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Research Notes

Evaluation of different CMS lines for out crossing potential in rice

M. Umadevi, P.Veerabadhiran, S.Manonmani and P.Shanmugasundaram

Abstract
A total of 74 CMS lines in rice and their maintainers were evaluated for morphological and floral characters influencing out crossing rate. Out of 74 CMS lines, forty two CMS lines were completely pollen sterile. For all other CMS lines spikelet fertility ranged from 0.51 to 4.55 per cent. The medium duration CMS lines *viz.,* COMS 13, COMS 15, IR 68281, IR 69626, DRR 7, RTN 6, RTN 13 and PMS 17 were found promising for the characters *viz.,* pollen sterility (%), glume angle, panicle exsertion (%), stigma exsertion (%), natural out crossing (%) and medium duration favorable for out-crossing during seed production of A x B and A x R combinations. These CMS lines offer scope for utilizing in the development three line hybrids with high yield in rice.
Key words: CMS lines, rice, morphological and floral traits, out crossing rate.

Rice is strictly self pollinated crop and natural out crossing rate is extremely low. Hybrid rice giving a yield advantage of about 20-30 % over high yielding homozygous varieties (Yuan, 2002) is a better choice. Higher yield in hybrid seed production depends on CMS lines and out crossing rate is influenced by various morphological and floral traits. For commercial application of heterosis, the three line breeding method is most commonly used in China and elsewhere. Successful development of hybrid rice depends on improvement of parental lines *viz.,* A, B and R. The search for alternate sources of CMS in hybrid rice breeding is a priority because more than 90 per cent of the hybrids released throughout the world are based on a single sterile cytoplasm, wild abortive (WA). Hence, the present study was initiated to evaluate different rice CMS lines and their maintainer lines for pollen sterility, spikelet fertility, glume angle, agronomic characters and natural out crossing percentage for developing three line hybrids in rice.

Seventy four CMS lines and their maintainer lines were raised at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore, India during July 2007. Three pairs of each CMS lines and their maintainer lines were planted side by side in single row plots having twelve hills per row with two replications and a spacing of 20 x 20 cm. During the crop growth, recommended package of practices were followed. Observations were recorded for stigma exsertion %, pollen sterility %, spikelet fertility %, glume angle, anthesis time, panicle exsertion %, tip and awn colour and natural seed set (%). About 10-15 spikelets from the freshly emerged panicles of all the 12 plants were collected and examined under microscope with 1% Iodine Potassium Iodide (I-KI) solution for pollen sterility assessment. Five panicles per plant were evaluated for natural seed set per cent.

For glume angle, at the time of flowering, three well-opened florets of the primary panicle were collected. The angle of the opened floret was measured using protractor. The stigma exsertion was calculated by the ratio of spikelets with exserted stigma to the total number of spikelets and expressed in percentage. Panicles emerging from the sheath were bagged with butter paper bags prior to anthesis to prevent cross-pollination. Bagged panicles were harvested to assess seed setting per cent.

Analysis of variance showed significant differences among the lines for all the characters (table 1). Taller pollen parent and clear panicle exsertion would facilitate better pollen dispersal resulting in higher

Centre for Plant Breeding and Genetics,
Tamil Nadu Agrl. University, Coimbatore – 641 003.
Email: keerthitnau@yahoo.com

seed set. All the floral characteristics of 74 CGMS lines showed in table 2. The mean, range, GCV, PCV, CD %, CV %, heritability (broad sense), GA as percentage of mean for six floral traits was worked out and presented in table 3. .

Angle of floret opening for all the lines varied from 15 to 30^0. In the present study maximum angle was observed in COMS 15A, IR 68892A and PMS 17A. Sing and Rang (1999) observed a range of 35 to 48^0.

The minimum days to 50 % flowering 86.50, which was recorded in case of DMS 3A and Zhenshan 97A, where as it was maximum in case of KJT CMS 6A (113.50).

