen fertility

status was observed under a compound microscope. The entire slide was scanned and pollen fertility was counted in three random fields. The pollen grains of F_1s were classified as follows based on the extent of pollen sterility (Virmani *et al.*, 1997).

Pollen sterility (%)	Category
100	Completely sterile (CS)
91-99	Sterile (S)
71-90	Partially sterile (PS)
31-70	Partially fertile (PF)
21-30	Fertile (F)
0-20	Fully fertile (FF)

Only two characters like pollen sterility percentage and spikelet fertility percentage were recorded to identify maintainers and restorers of CMS lines. The following formulae were used to calculate pollen sterility and spikelet fertility (%).

$$\text{Pollen sterility (\%)} = \frac{\text{No. of sterile pollens}}{\text{Total no. of pollens}} \times 100$$

$$\text{Spikelet fertility (\%)} = \frac{\text{Filled grains per panicle}}{\text{Total spikelets per panicle}} \times 100$$

Results and Discussion

Identification of maintainer and restorer lines against IR58025A

Pollen sterility and spikelet fertility of 43 F_1s between IR58025A and 41 local aromatic genotypes and two released aromatic rice varieties were determined during Boro and T. Aman seasons of 2006-07 for identification of maintainer and restorer lines. In T. Aman 2007 season, pollen sterility ranged from 15.28% (IR58025A × Benaful) to 100% (IR58025A × Sorukamini-2 and IR58025A × Kalijira-9) and the highest spikelet fertility of 82.91% was recorded in F_1s of the cross IR58025A × Agali (Table 1). Considering the results of two seasons, two F_1s were designated as completely sterile, one as sterile, six as partially sterile, 28 as partially fertile, three as fertile, and three as fully fertile (Table 1 and 4). The F_1s of the crosses, IR58025A × Kalijira-9 and IR58025A × Sorukamini-2 showed 100% pollen sterility and less than 3% spikelet fertility indicated that the pollen parents (Kalijira-9 and Sorukamini-2) carry maintainer genes. So, Kalijira-9 and Sorukamini-2 might be designated as maintainer lines against IR58025A.

Table 1. Sterility maintenance and fertility restoration ability of 41 local aromatic rice genotypes and two aromatic rice varieties against alien CMS line, IR58025A.

Pollen parents	Pollen sterility (%) of F_1		Spikelet fertility (%) of F_1		Status	Remarks
	Boro 06-07	T. Aman 07	Boro 06-07	T. Aman 07		
Agali	19.02	16.43	69.71	82.91	FF	Restorer
Badshabhog (colored)	NF	56.68	NA	51.06	PF	
Badshabhog-4	34.67	37.66	54.31	65.72	PF	
Badshabhog-5	42.73	33.47	63.58	74.28	PF	
Badshabhog-6	68.41	61.73	25.69	28.74	PF	
Badshabhog-7	56.39	48.64	37.45	36.43	PF	
Badshabhog-8	46.26	38.87	50.01	60.33	PF	
Badshabhog-9	58.33	49.07	57.63	60.13	PF	
Badshabhog-10	44.29	34.51	51.38	49.96	PF	
Badshabhog-11	52.67	54.88	33.50	34.83	PF	
Basmati-2	86.37	74.51	16.56	18.54	PS	
Benaful	NF	15.28	NA	80.64	FF	Restorer
BRRI Dhan-34	82.63	78.35	18.71	22.96	PS	
BRRI Dhan-38	72.53	66.97	24.61	23.75	PF	
Buchi	32.58	36.94	57.33	70.12	PF	
Chinikamini	24.81	28.98	67.58	69.57	F	
Chinisakkor-1	34.85	29.33	55.77	74.62	F	
Dakshahi	45.62	42.56	30.76	36.20	PF	
Duksail	49.64	53.18	29.24	32.14	PF	
Guamori	64.18	59.71	41.36	31.76	PF	
Jirabhog finer	36.18	38.41	50.73	63.63	PF	
Kalgochi	NF	48.44	NA	38.48	PF	
Kalijira-4	43.33	37.54	42.42	65.94	PF	
Kalijira-5	76.49	63.26	29.76	42.77	PF	
Kalijira-6	84.69	71.42	11.99	23.51	PS	
Kalijira-7	78.26	74.25	16.52	15.92	PS	
Kalijira-8	83.94	54.76	20.56	32.75	PF	
Kalijira-9	NF	100.00	NA	1.97	CS	Maintainer
Kalijira-10	53.37	50.13	52.66	62.54	PF	
Kalijira-11	87.35	65.24	13.71	17.96	PF	
Kalijira-12	68.29	57.83	35.36	47.39	PF	
Kalijira-13	NF	61.51	NA	26.54	PF	

