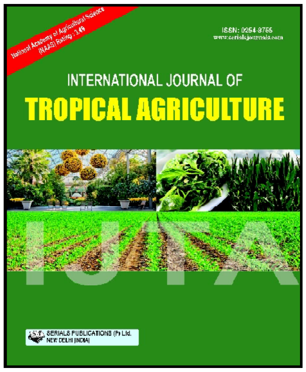

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Identification of Restorers and Maintainers for different CMS lines of Aromatic Rice (*Oryza sativa* L.).

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Abstract: Hybrid rice technology is one of the potential option for increasing rice production and productivity. The practical utility of hybrid rice is mainly dependent upon the availability of cytoplasmic male sterile line, identification of suitable restorers and maintainers, heterotic expression to surpass the yield level of locally available cultivars. This necessitates identification of restorers for different cytoplasm. Aroma of rice plays a role in its consumer acceptability and draws a premium price more than the other non aromatic rices. If aromatic rice hybrids are preferred at least one of the parents must be aromatic. In present investigation 31 genotypes belonging to aromatic/non aromatic or basmati/ non-basmati were crossed with 4 stable aromatic/non aromatic CMS lines of various cytoplasmic sources during *rabi* – 2009-10. The 124 F_1 hybrids and parental lines were evaluated during *kharif*-2010. Among the 31 high yielding varieties, the occurrence of restorer was higher in CMS lines IR 58025A of WA source (67.72%) followed by KJTCMS 6A (58.06%) of WA source, IR 62829A (51.61%) of WA sources and RTN 17A (45.16%) of Dissi source. Ten genotypes viz., SYE 131-16, GR 7, Pusa Sugandh 3, PR 113, PKV Makarand, Narmada, SYE 14-9, Pusa Sugandh 2, CSR-30 and Pusa Sugandh 4 were identified as common effective restorers for all the four CMS lines having cytoplasmic source viz., WA and Dissi. Among these 10 common restorers, 7 genotypes were aromatic while 3 were non aromatic. None of the genotypes observed as maintainer with the CMS lines studied. This suggests that, it is very complex mechanism to restore the fertility in this line possibly due to presence of excess sterility nuclear genes. The average proportion of effective restorers, partial restorers, partial maintainers and maintainers observed during study were 55.6: 30.6: 13.7: 00.0 % respectively. The identified restorers and maintainers could be utilized for development of new rice hybrids and CMS lines respectively in future.

Key words: Aromatic rice, restorers, maintainers, cms lines.

INTRODUCTION

Among the many genetic approaches being explored to break the yield barrier in rice production and productivity, hybrid rice technology is one of the potential option for increasing rice production and productivity. The practical utility of hybrid rice is mainly dependent on the availability of cytoplasmic male sterile line, identification of suitable restorers and maintainers, heterotic expression to surpass the yield level of locally available cultivars besides reasonable degree of outcrossing to produce F_1 seeds in bulk quantities with minimum cost. This necessitates identification of restorers for different cytoplasm. This will extend broad genetic base of the cytoplasmic male sterile lines, so as to prevent any possible - catastrophe due to outbreak of biotic stresses like insect pest or diseases. Aroma of rice plays a role in its consumer acceptability and draws a premium price more than the other non aromatic rices. Among the aromatic rices, long grain basmati types fetch highest premium and are mostly accepted by the consumers. If aromatic rice hybrids are preferred at least one of the parents must be aromatic (Shobha Rani *et al.,* 2001). To know the fertility restoration of aromatic/non aromatic CMS lines, 31 high yielding aromatic/non aromatic/basmati lines were utilized for making test crosses with four CMS lines developed from WA and Dissi cytoplasm. The resultant 124 test crosses were studied for their restoration reaction based on the spikelets and pollen fertility percentage.

