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Identification of Restorers and Maintainers for different CMS Lines of Rice

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Abstract : Hybrid rice technology has been successfully developed and is one of the potent options for increasing rice production in irrigated areas. For evolution of new rice hybrids, there is need for diversified CMS sources from local adaptable lines and identification of local adaptable restorers. In present investigation 145 genotypes were crossed with 10 stable CMS lines during *Kharif*, 2002. The 220 F_1 hybrids and parental lines were evaluated during *Kharif*, 2003. Genotypes were categorized as effective restorers (>80% spikelet fertility), partial restorers (20 to 79% spikelet fertility), partial maintainers (10-19% spikelet fertility) and maintainers (<10% spikelet fertility). Total 40 effective restorers and 77 maintainers were identified among 145 genotypes for ten CMS lines. Maximum maintainers were observed for PMS-5A line (72.5%) followed by COMS-9A (60%), IR-62275A (43%), PMS-11A (26%) and IR-68892A (23%). The maximum effective restorers were observed for IR-68899A (55%) followed by IR-68275A (36%), IR-58025A (34%) and IR-68885A (33%). The average proportion of maintainers, partial maintainers / partial restorers and effective restorers were 35:47:18, per cent, respectively in these crosses. The identified restorers and maintainers could be utilized for development of new rice hybrids and CMS lines, respectively in future.

Keywords : Restorers, maintainers, partial restorers / partial maintainers, pollen sterility, spikelet fertility.

Introduction

Rice, the traditional self pollinated crop, has witnessed all round success of hybrid cultivars in China, where hybrid rice technology has enable to increase in both biomass and harvest index (Yuan, 1992 and Virmani, 1994). Hybrid rice technology has been successfully developed and is one of the potent options for increasing rice production in irrigated areas. India and Vietnam are other important countries, which adopted hybrid rice technology on large scale. The availability of stable cytoplasmic male sterility and fertility restorer system is vital for commercial exploitation of heterosis in any crop. With the discovery of the wild abortive (WA) male sterility inducing cytoplasm from *Oryza sativa spontanea* and subsequent development of three line hybrids make a breakthrough in exploitation of heterosis in rice (Lin and Yuan, 1980). The low frequency of restores and maintainers among rice cultivars is a serious handicap in exploitation of rice hybrids of various groups with quality traits. The number of restorers for “WA” cytosterility was higher among five IRRI lines, as reported by Mohanty and Sharma (1983) and Govinda Raj *et al.* (1984).

In Maharashtra state, hybrid rice technology was introduced in 1992 on experimental basis and is now becoming popular among the rice –growing farmers (Deshpande *et al.,* 2002).

In present investigation, efforts were made to identify the maintainers and restorers among the local rice varieties for ten diverse CMS lines to develop potential rice hybrids.

Materials and Methods

The 145 varieties / lines were crossed with stable 10 cytoplasmic male sterile lines (CMS line) *viz.*, PMS-5A, IR-58025A, COMS-9A, PMS-11A, CRMS-22A, PMS-14A, IR-68275A, IR-68892A, IR-68885A and IR-68999A received from various sourcs during *kharif*, 2002 and their 220 F_1's were evaluated under rainfed transplanted conditions under normal fertility (100 kg N/ha, 50 kg P/ha and 50 kg K/ ha) during *kharif*, 2003.

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 220 F_1's 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 :

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

Five randomly selected emerging panicles from each F_1 hybrid were bagged (to avoid outcrossing) 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 :

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

The cultivars 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 (Datta and Mani, 2002).