Table 1. Cont'd.

Pollen parents	Pollen sterility (%) of F_1		Spikelet fertility (%) of F_1		Status	Remarks
	Boro 06-07	T. Aman 07	Boro 06-07	T. Aman 07		
Keora	28.59	32.01	61.34	57.62	PF	
Khasa	18.83	17.96	39.57	80.06	FF	Restorer
Maloti-1	27.94	25.57	43.52	68.11	F	
Maloti-2	84.23	73.49	19.75	18.48	PS	
Oval Tapl	98.54	94.66	7.63	7.73	S	
Radhunipagal-3	41.27	40.86	65.03	61.36	PF	
Rajbhog-1	70.47	69.23	24.67	25.39	PF	
Saibail	66.27	54.06	28.27	26.87	PF	
Sorukamini-1	97.84	84.22	6.53	10.38	PS	
Sorukamini-2	100.00	100.00	0.86	2.46	CS	Maintainer
Thakurbhog	79.52	67.87	16.31	30.71	PF	

NF = No flower, NA = Not applicable, CS = completely sterile, S = Sterile, PS = partially sterile, F = Fertile, and FF = fully fertile.

Efforts were made to convert Kalijira-9 and Sorukamini-2 into local cyto-sterile lines through several backcrossings with the sterile F_1s of the crosses, IR58025 × Kalijira-9 and IR58025 × Sorukamini-2. Kumar *et al*. (1998) produced new CMS line APMS5A by MTU4870 with background of IR58025A which facilitated to develop long duration rice hybrids. Zaman *et al.* (1998) test crossed various Basmati lines with IR68885A. Pusa Basmati-1 showed complete sterility and proved to be a perfect maintainer of wild abortive (WA) cyto-sterility. On the other hand, F_1s involving IR58025A along with Agali, Benaful, and Khasa produced more than 80% pollen and spikelet fertility in both Boro and T. Aman seasons of 2006-07 indicating that these pollen parents carry restorer genes against IR58025A cytoplasm. Therefore, Agali, Benaful and Khasa might be denoted as restorer lines against IR58025A (Table 1). Other crosses showed variable percentage of pollen sterility and spikelet fertility indicating that the involved pollen parents were heterozygous for sterility or fertility.

Identification of maintainer and restorer lines against IR62829A

Pollen sterility of 43 crosses between CMS line IR62829A and 41 local aromatic rice genotypes along with BRRI released two aromatic rice varieties ranged from 0.96 % (IR62829A × Kalijira-4) to 100 % (IR62829A × Basmati-2, IR62829A × Chinisakkor-1, IR62829A × Kalijira-5, IR62829A × Kalijira-8, IR62829A × Kalijira-12 and IR62829A × Maloti-2). Likewise, spikelet fertility ranged from 1.76% (IR62829A × Kalijira-12) to 88.36% (IR62829A × Maloti-1) in T. Aman 2007 season (Table 2). Among 43 F_1s, six were identified as completely sterile, one as sterile, eight as partial sterile, 15 as partial fertile, six as fertile and seven as fully fertile. Pollen parents (Basmati-2, Chinisakkor-1, Kalijira-5, Kalijira-8,

Kalijira-12 and Maloti-2) of completely sterile crosses were identified as potential maintainers. The identified maintainer lines could be converted into CMS lines through subsequent backcrossing with the sterile F_1s. Borkakti and Chetia (2000) evaluated pollen and spikelet fertility of F_1s with five CMS lines and reported Satava as a potential maintainer for IR62829A.