Hundred per cent pollen and spikelet sterility in CMS lines is a highly desirable character for hybrid rice seed production. The results showed that, out of 74 CMS lines evaluated, thirty eight CMS lines namely, COMS 8, COMS 13, COMS 15, COMS 16, COMS 19, IR 66707, IR 68275, IR 68281, IR 68899, IR 68902, IR 70362, IR 69626, IR 75596, IR 68885, IR 70959, IR 80151, IR 80555, IR 80186, DRR 2, DRR 5, DRR 7, DRR 8, RTN 4, RTN 5, RTN 6, RTN 12, RTN 13, RTN 17, RTN 18, PMS 3, PMS 17, KJT CMS 5, KJT CMS 6, APMS 5, APMS 6, DMS 3, CMS 29 and CMS 39 had above 90 % pollen sterility and complete spikelet sterility. Regarding panicle exsertion, twenty six CMS lines *viz.,* COMS 9, COMS 11, COMS 12, COMS 13, COMS 15, COMS 19, IR 68275, IR 68280, IR 68281, IR 68890, IR 68892, IR 69626, IR 71321, DRR 3, DRR 5, DRR 7, DRR 8, RTN 1, RTN 3, RTN 6, RTN 12, RTN 13, PMS 17, APMS 6, CMS 29, CMS 39 exhibited above 80 % exsertion which is highly desirable for seed set as suggested by Virmani et al (1980) in Zhenshan 97. High percentage of stigma exsertion is an important character which directly affects the out crossing rate of A lines. Stigma exsertion of above 40 % was recorded for twenty one CMS lines *viz.,* COMS 13, COMS 15, IR 68229, IR 68281, IR 68285, IR 69626, IR 68885, IR 75596, IR 70369, IR 70959, IR 71321, IR 73320, IR 80151, IR 80156, DRR 7, DRR 12, RTN 6, RTN 13, PMS 17 APMS 6A and CMS 39. Eventhough the traits *viz.,* panicle and stigma exsertion are favourable in the CMS lines viz., APMS 6A and CMS 39A, their outcrossing is less which might be due to narrow glome opening. Out of 35 lines studied, 16 lines were observed having above 30% stigma exsertion (Sitdarthan *et al.,*2007).

In the present study, the traits *viz.,* days to 50 % flowering, percentage of panicle exsertion and stigma exsertion recorded higher heritability estimates in broad sense exceeding 95 per cent. The genetic advance as per cent of mean was found to be high for stigma exsertion % and out crossing percentage. Such high heritability coupled with high genetic advance was reported for stigma exsertion by Kamalahar (2003). On the contrary, high heritability and high genetic advance was reported by Seetharamaiah et al (2001) for panicle exsertion percentage.. PCV was higher than GCV for all the characters studied. Higher magnitude (more than 20 %) of PCV and GCV was recorded for out crossing percentage alone. Low GCV estimates were noticed in the present study for days to 50 % flowering, panicle exsertion % and pollen sterility %. Similar findings of low GCV for panicle exsertion percentage were reported earlier by Shivani and Sree Rama Reddy (2000) and Seetharamaiah et al (2001)

To conclude, eight CMS lines *viz.,* COMS 13, COMS 15, IR 68281, IR 69626, DRR 7, RTN 6, RTN 13 and PMS 17 were found to be promising for the characters *viz.,* 100 per cent pollen sterility, above 80 % panicle exsertion, above 40 % stigma exsertion, 25^0 and above glume angle, 39.8 to 46.5 % out crossing and medium in duration which offer scope for development of three line high yielding medium duration hybrids in rice provided good restorers are identified.