Result and Discussion

The genotypes were identified as restorers and maintainers as per their fertility restoring and sterility maintaining ability in F1 plants of respective CMS lines. Among 145 rice genotypes, 40 genotypes crossed with PMS-5A line. Twenty-nine maintainers (<10% spikelet fertility), 2 effect restorers (>80% spikelet fertility) and 9 partial restorers / maintainers were observed in above crosses. Twenty-nine maintainers showed below 10% spikelets fertility while 9 genotypes were observed partial maintainers (10-19% spikelet fertility) and partial restorers (20-79% spikelet fertility) for above CMS A line. Two genotypes *viz.*, IR-40R and IR-58025-126-1-2R were found as restorers for PMS-5A line with spikelet fertility above 80% in F1's. The pollen sterility ranged from 8-100%. Total 35 rice genotypes were crossed with IR-58025A. In these crosses,

Table 1. Spikelets and pollen fertility (%) in F_1's and identification of restorers and maintainers for various CMS lines.

Pedigree	Spikelet Fertility %	Pollen Fertility %	Classification
PMS-5A x IR-2199-16-2-2-1	2	3	M
PMS-5A x CR-191-41	9	10	M
PMS-5A x KJT-15-1-1-38-25-7	0	0	M
PMS-5A x Annada	3	4	M
PMS-5A x KJT-15-1-38-15-27	3	4	M
PMS-5A x KJT-9-26-5-40	0	0	M
PMS-5A x RTN-3	8	9	M
PMS-5A x KJT-11-1-26-5-11	5	6	M
PMS-5A x KJT-2-28-12-26-47-17-17	5	6	M
PMS-5A x KAU-4-4-2	2	3	M
PMS-5A x OR-1509-3-516	4	5	M
PMS-5A x OR-1516-1	0	1	M
PMS-5A x Aditya	0	1	M
PMS-5A x KJT-7-1-22-33-34	5	6	M
PMS-5A x KJT-2-83-15-9-41-8	2	3	M
PMS-5A x VDN-12400	4	5	M
PMS-5A x Prabhavati	7	8	M
PMS-5A x KJT-3-2-861-25-155	5	6	M
PMS-5A x KJT-8-3-271-38	3	4	M
PMS-5A x KJT-9-1-87-28-24	7	8	M
PMS-5A x RTN-73	3	4	M
PMS-5A x IR-42266-29-2-2-2	6	7	M
PMS-5A x KJT-17-4-49-2-1-2-7	9	10	M
PMS-5A x Krishna Hansa	5	7	M
PMS-5A x IR-59669-93-1-3	6	7	M
PMS-5A x IR-62037-129-2-3-3-3	8	10	M
PMS-5A x Pusa Basmati	8	9	M
PMS-5A x BR-827-35	2	3	M
PMS-5A x HMT-Sona	2	4	M
PMS-5A x IET-13840-RP-66-67	11	13	PM
PMS-5A x IR62030-54-1-2-2R	12	14	PM
PMS-5A x R-35	12	14	PM
PMS-5A x IR-8866-30-3-1-4-2R	11	12	PM
PMS-5A x IR-63877-43-2-1-3-1	24	25	PM
PMS-5A x TKM-6	4	5	PM
PMS-5A x IR-60819-15-10	64	65	PR

Table 1. Contd...