Table 2. Sterility maintenance and fertility restoration ability of 41 local aromatic rice genotypes and two aromatic rice varieties against alien CMS line, IR62829A

Pollen parent	Pollen sterility (%) of F_1		Spikelet fertility (%) of F_1		Status	Remarks
	Boro 06-07	T. Aman 07	Boro 06-07	T. Aman 07		
Agali	100	26.37	8.37	62.26	F	
Badshabhog (colored)	92.58	86.24	4.61	11.34	PS	
Badshabhog-4	43.77	39.73	40.39	51.58	PF	
Badshabhog-5	38.45	41.58	44.57	51.92	PF	
Badshabhog-6	31.37	27.63	54.34	59.72	F	
Badshabhog-7	58.46	44.19	53.63	52.83	PF	
Badshabhog-8	71.59	62.14	27.37	39.62	PF	
Badshabhog-9	56.86	50.73	34.63	31.75	PF	
Badshabhog-10	NF	89.52	NA	18.89	PS	
Badshabhog-11	NF	42.54	NA	62.17	PF	
Basmati-2	100	100	0.08	1.99	CS	Maintainer
Benaful	22.93	13.66	56.64	85.18	FF	Restorer
BRRI Dhan-34	NF	83.22	NA	17.53	PS	
BRRI Dhan-38	NF	76.31	NA	24.95	PS	
Buchi	71.51	66.13	26.36	38.58	PF	
Chinikamini	34.61	24.39	50.16	76.96	F	
Chinisakkor-1	100.00	100.00	1.54	2.89	CS	Maintainer
Dakshahi	100	28.19	2.56	65.23	F	
Duksail	72.16	58.23	22.46	32.45	PF	
Guamori	34.49	32.91	40.33	69.41	PF	
Jirabhog finer	54.36	47.26	37.24	40.61	PF	
Kalgochi	34.71	53.42	44.76	56.12	PF	
Kalijira-4	2.77	0.96	75.41	87.85	FF	Restorer
Kalijira-5	100.00	100.00	0.00	3.02	CS	Maintainer
Kalijira-6	92.26	91.48	6.48	16.73	S	
Kalijira-7	14.31	12.38	56.46	80.77	FF	Restorer
Kalijira-8	100	100	1.00	2.69	CS	Maintainer

Table 2. Cont'd.

Pollen parent	Pollen sterility (%) of F_1		Spikelet fertility (%) of F_1		Status	Remarks
	Boro 06-07	T. Aman 07	Boro 06-07	T. Aman 07		
Kalijira-9	100	70.64	1.54	30.76	PS	
Kalijira-10	84.57	72.18	36.49	40.03	PS	
Kalijira-11	100	81.26	3.72	21.17	PS	
Kalijira-12	100.00	100.00	0.00	1.76	CS	Maintainer
Kalijira-13	26.64	23.62	53.18	70.15	F	
Keora	3.86	1.53	70.37	83.63	FF	Restorer
Khasa	47.13	44.85	37.52	35.73	PF	
Maloti-1	5.18	2.77	72.62	88.36	FF	Restorer
Maloti-2	100	100	0.08	2.16	CS	Maintainer
Oval Tapl	10.61	8.62	56.47	81.96	FF	Restorer
Radhunipagal-3	67.82	50.27	25.14	37.43	PF	
Rajbhog-1	82.46	68.44	21.06	47.24	PF	
Saibail	NF	86.66	NA	20.69	PS	
Sorukamini-1	6.07	3.53	72.19	87.49	FF	Restorer
Sorukamini-2	32.64	26.69	29.09	75.12	F	
Thakurbhog	76.47	61.29	19.94	31.63	PF	

NF = No flower, NA = Not applicable, CS = completely sterile, S = Sterile, PS = partially sterile, F = Fertile, and FF = fully fertile.

