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Identification of restorers and maintainers for WA-CMS lines in rice (*Oryza sativa* L.)

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Abstract
Thirty early to medium duration genotypes of rice were crossed with male sterile lines *viz.* IR-68897A, IR-68888A and IR-58250A in line x tester fashion. Out of the resultant F_1s, ten restores and four maintainers were isolated for different CMS lines. The performance of pollen parents varied with the CMS lines. Based on the results, the potential restorers Jaya, Shivani, BPT-5204, Pant-12, Sarjoo-52, URG-22, URG-48, URG-51, URG-77 and URG-84, may be used for development of hybrid rice while the genotypes HUR 4-3, Jaya, URG-12 and URG-60 may be exploited through back cross breeding programme for development of new CMS lines in rice.

Keywords: Hybrid rice, heterosis, restorer and maintainer.

Introduction
Among the strategies adopted to enhance further the utilization of heterosis to raise economic grain yield levels, the development of commercial F_1 hybrids has already become popular in giving yield advantage of about 15-20% over high yielding homozygous varieties, of the various approaches for commercial application of heterosis, three line breeding methods are the most commonly used. The three line breeding method involves the use of a cytoplasmic male sterile line, its maintainer and a restorer line. A high percentage of pollen fertility restoration, stable restoring ability over locations and seasons and good combining ability are the important key attributes for developing commercially viable hybrid technology. A number of CMS and restorer lines for wild abortive (WA) cytoplasmic male sterility sources are available among indica rice cultivars (Sarial and Singh, 2000) [11]. An attempt was therefore made with the aim to isolate prospective restorers and maintainers for successful hybrid rice breeding programme.

Materials and Methods
Thirty early to medium duration rice genotypes were evaluated to identify the commercially usable restorers and maintainers at Agricultural Research Farm, Banaras Hindu University. 30 pollen parents and three cytoplasmic male sterile lines (IR-68897A, IR-68888A and IR-58025A) were grown in the field during *kharif*-2010. Staggered planting of CMS lines was done to ensure synchronous flowering. Crosses were made in all possible combination for developing F_1 hybrids. All the F_1s along with their parents were evaluated for their fertility on the basis of pollen and spikelet fertility during *kharif*-2011. Pollen studies were carried out for judging fertility/sterility of F_1 plants; fifteen spikelets from just emerged panicles from three randomly selected plants were collected. All the anthers from at least six spikelets were taken out and placed on glass slide with a drop of one per cent Iodine potassium iodide (I_2KI). Anthers were gently crushed by using needle to release pollen grains. After removing the debris, a cover slip was placed and slide was observed under microscope. For spikelet fertility/sterility five panicles of each F_1 were covered with butter paper bags to avoid foreign pollen contamination and were harvested at maturity. A standard method as proposed by Virmani *et al.* was used as criteria for classifying the parental lines as restorers and maintainers.

Results and Discussion
Out of 30 genotypes tested, three were identified as potential restorer, four as partial restorer,

four as weak maintainer and two as effective maintainer for the CMS line IR-68897A; three potential restorer, four partial restorer, seven weak maintainer and two effective maintainer for the CMS line IR-68888A and four restorers, six partial restorers, eight weak maintainers and only one maintainer for the CMS line IR-58025A (Table-1). Gautam and Singh (2004) [4] suggested that partial restorers (neither restorer nor maintainer) have no utility in the hybrid rice breeding programme. Frequency of restorers was highest for CMS line IR-58025A (14%) followed by IR-68897A and IR-68888A (10%), all of which belongs to WA (wild abortive) source of cytoplasm. The frequencies of restorers were higher compared to the frequency of maintainers. The same results were also found by Rosamma and Vijay Kumar (2005) [8], Saber *et al.* (2007) and Jaiswal and Parveen (2009) [5] who also reported that frequency of restorer was higher than the frequency of maintainers. In contrast, Ali and Khan (1996) [1] and Sabar and Akhtar (2002) reported that the frequency of maintainers higher than the restorer lines.