Pedigree	Spikelet Fertility %	Pollen Fertility %	Classification
PMS-5A x RDN-93-1-3	77	78	PR
PMS-5A x IR-60997-16-2-3-2-2	72	73	PR
PMS-5A x IR-58082-126-1-2-R	86	87	R
PMS-5A x IR-40	90	92	R
IR-58025 A x KJT-12-7-27-72	3	4	M
IR-58025 A x KJT-7-1-22-33-34	7	9	M
IR-58025 A x IR-654894	4	5	M
IR-58025 A x RTN-24	8	9	M
IR-58025 A x RTN-40-3-1-1	7	8	M
IR-58025 A x RTN-163-1-31-2	7	8	M
IR-58025 A x SYE-219-3-62-6	11	12	PM
IR-58025 A x BSI-329	66	68	PR
IR-58025 A x OR-1499-9	59	60	PR
IR-58025 A x KJT-14-1-511-54	67	68	PR
IR-58025 A x KJT-18-1-125-43	61	62	PR
IR-58025 A x Basmati-386	52	53	PR
IR-58025 A x KJT-15-1-38-31-32	53	55	PR
IR-58025 A x Basmati-622-410	73	74	PR
IR-58025 A x KJT-23-305-39-9	75	76	PR
IR-58025 A x Parimal	29	30	PR
IR-58025 A x Indryani	23	24	PR
IR-58025 A x PLG-1	25	26	PR
IR-58025 A x HMT Sona	46	47	PR
IR-58025 A x KJT-31-1-5-17-31	38	39	PR
IR-58025 A x MNG-12-2-18-1	70	71	PR
IR-58025 A x BR-736-30-3-1R	44	45	PR
IR-58025 A x RTN-27-1-1-3	49	51	PR
IR-58025 A x KJT-1-2-85-35	84	85	R
IR-58025 A x KJT-14-1-511-34	83	84	R
IR-58025 A x SKL-22-63-21-48	80	81	R
IR-58025 A x IR-22896-225R	91	92	R
IR-58025 A x IR-23557-1351	82	83	R
IR-58025 A x CR-5	96	97	R
IR-58025 A x Basmati (2)	80	81	R
IR-58025 A x KJT-11-1-5-30	80	81	R
IR-58025 A x KT-3-2-35	85	87	R
IR-58025 A x KJT-1-23-5-35	83	84	R
IR-58025 A x KJT-17-4-49-2-1-2-7	14	15	R

Table 1. Contd...

Pedigree	Spikelet Fertility %	Pollen Fertility %	Classification
IR-58025 A x KJT-11-2-26-5-11	81	82	R
COMS-91 x IR-62164-32-2-3-1-	6	6	M
COMS-91 x RTN-73	7	8	M
COMS-91 x KJT-9-26-5-35	6	7	M
COMS-91 x KJT-11-1-26-5-35	6	7	M
COMS-91 x KJT-11-1-26-5-11	3	4	M
COMS-91 x KAU-4-4-2	10	11	M
COMS-91 x Annanda	3	4	M
COMS-91 x OR-1509-3-5	2	4	M
COMS-91 x IR-8866-30-3-1-4-2	8	9	M
COMS-91 x IR-32809-26-3-3	4	5	M
COMS-91 x RDN-93-1-3	3	4	M
COMS-91 x IR-58082-16-1-2	8	9	M
COMS-91 x KJT-8-3-271-38	2	4	M
COMS-91 x KJT-11-1-5-30	5	6	M
COMS-91 x PND-11-4-2-1-1	4	5	M
COMS-91 x KJT-9-1-87-28-4	2	3	M
COMS-91 x IR-58103-62-3	10	11	M
COMS-91 x Indryani	0	1	M
COMS-91 x HMT Sona	6	7	M
COMS-91 x Panvel-2	0	0	M
COMS-91 x TKM-6R-39	7	8	M
COMS-91 x KJT-11-1-26-25-23	5	6	PM
COMS-91 x KJT-7-1-22-33-34	17	18	PM
COMS-91 x VDN-12400	12	14	PM
COMS-91 x R-148	17	18	PM
COMS-91 x IR-2336-21	17	18	PM
COMS-91 x Pusa Basmati	15	17	PM
COMS-91 x R-35	74	76	PR
COMS-91 x IET-23557-135	43	45	PR
COMS-91 x KJT-12-7-27-72	54	55	PR
COMS-91 x IR-56456-4-2-3	21	22	PR
COMS-91 x IR-60819-34-2-1	36	37	PR
COMS-91 x Basmati Mahes	24	25	PR
COMS-91 x IR-23352-7	86	87	R
PMS-11A x BSI-336	0	0	M
PMS-11A x CR-191-41	6	7	M

Table 1. Contd...

