Seed Production of Basmati Hybrids in Jammu using WA Type CMS System

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Abstract

In hybrid rice research and production, the success of the female seed production plays the decisive role to the cost of F_1 seed production expenses of commercial rice production. Three wild abortive (WA) cytoplasmic-genetic male sterile (CMS) lines in basmati background namely Pusa 3A, Pusa 5A and Pusa 6A procured from IARI, New Delhi, were used for seed production of hybrids and male sterile lines with their respective restorers (R) and maintainers (M) in 6:2 and 8:2 row ratios. Pusa 5A x Basmati 564 had the highest out-crossing rate of 27.43 per cent under flag-leaf clipping supplemented with GA_3 spray conditions and 24.45 per cent under unclipped conditions in 6:2 row ratio, whereas this cross combination showed 25.42 and 21.23 per cent out-crossing under flag-leaf clipping and under unclipped conditions, respectively. In seed production of hybrids as well as CMS lines, 6:2 row ratio found to be more effective in this region compared to 8:2 row ratio due to low wind velocity during the peak pollination period. One spray of gibberellic acid (GA_3) at panicle initiation stage has enhanced panicle as well as stigma exsertion in CMS lines which resulted in high out-crossing and higher seed set in flag leaf clipped conditions.

To meet the demands of increasing population and to sustain self sufficiency in rice production, the current production level of around 90 million tonnes needs to be achieved in the backdrop of declining and deteriorating resource base such as land, water, labour and other inputs and that too without adversely affecting the quality of environment. This indeed is a herculean task, with the available technological options. Moreover there is hardly any scope for bringing more area under rice cultivation. Under such situations, where the productivity has come to stagnation since last two decades and all the efforts have failed to give tangible results to break the genetic yield barrier in rice. Of the various approaches contemplated to break the existing yield barriers in rice to feed the burgeoning population, hybrid rice technology is practically feasible and readily adoptable genetic option to increase the rice production and is considered as one of the promising, sustainable and eco-friendly technology. Hybrid rice varieties yield about 15 to 20 per cent more than even the best of the improved or high yielding inbred varieties do and has a particularly good potential to improve the food security of poor countries where arable land is scarce, populations are expanding and labour is cheap. Impressive progress in China encouraged other rice growing countries to adopt this technology.

In hybrid rice research and production, the success of the female seed production plays the decisive role to the cost of F_1 seed production expenses of commercial rice production. The use of male sterility is a pre requisite for commercial exploitation of heterosis since rice is a self-pollinated crop. However, seed setting in a cytoplasmic-genic male sterile (CMS) line depends upon the extent of out-crossing which is a function of floral morphology and flowering behaviour of CMS lines and the male parents (Oka and Morishima, 1967). The present study was carried out to know the extent of out-crossing and seed setting in seed production of hybrid and male sterile lines in basmati rice in Jammu region.

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Materials and Methods

Three wild abortive (WA) cytoplasmic-genetic male sterile (CMS) lines in basmati background namely Pusa 3A, Pusa 5A and Pusa 6A (A lines) alongwith their maintainers (B lines) were obtained from Division of Genetics, IARI, New Delhi (Table 1). These lines were crossed with local/improved breeding of basmati to identify effective restorers and maintainers in the Division of Plant Breeding and Genetics, Sher-e-Kashmir University of Agricultural Sciences & Technology, Chatha, Jammu and Kashmir, India during *kharif* 2003. Test crosses alongwith the parents were evaluated during *kharif* 2004. Among the improved basmati/ breeding lines, Basmati 564 found to restore the fertility of all the three CMS lines. Genotype HUR-FG-78 found to be effective restorer with Pusa 3A and Pusa 6A, whereas, HUR-FG-79 and HUR-FG-81 restored the fertility with Pusa 3A and Pusa 5A, respectively. Simultaneously, these elite restorer lines were crossed with their respective CMS lines during *kharif* 2004 and evaluated at Jammu during *kharif* 2005 for further confirmation of fertility restoration of newly identified restorer lines. Seed production of hybrids with their respective restorers (R) and maintainers (B) was carried out in 6:2 and 8:2 row ratios during *kharif* 2006. The seed production technology was supplemented with flag-leaf clipping, rope pulling and gibberellic acid (GA_3) spray.