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Table 1. Analysis of variance for various traits of 74 CMS lines

Characters	Mean sum of square		
	Replication DF =1	Genotype DF=73	Error DF=73
Days to 50 % flowering	5.297	98.069**	6.188
Panicle exsertion %	8.463	53.129**	2.654
Stigma exsertion %	41.573	92.497**	1.695
Pollen sterility %	1.088	0.786*	0.205
Glume angle (^{0})	21.19	31.74**	0.53
Out crossing %	1.613	130.678*	23.173

** Highly significant * Significant

Table 2. Evaluation of seventy four rice CMS lines for pollen sterility and other floral traits

Sl.no	Entries	Days to 50 % flowering	Anthesis time (hrs)	Glume angle (^{O})	Panicle exsertion %	Stigma exsertion %	Pollen sterility %	Spikelet fertility %	Out crossing %	Tip colour	Awning	Stigma colour
1	COMS 8	88.50	10.45	25.00	79.86	33.69(T.S)	99.98	0.00	27.00	Green	-	White
2	COMS 9	93.50	10.30	25.00	86.71	31.08(T.S)	99.75	0.51	19.00	Purple	-	Purple
3	COMS 11	97.00	10.45	20.00	81.12	26.51(T.S)	99.43	0.89	21.50	Green	-	White
4	COMS 12	95.50	10.30	25.00	81.39	35.98(T.S)	99.39	0.78	19.50	Purple	-	Purple
5	COMS 13	99.50	10.30	25.00	87.63	41.85(O.S)	100.00	0.00	46.50	Green	Small	White
6	COMS 14	95.00	10.30	20.00	74.67	38.89(O.S)	99.59	0.68	35.00	Green	-	White
7	COMS 15	99.00	11.00	30.00	81.25	41.95(O.S)	100.00	0.00	40.00	Green	-	White
8	COMS 16	96.00	10.40	20.00	75.41	36.96(O.S)	99.99	0.00	30.50	Green	-	White
9	COMS 18	99.50	10.45	25.00	77.36	30.19(T.S)	98.89	0.74	33.00	Green	-	White
10	COMS 19	98.00	10.45	20.00	81.61	37.09(O.S)	99.95	0.00	27.00	Green	-	White
11	IR 66707	95.50	10.45	25.00	71.79	34.09(T.S)	99.93	0.00	21.00	Green	small	White
12	IR 68229	88.50	10.30	25.00	79.08	42.19(T.S)	98.54	0.93	19.00	Green	Small	White
13	IR 68275	99.50	10.45	20.00	81.28	31.15(O.S)	100.00	0.00	22.50	Green	-	White
14	IR 68280	102.00	11.00	20.00	80.95	31.48(O.S)	98.81	1.47	31.00	Green	small	White
15	IR 68281	107.5	10.45	25.00	89.68	41.09(T.S)	99.94	0.00	44.00	Purple	-	Purple
16	IR 68285	109.00	11.00	20.00	79.90	41.20(T.S)	99.06	0.94	29.50	Yellow	-	White
17	IR 68890	102.50	11.15	25.00	83.75	35.20(O.S)	98.28	1.52	22.00	Purple	-	Purple
18	IR 68892	105.50	10.45	30.00	81.38	37.89(T.S)	99.19	0.68	19.00	Green	-	White
19	IR 68899	107.50	10.45	20.00	74.25	36.44(O.S)	99.94	0.00	19.50	Green	Medium	White
20	IR 68902	104.00	10.30	20.00	76.12	37.50(T.S)	99.94	0.00	26.50	Green	Medium	White
21	IR 69628	106.50	10.30	15.00	79.76	24.84(O.S)	99.17	0.93	29.50	Green	-	White