Pedigree	Spikelet Fertility %	Pollen Fertility %	Classification
PMS-11A x KJT-15-1-38-15-2	10	11	M
PMS-11A x KJT-15-1-38-18-9	3	4	M
PMS-11A x BSI-329	4	5	M
PMS-11A x KJT-11-1-26-25-23	7	8	M
PMS-11A x RDN-93-1-3	2	3	M
PMS-11A x IET-8585	8	9	M
PMS-11A x IR-63881-49-2-1-3-2	16	17	PM
PMS-11A x BSI-341	19	21	PM
PMS-11A x KJT-23-305-39-9	17	19	PM
PMS-11A x IR-64	12	14	PM
PMS-11A x KJT-3-2-35	38	39	PM
PMS-11A x Prabhavati	17	8	PM
PMS-11A x Triguna	58	59	PR
PMS-11A x PNR-590-12	56	57	PR
PMS-11A x KJT-10-7-76-74-28-58	74	75	PR
PMS-11A x IR-62030-2331	71	72	PR
PMS-11A x KJT-11-1-5-30	60	62	PR
PMS-11A x IR-62037-129-2-3-3-3	32	34	PR
PMS-11A x KJT-11-1-26-5-35	61	62	PR
PMS-11A x VDN-12400	60	61	PR
PMS-11A x IR-23352-7	79	80	PR
PMS-11A x IR-33509-26-2-2	68	69	PR
PMS-11A x IR-62036-222-3-3-1-3	39	40	PR
PMS-11A x IR-62161-184-3-1-3-2	25	26	PR
PMS-11A x IR-63877-43-2-1-3-1	33	34	PR
PMS-11A x IR-63879-195-2-2-3-2	46	47	PR
PMS-11A x IET-23557-135	97	98	R
PMS-11A x IR-33509-26-2-2-2	88	89	R
PMS-11A x IR-63879-195-2-2-3-2	85	87	R
PMS-11A x Basmati-370	91	92	R
CRMS-22A x KJT-3-2-861-25-155	4	5	M
CRMS-22A x BSI-341	11	12	PM
CRMS-22A x Parag	18	19	PM
CRMS-22A x IR-58082-126-1-2	53	54	PR
CRMS-22A x IR-62164-32-2-3-1	65	66	PR
CRMS-22A x IET-13840-RP-66-67	69	70	PR
CRMS-22A x RTN-73	33	35	PR
CRMS-22A x KJT-15-1-1-38-25-7	65	66	PR

Table 1. Contd...

Pedigree	Spikelet Fertility %	Pollen Fertility %	Classification
CRMS-22A x KJT-17-6-8-26-2	65	66	PR
CRMS-22A x Ratna	41	42	PR
CRMS-22A x KAU-4-4-2	69	70	PR
CRMS-22A x OR-1628-7	74	75	PR
CRMS-22A x KJT-184	38	39	PR
CRMS-22A x RTN-40-3-1-1	66	67	PR
CRMS-22A x IR-63870-43-2-1-3-1	68	69	PR
PMS-14A x Parag	4	5	M
PMS-14A x IET-7575	3	4	M
PMS-14A x MNG-12-2-18-1	58	59	PR
PMS-14A x IR-60821-34-1-2	70	72	PR
PMS-14A x IR-56456-4-2-3	49	50	PR
PMS-14A x IR-63870-123-2-2-2-2	73	74	PR
PMS-14A x Basmati-402	21	22	PR
PMS-14A x Basmati-370	57	58	PR
PMS-14A x Basmati-6224	50	52	PR
PMS-14A x PLG-1	69	70	PR
PMS-14A x IR-2199-16-2-2-1	89	91	R
PMS-14A x VDN-12400	81	82	R
PMS-14A x IR-62037-129-2-3-3-3	90	91	R
PMS-14A x BR-827-35	93	94	R
IR-68275A x KJT-12-7-27-72	0	1	M
IR-68275A x Indrayani	0	1	M
IR-68275A x KJT-14-1-511-34	4	5	M
IR-68275A x KJT-9-19-15-5-20	8	9	M
IR-68275A x KJT-16-10-301-2	0	0	M
IR-68275A x IET-7575	1	2	M
IR-68275A x KJT-3	34	35	PR
IR-68275A x KJT-1-41-1-34	76	77	PR
IR-68275A x KJT-1-76	49	50	PR
IR-68275A x KJT-3-2-35	83	85	R
IR-68275A x RNT-46-1-2-	90	91	R
IR-68275A x IR-50	95	96	R
IR-68275A x BR-736-20-3-1	89	80	R
IR-68275A x IR-64	81	82	R
IR-68275A x OR-1509-3-516	4	5	M
IR-68892A x RAV-1344-7	5	6	M

