research article | *International Journal of Plant Sciences,* (January to June, 2010) Vol. 5 Issue 1 : 87-92

Evaluation of new non-scented CMS lines and their maintainer lines of rice (*Oryza sativa* L.) for their agronomical and floral traits

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Accepted : September, 2009

SUMMARY

Eighteen CMS lines and their isogonic maintainers were evaluated for agronomical traits *viz.*, days to 50% flowering, plant height (cm), number of panicles per plant, number of spikelets per panicle, spikelet fertility (%),panicle exertion (%),scent and floral traits *viz.*, pollen fertility (%), stigma length (mm), style length (mm), angle between stigma lobes (q), anther length (mm), anther breadth (mm), filament length (mm) and out crossing rate of CMS lines (%) with standard check cms line IR 58025A. Generally A lines took more number of days to 50 per cent flowering than the corresponding B lines. All the CMS lines were shorter than their corresponding maintainers. Number of panicles were more in B line than in A lines. More number of spikelets per panicle was observed in KCMS 17A, KCMS 16A and KCMS 21A. Maximum out crossing rate was noticed in KCMS 11A, KCMS 16A, CRMS 31A and KCMS 12A. Most of the CMS lines showed 100 per cent pollen sterility and less than 3.4 per cent spikelet fertility. All the CMS lines were non-scented in nature. Genotype KCMS 11A and IR 68888A were promising for panicle exsertion, the CMS lines IR 70369A, CRMS 32A, KCMS 17A, KCMS 12A, KCMS 22A and KCMS 25A had long stigma. The style length of RTN 10A and CRMS 32A were high, while KCMS 25A and CRMS 32A exhibited greater angle between stigma lobes. The maintainer lines KCMS 10B, IR 70369, RTN 10B, IR 68888B excelled in anther length, anther breadth and filament length. Two CMS lines *viz.*, KCMS 11A, KCMS 16A and CRMS 31A were identified as promising ones as they showed high out crossing rate, low pollen fertility and low spikelet fertility and are suitable for hybrids development.

Key words : Rice, CMS lines, Maintainer lines, Agronomic traits, Floral trait

Rice (*Oryza sativa* L.) is the most important staple food crop of the world. In India rice is also the most important and stable food crop of more than two third of the population. The slogan *'Rice is life'* is the most appropriate for India as this crop plays a livelihood for millions of rural households. India has the largest area under rice (44.6m.ha) and it ranks second only to china in production (90 million tones). However the productivity of India is 2086 kg/ha (Mishra, 2005).

Jones first reported heterosis in rice in 1926, but Chinese demonstrated the commercial exploitation of heterosis in early 1970's and they developed rice hybrids that had yield 20% higher production over the high yielding cultivars (Yuan, 1997). In India too, hybrid rice breeding programme gained momentum from 1989 onwards (Anonymous, 2002). The advantage observed at field level is in the range of 15-20 per cent over the highest yielding check varieties of corresponding duration (Paroda, 1998, Mangla Rai, 1998).

In hybrid rice research, CGMS or 3-line system is the most effective and stable system being used to develop rice hybrids. With the introduction of hybrid rice technology, WA (Wild Abortive) male sterile cytoplasm has been used every year in more than 93% of the total area under hybrid rice in China. However, in India, the most of the released hybrids are based on WA-CMS line IR 58025A. Hybrid production faces a potential threat from pests and diseases due to homogeneous narrow genetic base as it makes them genetically vulnerable (Xiao *et al.*, 1998). Since, rice is self pollinated crop, seed yield in hybrid seed production plots is very less (1.5 t/ha) and it is mainly depends on out crossing and out crossing depends on morphological and floral traits of CMS lines. Hence, the development and identification of new CMS lines with good morphological and floral characters is essential to increase the seed yield and hybrid seed production. Thus, a research study was undertaken to evaluate new non-scented CMS lines and their maintainer

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lines for floral and morphological traits.

