RESEARCH ARTICLE

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IDENTIFICATION OF RESTORERS AND MAINTAINERS FOR THE DEVELOPMENT OF DROUGHT TOLERANT RICE HYBRIDS FOR EASTERN UTTAR PRADESH

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SUMMARY

Twenty eight rice genotypes were selected for identification of fertility restoration for three CMS lines (Pusa 6A, IR79156A and IR68897A) with WA cytoplasm. On the basis of pollen fertility (%) and spikelet fertility (%), restoration of fertility was identified. Out of the 28 genotypes, 5 genotypes (Dantheshwari, Akshyadhan, IR36, URG-42 and URG-30) showed complete restoration for two CMS lines i.e. Pusa 6A and IR79156A , URG-1 showed complete sterility for three CMS lines (Pusa 6A, IR79156A and IR68897A) and Anjali showed complete sterility for two CMS lines (Pusa 6A and IR79156A). Vandana showed partial maintainer for three CMS lines (Pusa 6A, IR79156A and IR68897A) and 2 genotypes (URG 24 and N22) showed partial maintainer for two CMS lines (Pusa 6A and IR79156A). NDR-97 showed partial restorer for the CMS line IR79156A and 6 genotypes (Baranideep, URG-8, URG-3, URG-5, URG-22 and MTU-1010) showed partial restorer for the CMS line Pusa 6A.

Key words: *Oryza sativa* L., fertility restoration, WA-CMS, pollen fertility (%), spikelet fertility (%)

Key findings: Out of the 28 genotypes tested with the CMS lines having WA cytoplasm, 11showed stable restoration with Pusa 6A and 6 genotypes showed stable restoration with IR79156A. Five genotypes i.e. Dantheshwari, Akshyadhan, IR36, URG-42 and URG-30 showed complete restoration for two CMS lines i.e. Pusa 6A and IR79156A. Anjali showed complete sterility for two CMS lines (Pusa 6A and IR79156A).

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INTRODUCTION

Rice is the second most important cereal crop of the world as well as of Indian subcontinent after wheat. The productivity of rice has now stagnated. Hybrid rice technology is one of the most practically feasible tools to break the yield barriers. In China, the first hybrid rice variety for commercial cultivation was released in the year 1974. India also started this programme in 1989 and released 65 hybrid rice varieties till 2014 (Singh *et al.*, 2015). Hybrid rice offers an opportunity to boost the yield potential of rice with yield advantage of 15-20% over conventional high-yielding varieties (Dar *et al.*, 2014). In India, Three line cytoplasmic genetic

male sterility (CGMS) system is being used for hybrid rice seed production at a commercial scale. As in China, the WA type of cytoplasmic male sterility (CMS) source was developed, the other sources are also to be developed for diversification of genetic materials to exploit usable heterosis. In CGMS system, it is essential to identify the promising restorers and maintainers against available specific CMS lines. Therefore, the present study was undertaken to assess the fertility restoration and also to identify best restorer cross combinations for commercial utilization.

MATERIALS AND METHODS

The experimental hybrids (56) were developed during *kharif* 2014 by using 3 wild abortive (WA) CMS lines viz., Pusa 6A, IR79156A and IR68897A crossed with 28 male genotypes. These 28 genotypes have been selected on the basis of their high yielding potential in this area and many of them are having drought tolerance. Only 56 cross combinations could be made perfectly. The experiment was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India during *kharif* 2015 with 56 experimental hybrids grown along with parents and checks, NDR-97(inbred variety) and Arise-6444Gold (popular hybrid) and three maintainers (Pusa 6B, IR79156B and IR68897B) of three CMS lines (Pusa 6A, IR79156A and IR68897A in a single row of 3 m with spacing of 20 x 15 cm^2 between row to row and plant to plant respectively in RBD with 3 replications. All the recommended agronomic practices were adopted to raise the crop under rainfed condition. Pollen and spikelet fertility of all the F_1 hybrids were studied. Pollen fertility was tested by using flowering stage panicles from each line/F_1 and fixed in aceto-alcohol (1:3) for 24 hours, and then preserved in 70% ethanol. Mature anthers from five randomly selected spikelets each from top, middle and bottom of the panicle were taken, crushed, smeared and stained in freshly prepared 1 per cent I_2-KI solution separately, and examined under a light microscope. Deeply stained, fully developed and round pollen grains were counted as fertile, whereas weakly stained/unstained and irregular shaped pollens were grouped as sterile. Pollen fertility was computed in percentage according to the formula given by Choudhary *et al.* (1981).

