

Original Research Article

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Identification of Promising IRRI CMS Lines through OCR in Chhattisgarh, India

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ABSTRACT

The investigation was carried out to estimate the component of genetic variability and associated parameters among 12 IRRI CMS lines and evaluated for morphological characteristics that influence outcrossing rate in hybrid rice. There was a marked variation in out crossing rate of CMS lines ranging from 18% to 45% under uniform weather conditions for all the CMS lines. Variation in plant height, number of panicle per plant and panicle length appeared to have an influence on outcrossing rate. Phenotypic acceptability, plant height (cm), days to 50% flowering, Panicles per plant and out crossing rate (OCR) here assessed. IR 102760A found best CMS lines with highest OCR % and yield per plant among 12 CMS lines. It means such type of CMS line will be suitable for hybrid seed program and profitable in hybrid rice seed business followed by IR 105688A, IR 102757A, IR 105687A and IR 102571A may also be a promising CMS lines for hybrid rice seed program and heterosis breeding since they possess critical outcrossing traits such as panicles per plant and panicle length. Plant height, panicle per plant and plant length, had moderate heritability with high genetic advance expected in the subsequent generation revealed role of additive gene action. The GCV and PCV somewhat varied from each other for most of the characters studied showed, there is no environmental influence on these traits. Genotypic correlation coefficient were higher than strong relation to phenotypic correlation coefficient indicated high relation among the studied character.

Keywords

CMS line, OCR, Rice, Spikelet fertility, Variability

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Introduction

Rice is the staple food for the millions of people in the world. Hybrid rice technology is considered as one of the promising, practical, sustainable and eco-friendly options to break the yield ceiling in rice (Sheeba *et al.*, 2009). The use of hybrid rice varieties on commercial scale utilizing male sterility and fertility restoration system has proved to be one of the mile stones in the history of rice

improvement. The hybrid rice technology now in operation, aims at yield increment through higher exploitable heterosis levels (Islam *et al.*, 2010).

In three line system of hybrid rice variety development system, three lines, A, B and R are required. A line is the cytoplasm-genetic male sterile line where the male sterility is jointly controlled by recessive nuclear gene and sterile cytoplasm.

B-line is isogenic line of A-line, only difference in male sterility and fertility. R-line possesses fertility restoration gene (Islam *et al.*, 2014). A commercial A-line is characterized by the absence of pollen grains or rudimentary pollens, agronomically superiority, stable sterility, wide regeneration spectrum, abortive anther and highly synchronized (Yuan *et al.*, 1998). B line is the maintainer line characterized by normal anthers, functional pollens and seed setting on selfing. While normal anthers, functional pollens, abundant pollen producing capacity, strong restoring ability, good combining ability, high out crossing rate, and genetically diverse from CMS line (Islam *et al.*, 2009 and Mian *et al.*, 2010) are the main characteristics of R-line. It is 30 years since the first commercial release of hybrid rice. Plant cytoplasmic male sterility (CMS), a maternally inherited trait that prevents plants from producing functional pollen, has been identified in many higher plants, including rice, cotton, maize, and sorghum. CMS restorer systems have been widely exploited to produce hybrids that outperform their inbred parents in yield, biomass, or other traits.

The discovery of CMS in rice suggested that breeding could develop a commercially viable F₁ hybrid (Athwal and Virmani, 1972). The most promising hybrids yielded 20-30% (Lin and Yuan, 1980) and 15-20% (Yuan, 1998) higher than the best conventional rice varieties. Therefore, to break through the present yield ceiling of semi dwarf modern varieties, hybrid rice seems to be an attractive viable alternative. It is urgently needed to develop parental lines viz. A lines, B lines and R lines for developing hybrid rice varieties, with resistance to disease or environmental changes. Cytoplasmic genetic male sterility (CGMS) resulting from nuclear-cytoplasmic interaction has been commercially exploited for the production of

F₁ hybrid seed in rice. Iso-cytoplasmic restorers have been developed successfully for many CMS lines. CMS sources are distinguished from one another on the basis of the fertility of crosses involving CMS lines and restorers (Eusebio *et al.*, 2002).

Materials and Methods

The present study and experiment was conducted at university research field cum instructional farm, hybrid rice section, department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India. It is situated at 21°16' N Latitude and 81°36' E longitude at an altitude of 289.60 meters above mean sea level. 12 WA CMS lines collected from IRRI, Philippines, Manila was grown during summer rice season of 2020. The experiment was conducted as randomized complete block design with two replications with inter-row and intra row spacing of 20 cm.