Male parents (Benaful, Kalijira-4, Kalijira-7, Keora, Maloti-1, Oval Tapl, and Sorukamini-1) of fully fertile crosses were identified as restorers against IR62829A. Singh *et al.* (2000) identified Sarjoo52, Saket4, IR24, and Narendra118 as restorers against IR62829A. Fertility restoration ability of those pollen parents with different CMS lines will confirm their potentiality as aromatic restorer lines and help developing fine grain aromatic hybrids if crossed with proper aroma containing CMS lines.

Identification of maintainer and restorer lines against IR68885A

Among crosses between IR68885A and 41 Bangladeshi local aromatic rice genotypes as well as two BRRI released aromatic rice varieties, the highest (100 %) pollen sterility was observed in F_1s of the crosses IR68885A × Badshabhog-10, IR68885A × Kalijira-9, IR68885A × Saibail and IR68885A × Sorukamini-2 and the lowest one was 13.83% (IR68885A × Badshabhog-6) in T. Aman 2007 season. On the other hand, spikelet fertility was the lowest in the cross IR68885A × Saibail (2.97%) and the highest in the F_1s of IR68885A × Badshabhog-6 (82.21%) in T. Aman 2007 season (Table 3). Out of 43 F_1s, four were found as completely sterile, four as sterile, seven as partial sterile, twenty two as partial fertile, five as fertile and a single cross as fully fertile (Table 3).

Table 3. Sterility maintenance and fertility restoration ability of 41 local aromatic rice genotypes and two aromatic rice varieties against alien CMS line, IR68885A.

Pollen parent	Pollen sterility (%) of F_1		Spikelet fertility (%) of F_1		Status	Remarks
	Boro 06-07	T. Aman 07	Boro 06-07	T. Aman 07		
Agali	NF	76.22	NA	46.71	PS	
Badshabhog (colored)	93.44	80.38	5.64	14.72	PS	
Badshabhog-4	24.55	27.78	41.39	71.41	F	
Badshabhog-5	33.79	29.94	46.73	66.74	F	
Badshabhog-6	22.54	13.83	38.76	82.21	FF	Restorer
Badshabhog-7	54.61	46.33	53.05	51.19	PF	
Badshabhog-8	31.88	28.62	50.67	72.89	F	
Badshabhog-9	26.45	29.54	56.73	65.36	F	
Badshabhog-10	100.00	100.00	1.69	3.14	CS	Maintainer
Badshabhog-11	67.22	61.17	22.55	41.21	PF	
Basmati-2	58.03	49.54	40.42	43.62	PF	
Benaful	34.92	36.07	32.74	66.86	PF	
BRRI Dhan-34	45.21	41.19	51.23	62.33	PF	
BRRI Dhan-38	NF	57.42	NA	50.34	PF	
Buchi	87.59	54.16	51.45	52.48	PF	
Chinikamini	39.63	28.14	38.34	57.36	F	
Chinisakkor-1	62.53	54.86	32.19	48.29	PF	
Dakshahi	100	96.11	5.14	14.73	S	
Duksail	65.28	53.32	37.45	41.34	PF	
Guamori	100.00	83.27	5.65	26.31	PS	
Jirabhog finer	92.18	82.24	11.74	20.84	PS	
Kalgochi	97.53	92.48	11.36	15.22	S	
Kalijira-4	78.37	56.97	42.57	47.41	PF	
Kalijira-5	29.89	30.58	43.87	70.54	PF	
Kalijira-6	94.27	43.22	16.29	48.63	PF	
Kalijira-7	74.19	55.46	28.47	38.56	PF	
Kalijira-8	63.23	54.67	47.34	46.39	PF	
Kalijira-9	NF	100	NA	3.87	CS	Maintainer
Kalijira-10	100.00	94.56	3.62	11.62	S	
Kalijira-11	62.37	50.24	26.36	56.32	PF	
Kalijira-12	100.00	91.88	7.45	17.53	S	
Kalijira-13	81.33	74.63	36.43	35.47	PS	

Table 3. Cont'd.