Table 1. Parents along with their sources

Parent	Source
A. CMS lines	
Pusa 3A	IARI, New Delhi
Pusa 5A	-do-
Pusa 6A	-do-
B. Maintainers	
Pusa 3B	IARI, New Delhi
Pusa 5B	-do-
Pusa 6B	-do-
C. Restorers	
Basmati 564	SKUAST-J, Jammu
HUR-FG-78	Directorate of Rice Research, Hyderabad

The experimental material was planted in sets for each A/B and A/R lines. Each set were transplanted twice in a randomized block design. Single seedlings were transplanted of A and B, and A and R plants with a spacing of 20 x 15 cm between rows and plants. Each set were isolated by 1.25 m on all the sides. The isolation was done by using a high density polythene sheets. A three metre tall cotton cloth screen provided along the centre of the ridge was enough to check movement of any stray pollen (Sneep *et al.,* 1979). At booting stage, the upper leaves of the CMS plants were held firmly and cut with a sharp sickle in such a way that 1/2 to 1/3 of the flag-leaf was removed. Gibberellic acid (GA_3) was sprayed @ 75 ppm when 20 per cent of the tillers had headed. Fifteen panicles were selected randomly from the centre of each set for counting the filled and unfilled seeds per panicle. Data were analyzed using standard methods of Panse and Sukhatme (1984).

Results and Discussion

Out-crossing in CMS lines: The cytoplasmic-genetic male sterile (CMS) line Pusa 5A showed the highest out-crossing rate in male sterile (24.01 and 20.45%) and hybrid (25.30 and 21.05%) seed production compared to Pusa 3A and Pusa 6A in 6:2 row ratio (Table 2). Similar trend was shown by Pusa 5A for hybrids and male sterile seed production in 8:2 row ratios (Table 3). The lowest out-crossing rate was shown by CMS line Pusa 3A for hybrid (20.11 and 18.50%) and male sterile (17.09 and 14.49%) seed production in 6:2 row ratios. Similarly, this line also showed the lowest out-crossing and lowest seed set percentage in 8:2 row ratios. The low out-crossing in Pusa 3A and Pusa 6A may be due to poor panicle exsertion and stigma. Thus, CMS line Pusa 5A can be used efficiently for the production of hybrid seed and may be exploited in hybrid rice breeding programme. Silitonga (1985) also reported low out-crossing rate and seed set in cytoplasmic-genetic male sterile lines of rice due to poor exsertion of panicle from flag-leaf.

Effect of flag-leaf clipping on out-crossing: The out-crossing rate was higher under flag-leaf clipped compared to unclipped conditions in 6:2 as well as 8:2 row ratios (Tables 2 and 3). The out-crossing and seed set percentage, in general 2-5 per cent higher under flag-leaf clipped conditions compared to unclipped conditions. The high out-crossing and seed set percentage observed to be due to easy and uniform dispersal of pollen grains under flag-leaf clipped condition which results in high cross pollination. An increase in out-crossing in CMS lines by flag-leaf clipped technique has also been reported by Lin and Yuan (1980).

Effect of flag-leaf clipping supplemented with GA_3 spray: Significant increase in out-crossing rate was observed under flag-leaf clipping supplemented with GA_3 spray compared to unclipped conditions for seed production of both CMS lines as well as hybrids (Tables 4 and 5). The cross combination Pusa 5A x Basmati 564 had the highest out-crossing rate of 27.43 per cent under flag-leaf clipped conditions and 24.45 per cent under unclipped conditions in 6:2 row ratio, whereas this cross combination showed 25.42 and 21.23 per cent out-crossing under flag-leaf clipping and under unclipped conditions, respectively. Similar trends for hybrids and male sterile seed production were observed in 8:2 row ratios when supplemented with GA_3 spray. Enhanced panicle and stigma exsertion was observed in flag-leaf clipped CMS lines when sprayed with GA_3 under both the row ratios compared to flag-leaf unclipped conditions that results in high pollination and seed set percentage in cytosterile (A) lines.