All recommended agronomical practices were followed to raise the ideal crop stand. 13 important traits like Days to 50% flowering, Plant Height, effective tillers per plant, panicle length, number of fertile spikelets per panicle, sterile spikelet per plant, Outcrossing rate, Biological weight, grain weight were recorded.

Analysis of variance (ANOVA) was conducted and variance within the population was determined along with important parameters like Genotypic Coefficient of Variability (GCV), Phenotypic Coefficient of Variability (PCV), Heritability %, Genetic Advance (GA)% were calculated. Correlation coefficient analysis in order to determine the genotypic and phenotypic correlation among the 13 traits was also conducted. Outcrossing rate (OCR %) calculated by given equation and scale suggested in IRRI hybrid rice breeding manual (Virmani *et al.*, 1997).

Outcrossing rate (OCR%)

It refers to extent of seed set on open pollinated panicles which is expressed in percentage.

$$OCR (\%) = \frac{\text{No. of Filled Spikelets}}{\text{Total no. of spikelets}} \times 100$$

Scale	No. of seed set on open pollinated panicle
1	>35
3	25-35
5	15-25
7	5-15
9	0-5

Results and Discussion

Cytoplasmic male sterility (CMS) lines in hybrid rice breeding programme, outcrossing rate is one of the most important characteristics hybrid seed production program. Analysis of genotypic and phenotypic coefficient of variation was not remarkably varied from each other for most of the character studied.

Analysis of genotypic and phenotypic coefficient of variation was not remarkably varied from each other for most of the characters studied, indicated negligible environmental influence on these traits. Variation exhibited highly significant differences among the CMS lines for the characters studied.

Assessment based on mean value

The study evinced that mean values indicated considerable variation for all the traits under study revealing scope of development of CMS lines with good outcrossing ability (Table 1). Days to 50 % flowering, No. of

panicles per plant, panicle length and Out crossing rate (%) were expressed differentially in different CMS lines. Duration of CMS lines ranged from 132 to 147 days. CMS line IR 102757A had the shortest growth duration and IR 102760A had the highest duration. Days to flowering ranged from 112 to 127 days. The CMS line IR 102760A required the longest time for days to flowering that was significantly different from rest of the CMS lines. The CMS line IR 102758A showed the highest plant height (97 cm.) as compared to others, followed by CMS lines, IR 102571A and IR 102573A. The other CMS lines exhibited medium short stature, such variations were also observed earlier by Hasan *et al.*, (2011). The genotypes were mostly dwarf to semi dwarf in nature with an average height of 85.44 cm.

The maximum number of productive tillers per plant was recorded in the CMSIR 102571A followed by IR 102572A and IR 102757A. Panicle length ranged from 21 to 28 cm. The longest panicle length was found in CMS line IR 68897A followed by IR 102758A. OCR % was found to be in a range of 18% to 45.02% with an average out crossing % of 32.21%.

Out crossing % which is the most vital trait for consideration was found to be highest in IR 102760A (45.02%) which is >35%. Sheeba *et al.*, (2006) and Virmani *et al.*, (1989) reported similar results on this traits. Five CMS lines performing highest scorer 42% (Fig 1) in outcrossing ratio (25-35%) out of 12 CMS lines and scored one (1) according Virmani *et al.*, (1997). The maximum coefficient of variation of OCR 8.16% indicated that out crossing rate was remarkably varied in the trial that could be minimized by statistical inference. Laut *et al.*, (1994) reported significant difference in outcrossing potential among the CMS lines. Most of the tested CMS lines were found stable in respect of pollen sterility (Table 1).

Assessment based on coefficient of variation, heritability and genetic advance

Genetic variability analysis revealed narrow difference between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for all the characters indicating the reliability of PCV as a measure of GCV.

In general the PCV were higher than the corresponding GCV (Table 2) and GCV provides a mean to study the genetic variability generated in quantitative characters. The genotypic and phenotypic coefficient of variations, broad sense heritability and genetic advance in percent of mean are presented in Table 2.

Genotypic coefficient of variation (GCV) ranged from 35.61 (Days to Flowering) to 225.66 (No. of sterile spikelet) and phenotypic coefficient of variation (PCV) ranged from 187.14 (Flag leaf length) to 245.81 (Fertile spikelet). The genotypic and phenotypic coefficient of variations remarkably differ in the tested entry for most of the characters studied, indicating maximum environmental influence on these traits (Similarly find by Singh *et al.*, 2015).