Pollen parent	Pollen sterility (%) of F_1		Spikelet fertility (%) of F_1		Status	Remarks
	Boro 06-07	T. Aman 07	Boro 06-07	T. Aman 07		
Keora	64.16	58.17	43.89	42.66	PF	
Khasa	82.46	79.77	30.32	28.47	PS	
Maloti-1	28.77	32.29	35.63	61.38	PF	
Maloti-2	NF	36.41	NA	62.23	PF	
Oval Tapl	76.58	71.35	19.59	17.87	PS	
Radhunipagal-3	48.51	43.97	56.44	59.99	PF	
Rajbhog-1	47.11	45.61	50.66	57.63	PF	
Saibail	NF	100	NA	2.97	CS	Maintainer
Sorukamini-1	42.66	34.21	32.07	61.48	PF	
Sorukamini-2	100.00	100.00	2.79	4.33	CS	Maintainer
Thakurbhog	57.82	68.24	23.81	35.68	PF	

NF = No flower, NA = Not applicable, CS = completely sterile, S = Sterile, PS = partially sterile, F = Fertile, and FF = fully fertile.

The pollen parents (Badshahbhog-10, Kalijira-9, Saibail, and Sorukamini-2) showed completely sterile F_1s indicated as maintainers against IR68885A. Jayamani *et al.* (1998) found F_1 of V20A × Dular as completely sterile and used for subsequent backcrossing up to BC_6 generation for developing new CMS line in the background of Dular. The pollen parent (Badshabhog-6) exhibited fully fertile F_1 suggesting as restorer against IR68885A. Considering pollen sterility and spikelet fertility pattern of the crosses, higher pollen sterility and less spikelet fertility were reported during Boro season than those of T.Aman season. Moreover, 15 out of 129 crosses did not produce any flower in Boro season even after dark treatment imposed to induce flowering. Temperature might play an important role for such behavior. Nonetheless, all the selected local aromatic rice genotypes as pollen parents were photosensitive in nature and cultivable in T. Aman season only.

Out of 41 local aromatic rice genotypes, identified maintainers were two for IR58025A, six for IR62829A, and four for IR68885A (Table 4). Among the maintainers, two genotypes (Kalijira-9 and Sorukamini-2) were common for IR58025A and IR68885A. Ultimately, 10 genotypes were found as maintainer against three CMS lines. The identified completely sterile crosses could be transferred as new CMS line through subsequent backcrossing with their respective pollen parents as recurrent parent. Ali and Khan (1995) crossed 15 aromatic and non-aromatic varieties with IR58025A, IR62829A and IR64608A and found 47456 and PK4112 as potential maintainers for all the CMS lines whereas 4029-2 and 4029-3 were restorers for all the three CMS lines.

Among 41 local aromatic rice genotypes, restorers were found as three for IR58025A, seven for IR62829A and one for IR68885A. Benaful was identified as common restorer for both IR58025A, and IR62829A. Actually 10 genotypes were identified as restorers against the three CMS lines.

Table 4. Pollen sterility or fertility status of F_1s produced by three CMS lines against 41 local aromatic rice genotypes and two BRRI developed aromatic rice varieties.

CMS line	No. of pollen parents accounts for					
	Completely sterile	Sterile	Partially sterile	Partially fertile	Fertile	Fully fertile
IR58025A	2 (4.65)*	1 (2.33)	6 (19.95)	28 (65.12)	3 (6.98)	3 (6.98)
IR62829A	6 (19.95)	1 (2.33)	8 (18.60)	15 (34.88)	6 (19.95)	7 (16.28)
IR68885A	4 (9.30)	4 (9.30)	7 (16.28)	22 (51.16)	5 (11.63)	1 (2.33)

*Figure in parenthesis expressing percentage of total genotypes.