Sl.no	Entries	Days to 50 % flowering	Anthesis time (hrs)	Glume angle (^{O})	Panicle exsertion %	Stigma exsertion %	Pollen sterility %	Spikelet fertility %	Out crossing %	Tip colour	Awning	Stigma colour
22	IR 70362	104.00	10.30	20.00	72.16	36.84(O.S)	99.93	0.00	27.50	Green	Medium	White
23	IR 69626	102.50	11.00	25.00	83.97	41.87(T.S)	99.92	0.00	39.80	Green	Medium	White
24	DRR 2	109.00	11.00	20.00	79.86	39.09(O.S)	99.04	0.00	29.50	Purple	-	Purple
25	IR 75596	107.50	11.00	25.00	77.09	41.40(O.S)	99.97	0.00	18.50	Green	-	White
26	IR 68885	99.00	11.00	20.00	71.46	40.87(O.S)	99.92	0.00	22.00	Green	-	White
27	IR 80155	109.00	11.00	25.00	77.03	34.29(T.S)	99.24	0.92	18.50	Green	Small	White
28	IR 70369	96.50	10.00	20.00	78.26	41.38(O.S)	98.89	1.74	15.00	Green	Medium	White
29	IR 70959	99.00	10.30	15.00	74.25	41.97(O.S)	99.93	0.00	33.00	Purple	-	Purple
30	IR 71321	107.50	10.15	20.00	88.48	47.06(T.S)	98.64	0.76	27.50	Green	Small	White
31	IR 73320	102.50	9.30	20.00	74.06	48.65(T.S)	99.28	0.94	14.00	Green	-	White
32	IR 73321	103.50	10.00	20.00	69.64	38.81(O.S)	98.51	1.02	34.50	Green	Medium	White
33	IR 73328	109.00	10.00	20.00	75.25	26.82(O.S)	98.53	1.04	19.50	Green	-	White
34	IR 79156	102.50	10.00	25.00	79.75	37.50(O.S)	99.95	0.51	25.50	Green	Medium	White
35	IR 80151	99.00	10.00	25.00	76.96	40.37(O.S)	99.98	0.00	19.00	Green	-	White
36	IR 80154	101.00	10.15	20.00	79.48	36.92(O.S)	99.13	0.74	19.00	Green	Small	White
37	IR 80156	99.00	10.30	25.00	78.03	41.35(T.S)	98.91	1.47	24.50	Green	-	White
38	IR 80555	98.50	10.00	20.00	69.23	39.86(T.S)	99.98	0.00	27.00	Green	Small	White
39	IR 80559	98.50	9.30	25.00	78.09	32.64(T.S)	99.15	1.00	28.00	yellow	Small	White
40	IR 80186	101.50	10.00	15.00	74.29	35.45(T.S)	100.00	0.00	30.50	Green	Medium	White
41	DRR 3	96.00	10.00	15.00	83.33	38.42(T.S)	99.93	0.97	29.00	Green	-	White
42	DRR 4	88.50	10.15	15.00	77.01	22.92(O.S)	98.79	1.23	54.50	Purple	-	Purple
43	DRR 5	88.80	10.15	20.00	80.77	34.00(O.S)	99.92	0.00	21.00	Green	-	White

Sl.no	Entries	Days to 50 % flowering	Anthesis time (hrs)	Glume angle (^{O})	Panicle exsertion %	Stigma exsertion %	Pollen sterility %	Spikelet fertility %	Out crossing %	Tip colour	Awning	Stigma colour
44	DRR 6	92.00	9.45	20.00	79.24	22.95(O.S)	99.28	0.91	36.50	Purple	-	Purple
45	DRR 7	90.00	9.30	25.00	88.81	41.36(T.S)	99.93	0.00	42.00	Purple	-	Purple
46	DRR 8	95.00	10.00	20.00	80.26	38.51(T.S)	100.00	0.00	29.00	Purple	-	Purple
47	DRR 10	99.50	10.30	15.00	70.78	38.89(T.S)	99.64	0.56	31.00	Green	-	White
48	DRR 12	102.50	9.45	20.00	79.10	46.79(O.S)	97.64	2.17	24.50	Green	-	White
49	RTN 1	96.50	10.00	20.00	80.53	26.09(T.S)	96.30	4.55	35.00	Green	-	White
50	RTN 2	90.00	9.30	20.00	74.68	37.50(T.S)	99.81	0.85	42.00	Green	-	White
51	RTN 3	96.50	10.30	25.00	81.92	35.00(T.S)	98.15	2.22	39.00	Green	-	White
52	RTN 4	112.50	11.00	20.00	70.11	25.68(T.S)	99.92	0.00	26.50	Green	Small	White
53	RTN 5	105.50	10.30	15.00	73.34	27.94(O.S)	99.90	0.00	29.00	Green	-	White
54	RTN 6	96.50	10.30	30.00	82.14	42.11(T.S)	99.97	0.00	40.50	Green	-	White
55	RTN 11	112.50	10.30	30.00	67.66	28.57(O.S)	99.25	0.53	26.75	Green	Small	White
56	RTN 12	99.00	10.30	25.00	81.84	27.07(T.S)	99.73	0.00	21.00	Green	-	White
57	RTN 13	111.00	11.00	25.00	81.25	41.59(T.S)	100.00	0.00	41.00	Green	Small	White
58	RTN 17	114.50	11.00	20.00	79.36	20.69(T.S)	99.74	0.00	29.75	Green	Small	White
59	RTN 18	92.50	11.00	25.00	71.17	36.56(O.S)	99.92	0.00	27.00	Green	Medium	White
60	PMS 3	102.50	11.00	25.00	71.74	29.58(T.S)	100.00	0.00	30.25	Green	-	White
61	PMS 10	106.50	11.00	20.00	74.78	34.68(O.S)	99.19	0.76	25.50	Green	-	White
62	PMS 17	104.00	11.15	30.00	82.84	45.04(T.S)	99.95	0.00	41.50	Green	-	White
63	CRMS 45	97.50	11.00	25.00	70.14	20.00(T.S)	99.11	0.78	33.13	Green	-	White
64	KJT 2	112.50	11.00	20.00	70.13	32.08(O.S)	98.63	1.85	24.00	Green	-	White
65	KJT 5	109.00	10.30	25.00	70.44	36.26 T.S)	100.00	0.00	23.15	Green	Small	White