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

Spikelet fertility

Five randomly selected panicles from each line/F_1 were covered with butter paper bags before anthesis. At maturity the bagged panicles were harvested and the numbers of filled and unfilled spikelets were counted in each of the panicles. Spikelet fertility was computed as percentage using the formula given by Choudhary *et al.* (1981).

$$\text{Spikelet fertility (\%)} = \frac{\text{Number of filled spikelet}}{\text{Total number of spikelet}} \times 100$$

On the basis of pollen and spikelet fertility percentage of F1s, the pollen parents were classified as maintainers, partial maintainers, partial restorers and restorers based on the criteria proposed by Virmani *et al.* (1997) (Table 1) (Figures 1,2,3 and 4).

RESULTS

Identification of restorers and maintainers

Out of the 56 F_1 hybrids having CMS lines with WA cytoplasm, 17 were completely fertile and 10 completely sterile. The remaining 29 hybrids expressed varying degrees of fertility. 7 of them were partial restorer and the remaining 22 were partial maintainer. Total 5 genotypes *viz.*, Danteshwari, IR36, URG-42, Akshaydhan and URG-30 were found to be common effective restorers for both the CMS lines (Pusa 6A and IR79156A). Genotype BPT-5204 was found to be effective restorer for CMS line IR79156A.

Table 1. Percent pollen, spikelet fertility and fertility classification of 56 hybrids involving three cytoplasmic male sterile lines at BHU (according to Viramani *et al*., 1997).

No.	Name of Varieties	Spikelet fertility (%)	Pollen fertility (%)	Fertility classification
1	Pusa- 6A X BG- 102	24	35.6	PM
2	Pusa-6A X Vandana	4.6	20.3	PM
3	Pusa-6A X Anjali	0	0	M
4	Pusa-6A X Danteshwari	75.3	86.2	R
5	Pusa-6A X Akshaydhan	84.8	90.7	R
6	Pusa-6A X NDR-97	43.7	46.8	PM
7	Pusa-6A X Sahbhagidhan	0	0	M
8	Pusa-6A X N-22	29.7	40.2	PM
9	Pusa-6A X Susksamrat	76.6	85.4	R
10	Pusa-6A X IR-36	78.8	88.2	R
11	Pusa-6A X IR-64	79	86.5	R
12	Pusa-6A X NDR-359	80.3	90.6	R
13	Pusa-6A X Pantdhan-12	84.5	88.7	R
14	Pusa-6A X Baranideep	58.1	65.8	PR
15	Pusa-6A X HUR-105	77.9	83.4	R
16	Pusa-6A X URG-1	0	0	M
17	Pusa-6A X URG-8	54.6	70.3	PR
18	Pusa-6A X URG-3	50.4	60.2	PR
19	Pusa-6A X URG-5	53.9	55.6	PR
20	Pusa-6A X URG-22	58.1	68.7	PR
21	Pusa-6A X MTU-10-10	60.4	72.5	PR
22	Pusa-6A X URG-42	86.7	92.3	R
23	Pusa-6A X URG-19	0	0	M
24	Pusa-6A X URG-24	19.8	35.2	PM
25	Pusa-6A X BD-105	0	0	M
26	Pusa-6A X HUR-3022	47.9	40.8	PM
27	Pusa-6A X URG-30	84.4	90.2	R
28	Pusa-6A X IET-22202	81.1	86.5	R
29	IR 79156A X Anjali	0	0	M
30	IR 79156A X NDR-97	61.8	72.5	PR
31	IR 79156A X Susksamrat	19.1	30.2	PM
32	IR 79156A X Danteshwari	78.3	84.3	R
33	IR 79156A X Vandana	13.8	35.8	PM
34	IR 79156A X URG-19	9.5	20.4	PM
35	IR 79156A X URG-5	16.6	24.1	PM
36	IR 79156A X NDR-359	32.9	42.6	PM
37	IR 79156A X BG-102	0	0	M
38	IR79156A X IR36	79.2	88.5	R
39	IR79156A X IR64	20.3	26.5	PM
40	IR 79156A X N-22	22.2	20.7	PM
41	IR 79156A X URG-3	34.4	40.2	PM
42	IR 79156A X Sahbhagidhan	14.6	20.4	PM
43	IR 79156A X URG-1	0	0	M
44	IR 79156A X Pantdhan-12	22.7	32.1	PM
45	IR 79156A X URG-8	33	45.6	PM
46	IR 79156A X BD-105	0	0	M
47	IR 79156A X URG-42	93.8	95.6	R
48	IR 79156A X Akshaydhan	81.8	88.8	R
49	IR 79156A X MTU-10-10	23.2	34.3	PM
50	IR 79156A X Baranideep	12.3	20.3	PM
51	IR 79156A X URG-22	21	33.2	PM
52	IR 79156A X URG-24	8.8	14	PM
53	IR 79156A X BPT-5204	77.3	86.4	R
54	IR 79156A X URG-30	78	85.8	R
55	IR 68897A X Vandana	3.7	12.5	PM
56	IR 68897A X URG-1	0	0	M