Table 1. Contd...

Pedigree	Spikelet Fertility %	Pollen Fertility %	Classification
IR-68892A x KJT-1-23-5-35	5	7	M
IR-68892A x CR-1	14	15	PM
IR-68892A x KJT-15-1-1-38-25-7	17	18	PM
IR-68892A x IR-62164-32-2-3-1	53	54	PR
IR-68892A x IR-63881-49-2-1-3-2	66	67	PR
IR-68892A x IET-13840-RP-66-67	55	56	PR
IR-68892A x Ratna	21	23	PR
IR-68892A x KJT-184	32	33	PR
IR-68892A x IR-56456-4-2-3-R	76	77	PR
IR-68892A x RTN-73	37	39	PR
IR-68892A x IR-58082-126-1-2	84	85	R
IR-68885A x Prabhavati	12	13	PM
IR-68885A x KJT-9-1-87-28-24	14	15	PM
IR-68885A x IR-33509-26-2-2	14	15	PM
IR-68885A x IR-60997-16-2-3-2-2	50	51	PR
IR-68885A x 62171-122-3-2-3-3	64	65	PR
IR-68885A x IR-63870-123-2-2-2-2	64	66	PR
IR-68885A x IR-63879-195-2-2-3-2	77	78	PR
IR-68885A x IR-62037-129-2-3-3-3	75	76	PR
IR-68885A x IR-8860-30-3-1-4-2	84	85	R
IR-68885A x IR-60966-119-2-3-1-2	80	81	R
IR-68885A x IR-59669-93-3-3	83	84	R
IR-68885A x BR-827-35	99	100	R
IR-68899A x Parag	0	0	M
IR-68899A x KJT-2-83-15-9-41-8	17	18	PM
IR-68899A x IR-40	55	56	PR
vIR-68899A x AD-95134	25	26	PR
IR-68899A x MNG-12-2-18-1	44	45	PR
IR-68899A x IR-62164-32-2-3-1r	80	82	R
IR-68899A x IR-62030-54-1-2-2	91	92	R
IR-68899A x IR58103-42-3	91	92	R
IR-68899A x KJT-17-4-49-2-1-2-7	80	81	R
IR-68899A x IR-60966-119-2-3-1-2	90	91	R
IR-68899A x IR-33509-26-2-2	83	85	R

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

Table 2. Proportion of maintainers, partial maintainers/ partial restorers and restorers in crosses of ten CMS lines of rice

S.No.	Name of the CMS line	Total crosses	Number of Maintainers observed	Total number of partial maintainers and partial restorers observed	Number of restorers observed	Proportion of M:PM & PR : R in per cent
1	PMS5A	40	29	9	2	72.5:22.5:5
2.	IR-58025A	35	6	17	12	17:49:34
3	COMS-9A	35	21	12	2	60:34:6
4	PMS11A	31	8	19	4	24:61:13
5	CRMS-22A	15	1	14	-	7:93:0
6	PMS14A	14	2	8	4	14:57:29
7	IR-68275A	14	6	3	5	43:21:36
8	IR-68892A	13	3	9	1	23;69:8
9	IR-68885A	12	-	8	4	0:67:33
10	IR-68899A	11	1	4	6	9:36:55
	Total	220	77	103	40	35:47:18