Sl.no	Entries	Days to 50 % flowering	Anthesis time (hrs)	Glume angle (^{O})	Panicle exsertion %	Stigma exsertion %	Pollen sterility %	Spikelet fertility %	Out crossing %	Tip colour	Awning	Stigma colour
66	KJT 6	113.50	9.45	20.00	69.75	29.21(O.S)	99.60	0.00	23.50	Green	-	White
67	APMS 5	99.50	10.00	20.00	79.64	31.76(O.S)	99.52	0.00	27.00	Green	Medium	White
68	APMS 6	100.50	10.30	20.00	89.21	42.12(T.S)	99.60	0.00	33.75	Green	-	White
69	DMS 3	86.50	10.00	15.00	79.69	35.54(O.S)	99.73	0.00	27.75	Green	-	White
70	DMS 4	87.50	11.00	15.00	76.26	32.31(O.S)	99.61	1.59	19.25	Green	Small	White
71	V 20	96.00	9.45	20.00	77.76	28.33(O.S)	99.26	0.56	17.75	Purple	-	Purple
72	Zhenshan 97	86.50	9.30	20.00	76.75	10.08(O.S)	98.86	1.02	19.75	Purple	-	Purple
73	CMS 29	94.00	10.00	20.00	89.90	35.65(T.S)	99.74	0.00	21.50	Green	Small	White
74	CMS 39	107.50	9.30	20.00	81.95	41.56(T.S)	100.00	0.00	24.00	Green	-	White

TS – Two side exsertion OS- One side exsertion

Table 3. Estimates of variability and genetic parameters of 74 rice CMS lines for floral traits

Characters	Mean	Range	S.E difference	S.E of mean	CD	CV%	GCV %	PCV %	Heritability %	GA %	GA % of mean
Days to 50 % flowering	100.28	86.50-113.50	2.49	1.75	3.48	2.48**	6.76	6.98	93.69	13.52	13.48
Panicle exertion %	78.04	67.66-89.90	1.63	1.14	2.28	0.46	6.43	6.60	95.00	10.09	12.93
Stigma exertion%	34.66	10.57-49.55	1.30	0.91	1.82	3.76**	19.44	19.62	98.17	13.75	39.68
Pollen sterility %	99.36	96.30-100.00	0.45	0.32	0.63	0.46	0.54	0.63	73.95	0.95	0.96
Glume angle (^{o})	22.07	15-30	0.73	-	1.45	3.30**	-	-	-	-	-
Out crossing %	27.86	14.00-54.50	4.81	3.38	6.74	17.28**	26.32	29.02	0.823	13.69	49.18