M = Maintainer; R = Restorer; PM = Partial Maintainer; PR = Partial Restorer

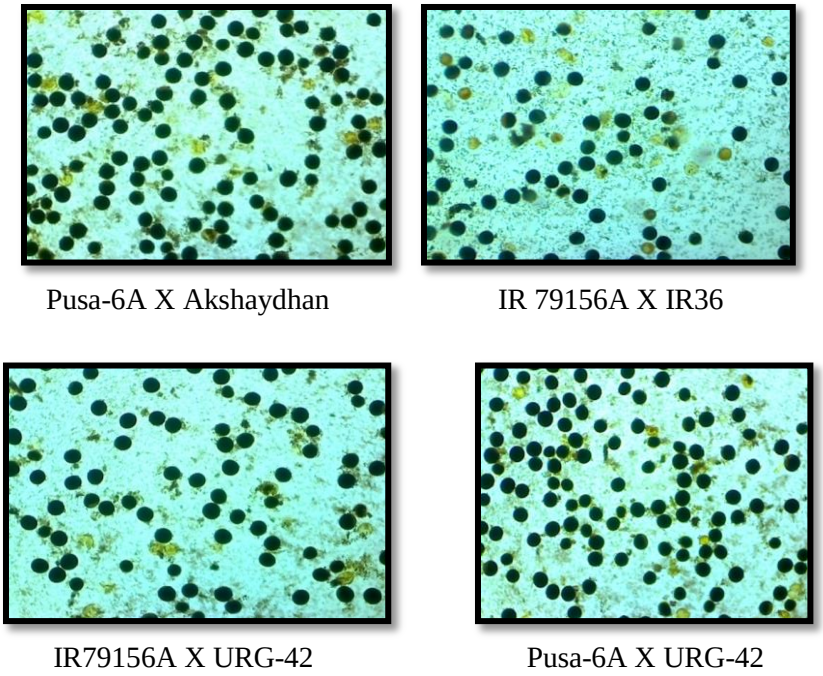


Figure 1. Microscopic photographs of full restorer pollen grains in F1 hybrid rice.

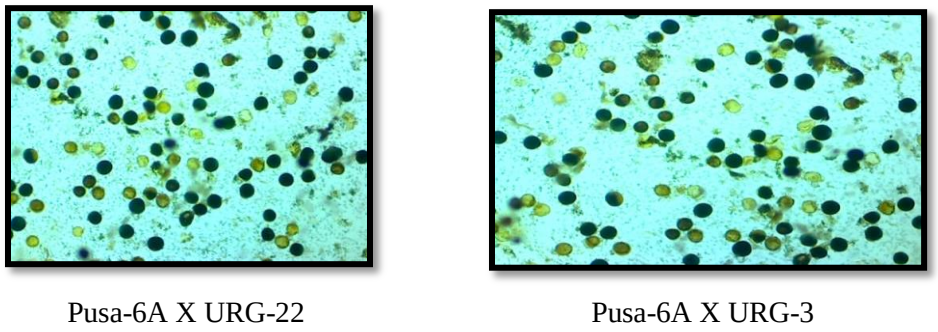


Figure 2: Microscopic photographs of partial restorer pollen grains in F_1 hybrid rice.

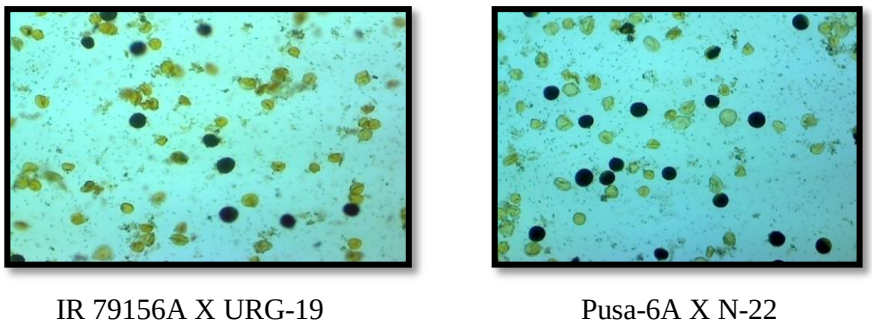
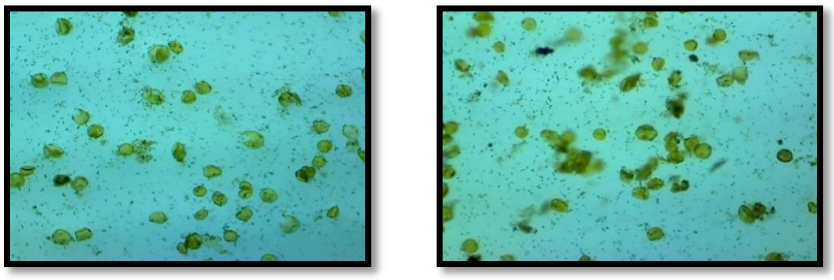