The genotype URG-12 was identified as effective maintainer for two CMS lines IR-68888A and IR-58025A; three genotypes were screened as effective maintainer for different CMS lines. Jaya acted as restorer for IR-68897A but maintainer for IR-68888A. URG-22 was restorer for IR-68897A and potential restorer for IR-68888A. Similarly, BPT-5204, URG-48, URG-51 and URG-84 which were restorers for different CMS lines but partial restorers for other CMS lines. URG-77 and Pant-12 (restorers) were identified as weak maintainer for IR-68888A. The genotype URG-84 shows restorer reaction for IR-68888A, partial restorer reaction for IR-58025A and weak maintainer reaction for IR-68897A and IR-58025A. Similar results were also reported by Bijral *et al.* (1993), Bobby and Nadarajan (1994), Singh *et al.* (1996) [12], Singh (2005) [13], Murugan and Ganeshan (2006) [7], Sabar *et al.* (2007) [10], Jayasudha and Sharma (2010) [6] and Upadhyay and Jaiswal (2012) [14] in their studies while using different elite lines. The study suggested that the effective maintainers *viz.* HUR 4-3, Jaya, URG-12 and URG-60 can be exploited for development of new CMS lines through recurrent back crossing while potential restorers *viz.* Jaya, Shivani, BPT-5204, Pant-12, Sarjoo-52, URG-22, URG-48, URG-51, URG-77 and URG-84 may prove useful for developing early to medium duration hybrids in rice.

Table 1: Per cent pollen and spikelet fertility of 30 upland rice genotypes involving three cytoplasmic male sterile lines.

	IR-68897A			**IR-68888A**			**IR-58025A**		
	PF (%)	**SF (%)**	**FC**	**PF (%)**	**SF (%)**	**FC**	**PF (%)**	**SF (%)**	**FC**
Pant-10	-	-	-	-	-	-	-	-	-
Pant-12	-	-	-	3.02	19.55	WM	90.02	96.32	**R**
Pant-16	42.20	39.18	PR	-	-	-	55.80	62.41	PR
Pusa-370	56.31	52.23	PR	52.10	60.00	PR	-	-	-
Pusa-44	4.01	32.63	*	36.35	68.72	PR	6.30	18.62	WM
Jaya	78.86	94.01	**R**	0.00	0.00	**M**	3.85	15.47	WM
Shivani	82.70	95.64	**R**	22.08	46.20	*	-	-	-
HUR-105	8.31	18.02	WM	3.21	16.62	WM	-	-	-
HUR-3022	32.40	88.80	*	3.50	20.41	WM	4.72	17.82	WM
BPT-5204	-	-	-	96.42	100	**R**	28.54	75.33	PR
HUR-36	16.24	52.80	*	32.06	86.35	*	14.63	66.02	PR
HUR-4-3	0.20	0.00	**M**	-	-	-	-	-	-
HUR-38	3.02	15.47	WM	8.80	18.24	WM	2.20	9.50	WM
Sarjoo-52	-	-	-	3.21	18.62	WM	88.81	97.04	**R**
URG-6	12.61	58.06	*	-	-	-	12.32	75.64	*
URG-12	8.24	20.02	WM	0.00	0.00	**M**	0.00	0.00	**M**
URG-19	3.29	78.66	*	14.37	69.12	*	3.20	20.64	WM
URG-22	94.81	98.20	**R**	45.09	78.60	PR	58.61	33.61	PR
URG-36	-	-	-	2.22	56.37	*	5.31	64.25	*
URG-48	45.73	55.10	PR	-	-	-	78.00	96.48	**R**
URG-51	35.64	78.45	PR	86.50	98.21	**R**	10.20	20.11	WM
URG-60	0.00	0.00	**M**	66.42	74.52	*	36.32	45.82	*
URG-67	66.75	92.65	*	3.05	17.38	WM	3.20	18.20	WM
URG-70	-	-	-	-	-	-	-	-	-
URG-72	14.31	88.06	*	32.17	16.82	PR	45.12	66.02	PR
URG-75	-	-	-	-	-	-	-	-	-
URG-76	52.46	92.3	*	3.09	16.23	WM	2.00	38.85	*
URG-77	-	-	-	8.62	18.00	WM	100.00	100.00	**R**
URG-83	-	-	-	54.72	78.01	*	52.42	78.82	PR
URG-84	16.02	20.32	WM	88.75	99.00	**R**	6.80	18.62	WM

PF=Pollen Fertility; SF=Spikelet Fertility; FC= Fertility Classification

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