MATERIAL AND METHODS

The experiment was carried out at Main Paddy Research Station farm, Navsari during rabi-2009-10. One hundred twenty four crosses were made in line x tester mating design among four cms lines viz. RTN 17 A (Dissi cytoplasm), KJTCMS 6A (WA cytoplasm), IR 58025A (WA cytoplasm) and IR 68829 A (WA cytoplasm) with 31 genotypes of paddy belonging to aromatic/non aromatic or basmati/non basmati groups. The parents and F_1s represented by a single row plot of 30 plants were planted at 20 x 15 spacing. All the agronomical practices and plant protection measures were followed as per recommendations. The observations were recorded on five randomly selected plants in each replication for pollen and spikelet sterility on all 124 F_1 crosses for identification of restorers and maintainers. The male parents were classified as restorer or maintainer or partial restorer or partial maintainer on the basis of pollen fertility and spikelet fertility of F_1 hybrids. The pollen fertility was recorded at the time of panicle emergence. Half emerged panicles were taken from randomly selected plants in individual 124 F_1s from the experimental field. Five anthers were plucked randomly from five spikelets and smeared in 1% IKI solution. The stain was prepared by dissolving of 1g iodine and 2g of potassium iodide in 100 ml distilled water and pollen sterility examined under the light microscope. About 200-400 pollen grains were examined. Unstained, half stained, shriveled and empty pollen grains were classified as sterile while well filled, stained and round pollen grains were recorded as fertile. The pollen fertility was calculated as follows:

$$Pollen\ fertility\,(\%) = \frac{Number\ of\ fertile\ pollen\ grains}{Total\ number\ of\ pollen\ grains\ examined} \times 100$$

Five randomly selected emerging panicles from each F_1 hybrid were bagged (to avoid out crossing) before flowering. The spikelet fertility and sterility was calculated on the basis of five randomly selected panicles from each F_1 at the time of maturity. Spikelet fertility was calculated as a percentage of filled grains. The percentage of spikelet fertility was calculated as given below:

$$Spikelet\ fertility\,(\%) = \frac{Number\ of\ grains\ in\ a\ panicle}{Total\ number\ of\ spikelets\ in\ a\ panicle} \times 100$$

The male parents of test cross hybrids were classified as effective restorers (>80% spikelet fertility), partial restorers (20-79% spikelet fertility), partial maintainers (10-19 % spikelet fertility) and maintainers (<10% spikelet fertility) on the basis of their spikelet fertility (Datt and Mani, 2002).

RESULT AND DISCUSSION

The information on fertility reaction of test cross hybrids and classification of genotypes in four categories is presented in table 1. It is revealed that, among 124 test crosses, 55.6 and 44.4 per cent were observed as restorers and partial restorers/ maintainers, respectively. The bulk of the male parents (44.4 %) were categorized as partial restorer (30.6 %) and partial maintainers (13.7 %) for all the CMS lines included in the study. The pollen and spikelet fertility in the test cross progenies ranged from 44.3 to 91.3 and 37.0 to 87.3%, respectively. The highest pollen and spikelet fertility was observed in test cross RTN 17A/PR 118 (91.3 and 87.1%) followed by KJTCMS 6A/ PR-118 (89.4 and 86.7%). About one hundred three test crosses exhibited more than 80 per cent pollen fertility and forty one test crosses exhibited more than 75 per cent spikelet fertility indicating fertile category i.e. effective fertile hybrids. Out of 31 high yielding aromatic varieties/ genotype, more than 80% fertility restoration was identified in 10 varieties (32.3%) with all the four cms lines. Fertility restoration of different CMS lines with different pollinator is given in table 2. Among 31 promising lines 23 genotypes exhibited fertility restoration with any one of the CMS line. Out of 23 genotypes, 10 (32.26%) genotypes were identified as common restorers with all the four CMS lines of two different sources (Table 1 & 2). Out of 10 common restorers, 7 genotypes were aromatic, while 3 were non aromatic. Among the 31 high yielding varieties, the occurrence of restorer was higher in CMS lines IR 58025A of WA source (67.72%) followed by KJTCMS 6A (58.06%) of WA source, IR 62829A (51.61%) of WA source, RTN 17A (45.16%) of Dissi source. Ten genotypes viz., SYE 131-16, GR 7, Pusa Sugandh 3, PR 113, PKV Makarand, Narmada, SYE 14-9, Pusa Sugandh 2, CSR-30 and Pusa Sugandh 4 were identified as common effective restorers for all the four CMS lines having cytoplasmic source viz., WA and Dissi. Out of these 10 common restorers, 7 genotypes were aromatic while 3 were non aromatic.

Present problem of grain quality of rice hybrids is primarily due to narrow genetic base of CMS lines being used. Most of the hybrids are developed and released by using WA cytoplasmic source. So far sixty-eight CMS sources have been reported of which the wild abortive (WA) cytoplasm is used extensively for the production of hybrids. About 95% of the area under cytoplasmic male sterile (CMS) derived hybrids are occupied from wild abortive (WA) cytosterility system (Yuan and Virmani, 1988). In India, 93 hybrids in rice based on WA cytosterility and other have been developed, (Anon., 2017).