Sterile spikelet showed high magnitudes of heritability and high genetic advances but low variations among the CMS lines. Maurya and Singh, (1986) reported that high heritability along with high genetic advance could be the effect for high selection response in low land rice. Plant height exhibited high heritability and moderate genetic advance but the difference between GCV and PCV Table 2.

Genetics parameter for different characters of 12 CMS lines was minimum in Days to flowering, it means highly influenced by environment. Out crossing rate had appreciable heritability and genetic advance

expected in the next generation due to high genetic advance with high heritability and selection may be effective on the basis of OCR %. In general, genotypic correlation coefficients were higher than corresponding phenotypic correlation coefficients, suggesting strong inherent relation among all the characters.

The height positive significant association both at genotypic and phenotypic levels with sterile spikelet of CMS lines and genotypic level with outcrossing rate in hybrid rice breeding. Panicles per plant had positive and highly significant association with panicle length. Hasan *et al.*, (1987) found plant height had positive and significant association with panicle length.

Dhanraj *et al.*, (1987) and found positive correlation between days to 50 % flowering with plant height and effective tillers per plant. Panicles per plant positively and highly significantly genotypic correlation associated with Out Crossing Rate (OCR). Virmani, (1994) and Sharma, (1995) found total number of spikelet per panicle with higher outcrossing rate. Panicle length showed positive and highly genotypic correlation significant association with Out Crossing Rate (OCR). Abeysekera *et al.*, 2003).

However, characteristics like plant height, panicles per plant and panicle length should be considered important in enhancing out crossing rate category which showed high performance of one or several characteristics associated with outcrossing. Among the eight CMS lines evaluated, IR 102760A, IR 105688A, IR 102757A, IR 105687A and IR 102571A may be exploited for heterosis breeding since they possess critical outcrossing traits such as OCR% (>35%), No. of panicles per plant and panicle length. IR 102760A showed highest yield per plant (20.77 gm.) with highest OCR % (45.02).

Table.1 Morphological characteristics and OCR % in IRRI WA CMS lines

CMS Line	Days to Flowering	No. of Tillers /plant	Productive Tillers /plant	Plant Height	Flag Leaf Length (cm)	Flag Leaf Width	Panicle Length (cm)	No. of Panicle	Fertile Spikelet	Sterile spikelet	OCR (%)	Biological weight (gm)	Grain weight (gm)
	1	2	3	4	5	6	7	8	9	10	11	12	13
IR 93558A	117.00	13.50	15.00	82.76	33.79	1.30	21.18	17.00	376.00	983.50	27.68	31.50	8.17
IR 105687A	114.50	18.00	14.00	83.19	27.63	1.38	23.68	17.05	929.50	1431.00	39.70	37.00	19.10
IR 102760A	126.50	22.00	17.50	82.53	24.04	1.42	23.79	21.88	958.50	1170.00	45.02	55.50	20.77
IR 102758A	123.50	14.50	12.50	96.51	25.98	1.32	27.88	12.14	358.00	914.00	28.13	32.00	7.37
IR 102573A	116.00	16.50	12.50	87.58	27.97	1.21	24.28	12.03	262.50	1200.50	18.00	40.00	10.70
IR 102572A	113.50	19.00	22.00	74.06	24.74	1.42	21.28	18.21	341.50	1165.50	22.67	39.00	4.24
IR 102571A	121.00	24.00	25.00	92.04	27.35	1.50	25.81	21.03	836.50	1447.50	36.62	51.50	19.05
IR 102569A	119.00	22.50	21.00	80.93	21.24	1.30	20.53	22.21	541.00	1581.50	25.49	51.50	12.88
IR 105688A	123.00	16.50	14.50	81.81	25.51	1.31	23.07	12.98	852.50	1205.50	41.42	43.00	16.14
IR 102757A	111.50	16.00	18.50	76.39	25.81	1.23	21.51	17.90	704.00	1022.00	40.64	48.00	16.61
IR 68897A	117.00	14.00	14.00	96.38	34.03	1.11	28.09	15.12	387.50	795.50	32.78	26.50	8.08
IR 58025A	124.50	12.50	12.50	91.13	27.60	1.22	26.45	14.03	390.50	988.00	28.38	31.50	8.07
G. Mean	118.92	17.42	16.58	85.44	27.14	1.31	23.96	16.80	578.17	1158.71	32.21	40.58	12.60
C.D.	7.05	5.24	3.77	2.03	0.86	0.04	0.52	1.50	101.34	198.79	5.85	5.57	1.53
SE(m)	2.24	1.66	1.20	0.65	0.27	0.01	0.16	0.48	32.17	63.11	1.86	1.77	0.49
SE(d)	3.17	2.35	1.69	0.91	0.39	0.02	0.23	0.67	45.50	89.26	2.63	2.50	0.69
C.V.	2.66	13.50	10.20	1.07	1.43	1.51	0.97	4.00	7.87	7.70	8.16	6.16	5.46