MATERIALS AND METHODS

The study on evaluation of new CMS lines and their maintainer lines in rice was conducted during *Kharif* 2005 at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bangalore. In the present investigation 17 CMS lines along with one standard check (IR 58025A) were evaluated for different morphological and floral traits. The seeds of all CMS lines (A lines) were sown on 29th July 2005 and seeds of their corresponding maintainer lines were sown on 1st August 2005 to make synchronization in flowering. Seedlings of both the lines were transplanted on 1st September 2005, with spacing of 15cm x 20cm in plots of 1.5m x 0.6m size. The observations were recorded on five randomly selected plants of CMS lines and their maintainers for different morphological *viz.*, days to 50% flowering, plant height (cm), no. of panicles per plant, spikelets per panicle, spikelet fertility (%),out crossing rate of CMS lines (%). and scent, floral traits *viz.*, panicle exertion (%) pollen fertility (%), stigma length (mm), style length (mm), angle between stigma lobes (q), anther length (mm), anther breadth (mm) and filament length (mm). The analysis of variance of all the characters studied was carried out as per Randomized Block Design with two replications following the method of Panse and Sukathme (1967).

RESULTS AND DISCUSSION

Analysis of variance was carried out for different morphological traits and floral traits. Highly significant differences were observed with in A lines and B lines and also between A and B lines for all characters studied traits (Table 1) and it indicates the suitability of materials for the study. The mean performance of 18 CMS lines and their maintainers for different floral and morphological traits are presented in the Table 2 and 3.

In general, CMS lines took more number of days for 50 per cent flowering than the corresponding maintainers (Table 2). The IR 68888A and KCMS 6A and their B lines flowered on the same day. Synchronization of flowering of A line and its B line on same the day is most desirable characteristic of CMS lines. It is envisaged that sterile cytoplasm has resulted in delayed heading and affected the flowering of CMS lines. The present observations are in conformity with their findings of Sawanth *et al*. (2003) and Ingale *et al*. (2004).

Among 18 CMS lines more number of spikelets per panicle were noticed in IR 68888A and KCMS 26A. Number of spikelets per panicles ranged from 115.60 to 270.40 spikelets per panicle in A lines and 103.5 to 243.50

Table 1 : Analysis of variances for morphological and floral characters of new CMS lines and maintainers in rice

Source of variation	df	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicles / plant	Spikelet fertility (%)	Spikelets / panicles	Grains/ panicle	Out crossing rate of CMS lines	Yield/ plant (g)	Panicle exsertion (%)	Pollen fertility (%)	Stigma length (mm)	Style length (mm)	Angle between stigma lobes (θ)	Anther length (mm)	Anther breadth (mm)	Filament length (mm)
Replication	1	0.2485	0.5959	0.02	0.248	6.49	6.48	8.79	0.186	0.28	0.0284	0.4737	0.0093	0.0027	0.1863	0.0685	0.0001	0.0001
Treatments (A+B)	35	46.60**	5.4073**	545**	2.91**	2841**	29997**	5806**		58.8**	545.21**	4788 **						
A lines	17	47.76**	4.6190*	18.911**	1.662**	71.11**	4019**	297.7**	108.6**	8.11**	18.9118**	986.3**	0.1032**	0.014**	60.54**			
B lines	17	43.87**	6.5061**	464**	4.12**	101.1**	2111**	961.5**		25.4**	464.06**	97.82**				0.0941**	0.0039**	0.2091**
A v/s B lines	1	373.2**	0.1323	17971**	3.4	96538**	71.6	181822**		1488**	10871.97**	148165.4**						
Error	35/17	2.153	1.0936	3.3	22.5	3.132	87.4	32.5	0.054	1.4	3.3365	1.8714	0.0106	0.0021	9.315	0.0267	0.0011	0.0268