In present investigation, the frequency of the male parents behaving as effective restorers was found to be maximum for IR 58025A (67.72%) of WA source followed by KJTCMS 6A (58.06%) of WA source, IR 62829A (51.61%) of WA sources, and RTN 17A (45.16%) of Dissi source indicating that the fertility in these CMS lines were easy to restore. Cytoplamic male sterility in rice is controlled by the interaction of cytoplamic and nuclear genes (Sampath and Mohanty, 1954; Katsuo and Mizushima, 1958). Presence or absence of dominant fertility restorer nuclear gene(s) is known to confirm fertility restoring or sterility maintaining ability of a genotype for a specific male fertility inducing cytoplasm. Pandya *et al.* (2001) recorded 100 % spikelet sterility in seven genotypes crosses with IR-58025A line.

Pusa Sugandh and IET 15138 behaved as partial restorers and Vasumati, Pusa Basmati 1, Tarori Basmati and VDN 96157 behaved as a partial maintainer for the CMS lines RTN 17A, IR 58025A, KJTCMS 6A and IR 62829A. PR 118, PR 113 and Pusa Sugandh 5 observed as restorers with RTN 17A, IR 58025A and KJTCMS 6A. However, these lines behaved as partial restorers with IR 62829A.

Table 1
Fertility restoration of genotypes with CMS lines (%)

CMS line and Source	*Restorer*	*Partial restorer*	*Partial maintainer*	*Maintainer*	*Total*
RTN 17 A(Dissi)	14(45.2)	12(38.7)	5(16.1)	0(0.0)	31
IR 58025A(WA)	21(67.7)	6(19.3)	4(12.9)	0(0.0)	31
KJTCMS 6A(WA)	18(58.1)	9(29.0)	4(12.9)	0(0.0)	31
IR 62829A(WA)	16(51.6)	11(35.7)	4(12.9)	0(0.0)	31
Grand total	69	38(30.6)	17(13.7)	0(0.00)	124
	55.6	44.36		0.00	