Effect of different row ratios on out-crossing: The out-crossing observed to be higher for hybrid as well as male sterile seed production in 6:2 row ratios compared to 8:2 row ratio under both flag-leaf clipped and unclipped conditions either it may be supplemented with GA_3 spray or not. In 6:2 row ratios, hybrid combination Pusa 5A x Basmati 564 produced the highest seed yield of 68.33g per plot under flag-leaf clipped conditions supplemented by GA_3 spray and 63.25g per plot under unclipped flag-leaf. Similar trend of hybrid seed production was also shown by hybrid combination Pusa 5A x Basmati 564 in 8:2 row ratio under flag-leaf clipped and unclipped conditions. The low out-crossing rate and seed set in 8:2 row ratio may probably be due to higher row numbers in 8:2 row ratio which subsequently increases the distance from their respective pollinator parents. Satota and Sutaryo (1989) and Bui-Ba-Bong (1992) have also reported low out-crossing rate and seed yield in male cytosterile lines with higher row ratio as compared to low ratio in their studies while using wild (WA) and Assam rice collection (ARC) male sterile lines. They have also reported that there is a decrease in out-crossing rate and seed yield in CMS lines with the increase in distance from the pollinators.

It can be concluded that the seed production of hybrids as well as CMS lines, 6:2 row ratio has been found to be more effective in this region which results in high out-crossing and higher seed set as compared to 8:2 row ratio. This may be because of high cross pollination by the pollen grains compared to 8:2 row ratios. Moreover, the pollen grains could not reach efficiently to the central rows of CMS lines in 8:2 row ratios due to low wind velocity during the peak pollination period compared to 6:2 row ratios. The out-crossing rate in CMS lines observed to be high under flag-leaf clipped conditions supplemented with gibberellic acid (GA_3) spray compared to unclipped conditions in both the row ratios. This may be due to easy and uniform dispersal of pollen grains on the CMS lines under flag-leaf clipped conditions. Gibberellic acid (GA_3) at panicle initiation stage observed to enhance panicle as well as stigma exsertion in CMS lines which resulted in high out-crossing and higher seed set percentage in flag-leaf clipped conditions.

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Table 2: Out-crossing rate of hybrid and male sterile lines of basmati rice in 6:2 row ratios

Females/Males	Plot size (m²)		Out-crossing rate (%)		Seed yield			
					Plot (g)		Hectare (kg)	
	LC	LUC	LC	LUC	LC	LUC	LC	LUC
Pusa 3A x Pusa 3B	2.02	2.02	20.11	18.50	55.41	50.25	274.30	248.76
Pusa 5A x Pusa 5B	2.02	2.02	24.01	20.45	60.14	56.21	297.72	278.26
Pusa 6A x Pusa 6B	2.02	2.02	23.15	19.14	50.23	46.25	248.66	228.96
Pusa 3A x Basmati 564	2.02	2.02	17.09	14.49	37.37	36.49	184.54	180.19
Pusa 5A x Basmati 564	2.02	2.02	25.30	21.05	65.24	60.26	322.97	298.31
Pusa 6A x HUR-FG-78	2.02	2.02	16.47	14.35	36.03	35.64	177.92	176.00
Pusa 6A x Basmati 564	2.02	2.02	20.05	17.05	43.82	42.62	216.39	210.46
SE(m) ±			2.55	1.00	1.50	1.57	1.61	2.00

LU = Leaf clipped and LUC = Leaf unclipped

Table 3: Out-crossing rate of hybrid and male sterile lines of basmati rice in 8:2 row ratios