Figure 3. Microscopic photographs of partial maintainer pollen grains in F_1 hybrid rice.



Pusa-6A X Sahbhagidhan IR79156A X BG-102

Figure 4. Microscopic photographs of maintainer pollen grains in F_1 hybrid rice heterosis.

Genotypes HUR-105, IET-22202, Susksamarat, IR64, NDR-359 and Pantdhan-12 were found to be effective restorer for CMS line Pusa 6A. Genotype BG-102 produced sterile hybrids when crossed with IR79156A. Sahbhagidhan and URG-19 produced sterile hybrids when crossed with Pusa 6A. Two genotypes (Anjali and BD-105) produced sterile hybrids when crossed with both the CMS lines (Pusa 6A and IR79156A). URG-1 produced sterile hybrids when crossed with all three CMS lines (Pusa 6A, IR79156A and IR68897A). Cross with CMS line IR68897A could be made successful only with two pollen parents i.e. Vandana and URG-1. Vandana showed partial maintainer whereas, URG-1 showed complete maintainer action with IR68897A.

All crosses showed marked variations for spikelet fertility and pollen fertility (Table 1). Pollen fertility of the hybrids produced from Pusa 6A ranged from 92.3% (Pusa-6A X URG-42) to 0.0% (Anjali, Sahbhagidhan, URG 1, URG 19 and BD 105) and 95.6% (IR79156A X URG-42) to 0.0% (Anjali, BG 102, URG 1 and BD 105) for IR79156A. Spikelet fertility ranged from 94.5% (Pusa-6A X Pantdhan-12) to 0.00% (Anjali, Sahbhagidhan, URG 1, URG 19 and BD 105) for Pusa 6A and 81.8% (IR79156A X Akshaydhan) to 0.0%(Anjali, BG 102, URG 1 and BD 105) for IR79156A.

DISCUSSION

Identification of restorers and maintainers is the foremost important step in production of hybrids. The restorers can be used to develop hybrids and the maintainers can be used in the development of new CMS lines. In this investigation, 3 cytoplasmic male sterile lines were used for the identification of fertility restoration in 28 genotypes. The frequency of restorers was more than the frequency of the maintainers. Similar results were also reported by Virmani and Edwards (1983), Das *et al*. (2013), Veeresha *et al*. (2013). In other study Rosamma and Vijayakumar (2005) and Ingale *et al.* (2005) reported that both restorers and maintainers are in equal proportions for the genotypes under their study. Variation in the fertility restoration of genotypes with different CMS lines for the same cytoplasmic source i.e. WA was observed in this study. Kumar *et al*. (2002), Hariprasanna *et al.* (2005) reported the same results. According to the above studies genotypes behaving as restorers may behave as partial restorers against the same CMS lines. The change in fertility restoration nature of some of the restorers with male sterile lines of same source or of different source could be due to fertility restoring genes or some modifying genes (Waghmode and Mehta, 2011). Virmani and Edwards (1983) suggested that the restoring ability of some genotypes is site specific. Some partial restorers or partial maintainers for different CMS lines were also observed in above investigation, but these partial restorers and maintainers doesn't have any importance in the

hybrid rice breeding programme (Gautham and Singh, 2004).

In conclusion, the potential restorers identified can be used for developing stable rice hybrids with enhanced heterosis for yield and yield related traits. In this study, many of the genotypes haven't been studied for their fertility restoration and stability which is giving a new idea to breeder for including these genotypes in future hybrid rice breeding program. The effective maintainers can be used to develop new CMS lines through recurrent back crossing. URG-1 has good yield under rainfed condition and behaved as stable maintainer for three CMS lines (Pusa 6A, IR79156A and IR68897A) used in the study. Thus URG-1 can be used for production stable CMS line for rainfed areas.

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