Table 2
Fertility reaction of test crosses

No	*Test crosses*	*Dissi*			*WA*			*WA*			*WA*		
	Females	*RTN 17A*			*IR 58025 A*			*KJTCMS-6A*			*IR 62829 A*		
	Males	*PF%*	*SF%*	*FR*	*PF%*	*SF%*	*FR*	*PF%*	*SF%*	*FR*	*PF%*	*SF%*	*FR*
1.	GR-104	79.2	73.2	**PR**	79.1	74.2	**PR**	81.0	79.5	**R**	79.2	73.1	**PR**
2.	Pusa Sugandh	77.8	71.5	**PR**	78.3	73.9	**PR**	79.2	74.2	**PR**	78.7	74.9	**PR**
3.	SYE-131-16	86.7	82.0	**R**	84.6	80.7	**R**	85.1	81.2	**R**	84.8	80.7	**R**
4.	GR-7	87.1	82.2	**R**	81.3	75.9	**R**	85.8	81.3	**R**	83.1	82.1	**R**
5.	Pusa Sugandh-3	83.1	78.0	**R**	84.1	79.5	**R**	88.7	84.4	**R**	83.7	80.2	**R**
6.	PR-118	91.1	87.1	**R**	84.7	79.5	**R**	89.3	86.7	**R**	79.8	73.8	**PR**
7.	GR-102	77.4	72.5	**PR**	78.8	73.3	**PR**	81.1	74.8	**R**	80.3	77.8	**R**
8.	PR-113	83.4	79.3	**R**	84.5	79.6	**R**	85.4	81.2	**R**	78.5	74.8	**PR**
9.	VDN-96204	78.4	74.6	**PR**	83.2	78.9	**R**	84.3	81.2	**R**	79.1	73.0	**PR**
10.	GR-101	77.2	73.3	**PR**	81.2	76.1	**R**	76.1	72.3	**PR**	78.2	74.1	**PR**
11.	PR-115	85.2	83.5	**R**	83.4	79.9	**R**	81.8	78.9	**R**	82.6	79.7	**R**
12.	Krishna Kamod	72.2	68.7	**PR**	83.1	76.5	**R**	72.2	67.1	**PR**	76.2	73.2	**PR**
13.	Pawana	76.2	74.1	**PR**	80.2	76.2	**R**	79.1	71.9	**PR**	81.1	77.4	**R**
14.	Vasumati	47.7	44.4	**PM**	47.2	41.0	**PM**	49.2	43.3	**PM**	44.4	37.4	**PM**
15.	PKV-Makarand	82.4	77.4	**R**	83.6	78.4	**R**	87.9	82.7	**R**	82.4	77.7	**R**
16.	Narmada	84.2	78.8	**R**	80.3	76.1	**R**	85.9	81.3	**R**	85.2	78.6	**R**
17.	SKL-41-30	79.7	74.8	**PR**	88.1	82.1	**R**	85.2	81.3	**R**	84.8	81.2	**R**
18.	Pusa Basmati-1	49.7	45.3	**PM**	48.4	44.7	**PM**	44.4	39.9	**PM**	46.2	42.2	**PM**
19.	PR-114	85.1	80.1	**R**	84.8	81.1	**R**	78.9	74.9	**PR**	84.8	80.1	**R**
20.	Pusa Sugandh-5	84.5	81.2	**R**	88.0	82.6	**R**	85.4	79.3	**R**	79.7	74.7	**PR**
21.	Tarori Basmati	51.7	47.3	**PM**	53.4	49.6	**PM**	49.2	43.9	**PM**	57.5	53.4	**PM**
22.	VDN 96157	44.4	37.2	**PM**	49.2	43.3	**PM**	47.2	40.9	**PM**	47.7	44.4	**PM**
23.	Pusa-33	46.9	37.2	**PM**	69.3	65.7	**PR**	73.7	69.9	**PR**	72.5	67.4	**PR**
24.	SYE-14-9	86.1	81.4	**R**	86.2	81.7	**R**	85.9	81.2	**R**	85.2	80.3	**R**
25.	Pusa Sugandh-2	83.2	79.8	**R**	85.2	80.3	**R**	85.1	82.4	**R**	87.3	81.9	**R**
26.	PR-116	79.9	72.9	**PR**	84.8	81.1	**R**	87.6	82.5	**R**	84.7	80.8	**R**
27.	CSR-30	84.4	78.5	**R**	86.5	81.5	**R**	86.6	81.6	**R**	84.8	80.9	**R**
28.	IET-15138	79.5	74.3	**PR**	78.4	72.4	**PR**	76.4	70.9	**PR**	79.1	71.9	**PR**
29.	VDN-90140	79.8	74.6	**PR**	81.4	80.8	**R**	78.7	73.8	**PR**	82.1	80.1	**R**
30.	Pusa Sugandh-4	84.3	81.3	**R**	82.7	77.2	**R**	80.8	75.4	**R**	85.2	81.2	**R**
31.	Phule Maval	79.2	71.8	**PR**	76.9	73.3	**PR**	79.8	74.4	**PR**	79.9	74.8	**PR**

R- Restorer, PR- Partial restorer, PM- Partial maintainer and M- Maintainer

Genotype PR 114 identified as restorers with RTN 17A, IR 58025A and KJTCMS 6A. However, genotype Pusa 33 behaved as partial maintainer for RTN 17A and partial restorer with CMS lines IR 58025A, KJTCMS 6A and IR 62829A. Genotype GR 104 identified as partial restorer for CMS lines RTN 17A, IR 58025A and IR 62829A.However, it behaved as restorer with KJTCMS 6A. None of the genotypes observed as maintainer with the CMS lines studied. This suggests that, it is very complex mechanism to restore the fertility in this line possibly due to presence of excess sterility nuclear genes, which could act as a inhibitor of pollen fertility restoration in the F_1 generation. This showed that there was differential behaviour of different genotypes with different CMS sources for their fertility restoration. The variation in the restoration ability of genotypes for the same source as well as different sources cytoplasm have also been confirmed by the studies of earlier worker viz., Salgotra *et al.* (2002), Malarvizhi *et al.* (2003), Singh (2005), Ingale *et. al.* (2005) and Kunkerkar (2006).

The effect of minor or modifier genes present in the pollinator could also result in differential fertility restoration (Bobby and Nadarajan, 1994 and Ganesan *et al.*, 1998). These presumptions also hold good for the differential behaviour of CMS lines of WA, Dissi, Mutant, Gambiaca and ARC cytoplasm for fertility restoration in the present study. The results of present study suggest that fertility restoration is CMS lines specific. Therefore, a pollen parent identified as a restorer cannot eventually be taken as a restorer for other CMS lines even of the same source. Hence, it is imperative to test the reaction of pollen parents in crosses with available CMS lines before their exploitation in further breeding work.

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