Females/Males	Plot size (m²)		Out-crossing rate (%)		Seed yield			
					Plot (g)		Hectare (kg)	
	LC	LUC	LC	LUC	LC	LUC	LC	LUC
Pusa 3A x Pusa 3B	2.70	2.70	18.11	17.50	53.47	48.15	198.03	178.33
Pusa 5A x Pusa 5B	2.70	2.70	23.21	18.44	55.19	52.18	204.40	193.25
Pusa 6A x Pusa 6B	2.70	2.70	22.18	18.24	47.20	44.22	174.81	163.77
Pusa 3A x Basmati 564	2.70	2.70	15.95	14.50	37.06	34.67	137.25	128.40
Pusa 5A x Basmati 564	2.70	2.70	21.28	17.55	58.22	55.66	215.62	206.14
Pusa 6A x Basmati 564	2.70	2.70	19.88	16.61	40.42	39.70	149.70	147.03
Pusa 6A x HUR-FG-78	2.70	2.70	16.15	14.76	46.45	44.48	172.03	164.74
SE(m) ±			1.52	1.00	1.25	1.55	1.64	1.59

LU = Leaf clipped and LUC = Leaf unclipped

Table 4: Out-crossing rate of hybrid and male sterile lines of basmati rice supplemented with GA3 spray in 6:2 row ratios

Females/Males	Plot size (m^2)		Out-crossing rate (%)		Seed yield			
					Plot (g)		Hectare (kg)	
	LC+ GA_3	LUC+ GA_3	LC+ GA_3	LUC+ GA_3	LC+ GA_3	LUC+ GA_3	LC+ GA_3	LUC+ GA_3
Pusa 3A x Pusa 3B	2.02	2.02	21.31	20.25	57.24	52.02	283.36	257.52
Pusa 5A x Pusa 5B	2.02	2.02	26.11	22.35	61.34	57.21	303.66	283.21
Pusa 6A x Pusa 6B	2.02	2.02	25.19	21.25	55.20	49.35	273.67	244.30
Pusa 3A x Basmati 564	2.02	2.02	19.78	16.74	39.03	38.24	193.21	189.30
Pusa 5A x Basmati 564	2.02	2.02	27.43	24.45	68.33	63.25	338.26	313.11
Pusa 6A x HUR-FG-78	2.02	2.02	19.40	16.55	38.15	36.86	188.86	182.47
Pusa 6A x Basmati 564	2.02	2.02	23.75	19.77	46.18	44.48	228.61	220.19
SE(m) ±			2.19	1.12	1.39	1.59	1.54	1.89

LU = Leaf clipped, LUC = Leaf unclipped and GA_3 = Gibberellic acid

Table 5: Out-crossing rate of hybrid and male sterile lines of basmati rice supplemented with GA_3 spray in 8:2 row ratios

Females/Males	Plot size (m^2)		Out-crossing rate (%)		Seed yield			
					Plot (g)		Hectare (kg)	
	LC+ GA_3	LUC+ GA_3	LC+ GA_3	LUC+ GA_3	LC+ GA_3	LUC+ GA_3	LC+ GA_3	LUC+ GA_3
Pusa 3A x Pusa 3B	2.70	2.70	19.21	18.75	55.44	50.44	205.33	186.81
Pusa 5A x Pusa 5B	2.70	2.70	24.12	20.46	56.00	53.46	207.40	198.00
Pusa 6A x Pusa 6B	2.70	2.70	24.11	20.77	48.23	46.58	178.62	172.51
Pusa 3A x Basmati 564	2.70	2.70	16.55	15.18	36.24	35.16	134.22	130.22
Pusa 5A x Basmati 564	2.70	2.70	25.42	21.23	60.02	57.06	222.29	211.33
Pusa 6A x Basmati 564	2.70	2.70	21.15	17.41	38.15	33.26	141.29	123.18
Pusa 6A x HUR-FG-78	2.70	2.70	19.11	16.26	48.09	45.18	178.11	167.33
SE(m) ±			1.45	0.89	1.16	1.65	1.74	1.85

LU = Leaf clipped, LUC = Leaf unclipped and GA_3 = Gibberellic acid

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