6 maintainers (<10% spikelet fertility), 12 effective restorers (>80% spikelet fertility) and 17 partial restorers / maintainers were observed in above crosses. Six genotypes viz., KJT- 12-7-27-72, KJT-7-1-22-33-34, IR-654894, RTN- 24, RTN-40-3-1-1 and RTN-163-1-31-2 were observed as maintainers for IR-58025A line with spikelet fertility below 10% in F1's. Twelve genotypes showed above 80% spikelet fertility and these were identified as potential restores for development of new hybrid combinations. Totally 17 partial maintainers (10-19% spikelet fertility) and partial restorers (20-79% spikelet fertility) were observed for above CMS line (Table 1). The pollen sterility ranged from 3 to 96% in above hybrids. The crosses IR-58025A x KJT-12-7-27-72 recorded maximum sterility (96%) while IR-58025 x CR-5 cross recorded minimum sterility (4%). On similar line, Naghia *et al.* (1994) recorded 95,98 and 100% spikelet sterility in F1's of IR-58025A, IR-62829A and PMS-10A, respectively. Ali and Khan (1995) reported that IR-47456 and PK-4112 were potential maintainers and PK-4029-2 and PK-4029-3 were restorers for IR-58025A and IR-62829A, respectively in their studies. Pandya and Tripathi (2001) recorded 100% spikelet sterility in the crosses of IET-12037, IET-13853, IET-138757, IET-12603, IET-12601, IET-13844 and IET-13164 with IR-58025A line. Ali and Khan (1996) reported KS282 and 1021-8 as restorers and the genotypes IR-6, 4048-3, 4029-B, GP-6, GP-15, GP-16, GP-43, 4029-3, 47456, PK-3717-12, PK-3727-2, DR-82, Basmati-370, 4289, 4334, 4365, PK-3355-5-1-4, PK-3303-7-2, 49818, 33608, 50020, 50021 and Basmati 198 as maintainers for IR-58025A and IR-62829A lines.

Among 35 rice genotypes 21 maintainers, 12 partial maintainers / partial restorers and 2 effective restorers were observed in F1 of COMS-9A line. The genotype Panvel-2 recorded maximum pollen sterility (100%) while the genotype IR-22509-26-2-2 recorded the minimum pollen sterility (10%) in F_1 when crossed with COMS-9A. Twenty-nine maintainers showed below 10% spikelets fertility and 2 potential restorers *viz.*, IR-23352-7 and IR-22509-26- 2-2 showed above 80% spikelet fertility when crossed with COMS-9A line.

Thirty one rice genotypes were crossed with PMS-11A line. In these crosses 8 maintainers, 19 partial restorers / maintainers and 4 restorers were observed for above CMS line. Eight genotypes *viz.,* BSI-336, CR-191-41, KJT-15-1-38-15-2, BSI-329, KJT-15-1-38-18-9, KT-11-1-26-25-23, RDN-93-1-3 and IET-8585 showed less than 10% spikelet fertility categorized as maintainers. The F1 of PMS-11A with IET-23557-135, IR-335092-26-2-2-2, IR-63879-195-2-2-3-2 and Basmati-370 recorded more than 80% spikelet fertility in above crosses categorized as effective restorers. The genotype BSI-336 recorded maximum pollen sterility (100%) in cross with PMS-11A line.

One maintainer and 14 partial restorers / partial maintainers were observed among, 15 rice genotypes crossed with CRMS-22A line. The genotypes KJT-3-2-861-25-155 recorded 4% spikelet fertility and categorized as maintainer for above CMS line. The pollen sterility was also maximum in above F_1's (95%).

Two maintainers, 4 restorers and 8 partial restorers / maintainers were observed in 14 rice genotypes when crossed with PMS-14A line. Parag and IET-7575 recorded less than 10 % spikelet fertility and identified as maintainers while, IR-2199-16-2-2-1, VDN-12400, IR-62037-129-2-3-3-3 and BR-827-35 recorded more than 80% spikelet fertility and were identified as effective restorers for PMS-14A line to develop new hybrid combinations.