Table.2 Genetics parameters for different characters of 12 tested entries

Characteristics	Range	Mean	PCV	GCV	Heritability (%)	Genetic Advance (%)
Days to Flowering	111-127	118.92	226.21	35.61	2.48	11.55
No. of Tillers/plant	13-24	17.42	233.38	64.34	7.60	36.54
Productive Tillers/plant	13-25	16.58	213.74	145.51	46.35	204.07
Plant Height	74-97	85.44	194.97	93.71	23.10	92.78
Flag Leaf Length (cm)	21-34	27.14	187.14	139.74	55.76	214.96
Flag Leaf Width	1.1-1.5	1.31	187.52	104.04	30.79	118.92
Panicle Length (cm)	21-18	23.96	213.35	145.43	46.46	204.21
No. of Panicle	12-22	16.80	206.65	163.20	62.37	265.52
Fertile Spikelet	262-989	578.17	245.81	224.62	83.51	422.84
Sterile spikelet	796-1582	1158.71	232.11	225.66	94.53	451.96
OCR %	18-45	32.21	196.97	182.66	86.00	348.93
Biological weight (gm)	27-56	40.58	197.57	192.58	95.01	386.67
Grain weight (gm)	4-21	12.60	207.27	194.84	88.37	377.31

Table.3 Genotypic and phenotypic correlation coefficients between yield and yield components in 12 CMS lines of rice

		2	3	4	5	6	7	8	9	10	11	12	13
1	GC	1.137**	1.915**	1.535**	2.346**	2.530**	1.660**	1.899**	2.194**	2.800**	2.709**	2.034**	2.872**
	PC	0.996**	0.998**	0.919**	0.874**	0.733**	0.553**	0.596**	0.617**	0.146NS	-0.023NS	0.474*	-0.122NS
2	GC		1.324**	1.141**	1.585**	1.736**	1.138**	1.274**	1.451**	1.826**	1.712**	1.211**	1.718**
	PC		0.992**	0.896**	0.831**	0.674**	0.561**	0.617**	0.647**	0.082NS	-0.095NS	0.530**	-0.062NS
3	GC			1.029**	1.038**	1.105**	0.977**	0.992**	1.009**	1.091**	1.009**	0.824**	1.059**
	PC			0.940**	0.890**	0.757**	0.595**	0.629**	0.644**	0.194NS	0.023NS	0.479*	-0.173NS
4	GC				1.109**	1.161**	1.040**	1.080**	1.119**	1.242**	1.310**	1.267**	1.598**
	PC				0.958**	0.888**	0.736**	0.710**	0.687**	0.495*	0.334NS	0.392NS	-0.485*
5	GC					1.023**	1.080**	1.067**	1.033**	1.025**	0.980**	0.942**	1.150**
	PC					0.970**	0.543**	0.495*	0.458*	0.553**	0.445*	0.146NS	-0.528**
6	GC						1.185**	1.173**	1.120**	1.065**	1.103**	1.236**	1.482**
	PC						0.490*	0.400NS	0.337NS	0.705**	0.635**	-0.031NS	-0.678**
7	GC							1.006**	1.032**	1.159**	1.219**	1.107**	1.374**
	PC							0.975**	0.948**	0.515*	0.306NS	0.680**	-0.502*
8	GC								1.012**	1.113**	1.103**	0.936**	1.164**
	PC								0.992**	0.377NS	0.141NS	0.805**	-0.317NS
9	GC									1.049**	0.982**	0.814**	1.001**
	PC									0.263NS	0.022NS	0.862**	-0.211NS
10	GC										0.915**	0.846**	1.000**
	PC										0.966**	-0.137NS	-0.890**
11	GC											1.051**	1.138**
	PC											-0.368NS	-0.900**
12	GC												1.013**
	PC												0.272NS

It is concluded that IR 102760A found best CMS lines with highest OCR % and yield per plant. It means such type of CMS line will be suitable for hybrid seed program and profitable in hybrid rice seed business followed by IR 105688A, IR 102757A, IR 105687A and IR 102571A may also be a promising CMS lines for hybrid rice seed program and heterosis breeding.

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