In case of maintainer and restorer identification, the same picture appeared as number of maintainers and restorers against IR62829A were higher than the rest of the two alien CMS lines. The findings of this investigation are somehow lower than the achievement of Gobinda Raj and Virmani (1989). They found 40% maintainer and 24% restorer when tested 37 indica/japonica derivatives against CMS-GA. This difference might be due to the genetic background of the test genotypes. Twenty three out of 129 crosses contributed directly to identify maintainers and restorers. Other crosses were more or less of intermediate type which indicated neither maintainer nor restorer.

References

Ali, S. S. and M. G. Khan. 1995. Maintainers and restorers identified from local germplasm in Pakistan using IRRI cytoplasmic male sterile lines. *Intl. Rice Res. Notes* **20**(2): 6.

Ali, S. S. and M. G. Khan. 1996. Development of rice cytoplasmic male sterile line 47456A in Kala Shah Kaku, Pakistan. *Intl. Rice Res. Notes* **21**(2-3): 31.

Borkakati, R. P. and S. K Chetia. 2000. Identification of parental lines for heterosis breeding in rice for Assam. *J. Interacademica* **4**(2): 224-229.

Govinda Raj K. and S. S. Virnami. 1989. Maintainer and restorers for different cytoplasmic male sterile systems. *Intl. Rice Res. Newsl*. **14**(5): 7-8.

Jayamani, P., K. N. Ganesan, K. Thyiyagarajan, M. Rangaswamy and P. Rangasamy. 1998. A new CMS line with a wide compatibility gene. *Intl. Rice Res. Notes* **23**(1): 5.

Julfiquar, A.W. J. M. Hasan, A. K. Azad and A. M. Nurunnabi. 2002. Research and development of hybrid rice in Bangladesh : A motivation to adoption. *Proc. First National Workshop on "Research and Development of Hybrid Rice in Bangladesh, Progress and Future Strategies"*. Bangladesh Rice Res. Inst., held on 5-6 January. 2002. 9-19Pp.

Kaul, M. L. H. 1997. Male sterility: cytological, biological and molecular alterations. In: Plant Breeding and Crop Improvement. Vol. (II) (Eds. Kapoor and Saini) CBS Publishers Distribution. New Delhi. 377-378Pp.

Kumar, R.V., P. V. Satyanarayana and M.S. Rao. 1996. New cytoplasmic male sterile lines developed in Andhra Pradesh, India. *Intl. Rice Res. Notes* **21**(2-3): 30.

Kumar, R.V., P. V. Satyanarayana and M.S. Rao. 1998. Identifying a new long-duration CMS line (APMS 5A) for coastal resigns. *Intl. Rice Res. Notes* **23**(1):5

Roy, A. K. 2006. Development of aromatic cytosource for hybrid rice production. *Ph.D. Dissertation*, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh. 166P.

Singh, D. K, S. Rajesh and R. Singh. 2000. Identification of parental lines for rice hybrids at varanasi location. *Crop Res. Hisar* **20**(2): 201-205.

Sutaryo, B. 1989. Evaluation of some F_1 rice hybrids developed using MB 365A as CMS line. *Intl. Rice Res. Newsl*. **14:** 7-8.

Virmani, S. S., B. C. Viraktamath, C. L. Casal, R. S. Toledo, M. T. Lopez and J.O. Manalo. 1997. Hybrid Rice Breeading Manual. Intl. Rice Res. Inst. *Los Banos,* Leguna, Philippines. 155P.

Zaman, F. U., M. J. Abraham, A. Natarajan, A. Mahendru and F. Mohammad. 1998. Developing Pusa 3A, a Basmati CMS line. *Intl. Rice Res. Notes* **23**(1):13.