Fourteen rice genotypes were crossed with IR-68275A line. Six genotypes *viz.,* KJT-12- 7-27-72, Indrayani, KJT-14-1-511-34, KJT-9-19-15-5-20, KJT-16-10-301-2 and IET-7575 showed less than 10% spikelet fertility in F_1 and categorized as maintainers for above CMS line KJT-3-2-35, RTN-46-1-2, IR-50, BR-736-20-3-1 and IR-DRR-64 showed more than 80% spikelet fertility and categorized as effective restorers for IR-68275A line. Among above crosses, F_1 of IR-68275A x KJT-16-10-301-2 recorded 100% pollen sterility and IR-68275A x IR-50 recorded minimum pollen sterility (4%).

Among thirteen crosses, 3 maintainers, 9 partial restorers / maintainers and 1 potential restorer were observed for IR-68892A. Besides OR-1509-3-516, RAV-1344-7 and KJT-1-23-5-35 recorded less than 10% spikelet fertility when crossed with above CMS line, were categorized as maintainers. The genotype IR-58082-126-1-2 was identified as effective restorer (>80% spiklet fertility) for IR-68892A line.

In 11 crosses of IR-68885A line, 4 potential restorers and 8 partial restorers / partial maintainers were observed. The genotypes *viz.,* IR-8860-30-3-1-4-2, IR-60966-119-2-3-1-2, IR-59669-93-3-3 and BR-827-35 recorded more than 80% spikelet fertility and they were the effective restorers for above CMS line to develop new hybrid combinations.

In 11 F_1's of IR-68899A, one maintainer, 6 effective restorers and 4 partial restorers / maintainers were observed. The genotype Parag recorded maximum pollen sterility (100%) while the genotypes IR-62030-54-1-

2-2 and IR-58103-42-3 (8%) recorded minimum pollen sterility in F_1's when crossed with IR-68899A. Further, the genotype Parag recorded less than 10% spikelet fertility and categorized as maintainer for development of new CMS lines from IR-68899A line while IR-62164- 32-2-3-1R, IR-58103-42-3, IR-62030-54-1-2-2-, KJT-17-4-49-2-1-2-7, IR-60966-119-2-3-1-2 and IR-33509-26-2-2 recorded more than 80% spikelet fertility and could be used as effective restorers for development of new hybrid combinations from above CMS line.

The proportion of maintainers, partial maintainers / partial restorers and restorers were recorded in ten CMS lines (Table 2). The maximum proportions of maintainers were observed for PMS-5A (72.5%) followed by COMS-9A (60%), IR-68275A (43%), PMS-11A (26%), IR-68892A (23%), IR-58025A (17%), PMS-14A (14%), IR-68899 (9%) and CRMS-22A (7%), which could be used in conversion of new CMS lines in hybrid rice breeding programme. The maximum proportions of restorers were observed for IR-68899A (55%) followed by IR-68275A (36%), IR-58025A (34%), IR-68885A (33%) PMS-14A (29%), PMS-11A (13%) IR-68892A (8%), COMS-9A (6%) and PMS-5A (5%) which could be used for development of new rice hybrid combinations. The average proportion of 35% maintainers, 47% partial maintainer / restorers and 18% restorers, were observed in 220 crosses with ten CMS lines under study.

Majority of the testers turned out to be either partial restorers or partial maintaines (54%) based on the spikelet fertility. Neither of these could be effective restorers or maintainers for use in hybrid rice breeding programmes. Several workers reported that the pollen or spikelet fertility were highly influenced by environmental conditions (Sharma and Reinberg, 1978; Zhou, 1984). Therefore, the effective restorers and maintainer could be confirmed after screening of F_1's in various locations and seasons.

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