* and ** indicates significant of values at P=0.05 and 0.01, respectively

Table 2 : Mean performance of new CMS lines and their maintainer lines for morphological characters

Sr. No.	CMS lines	Days to 50% flowering		Plant height (cm)		Panicle length (cm)		Panicles / plant		Spikelets/ panicle		Grains/ panicles		Spikelet fertility(%)		out crossing rate (%)	Yield/plant (g/plant)		Scent
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	A	B	A&B
1.	RTN 10	93	90	70.95	88.79	22.7	23.95	9.35	10.8	270.4	187	14.05	152.75	2.62	76.3	10.9	2.75	12.36	Absent
2.	IR 68888	88	88	77.72	87.93	19.85	21	8.7	9.75	240.2	103.5	28.91	90.85	2.99	93.06	3.18	4.72	10.71	Absent
3.	IR 70369	96	94	77.27	89.57	18.15	19.4	8.2	9.5	145.7	151.5	17.52	131.88	17.09	86.8	2.81	2.86	19.05	Absent
4.	CRMS 32	103	99	79.13	91.33	22.4	23.05	9.25	10.6	215	176	10.15	137.8	0	83.68	1.32	1.66	12.84	Absent
5.	CRMS 6	92	99	73.82	85.29	21.95	23.1	9.8	10.15	150.5	243.5	38.5	177.93	0.55	70.86	11.4	6.27	20.32	Absent
6.	CRMS 31	105	94	92.85	106.36	19.35	21.5	7	9.13	184	208.1	35.94	120.37	0.2	67.45	16.91	5.86	11.2	Absent
7.	KCMS 10	93	89	76.24	84.2	21.15	22.25	7.4	9	115.6	180.9	31.56	143.75	1.13	81.56	14.4	5.14	13.01	Absent
8.	KCMS 11	99	87	83.32	94.6	21.63	22.1	8.8	9.65	158.9	156.2	43	133.4	0. 13	66.45	23.4	7.01	10.85	Absent
9.	KCMS 12	93	91	74.23	85.64	23.56	24.6	11.95	12.63	187	175.2	37.18	147.88	7.5	80.26	16.2	6.06	13.93	Absent
10.	KCMS 13	100	94	74.69	80.1	22.4	21.6	11.8	12.75	204.9	171.7	37.08	114.8	3.15	70.92	4.49	6.04	11.69	Absent
11.	KCMS 15	99	96	74.03	85.9	20.9	21.65	10.3	11.88	118.4	145.4	20.7	102.6	0.5	72.06	3.73	2.91	10.09	Absent
12.	KCMS 16	99	99	74.72	85.15	18.32	19.83	8.65	9.43	162.7	179.5	46.92	140.4	0.42	77.55	22.6	7.64	12.14	Absent
13.	KCMS 17	101	99	75.39	81.26	21.16	23.25	10.75	12.32	140.9	132.7	51.69	102.15	17.58	77.27	7.36	8.42	16.59	Absent
14.	KCMS 21	97	93	83.65	95.92	21.2	23.95	11.5	11.6	155.5	165	44.09	147.9	8.76	81.14	14.2	7.52	20.36	Absent
15.	KCMS 22	106	102	81.21	92.21	21.68	23	7.1	8.93	130.3	154.5	39.14	143.8	1.22	83.97	0.46	6.38	17.07	Absent
16.	KCMS 25	96	103	102.4	111.45	19.83	20.9	10.5	11.7	136.7	182.5	25.38	151.1	0.34	80.62	3.4	3.73	16.79	Absent
17.	KCMS 26	99	94	86.44	93	19.2	20.85	8.9	10.35	236.25	125.3	18.88	111.7	1.08	78.86	1.95	3.08	11.02	Absent
18	IR 58025	100	96	77.7	87.5	21	22.5	8.75	9.9	202.1	204.25	43.53	142.25	1.15	79.69	22.2	7.09	18.76	Present
	Grand Mean	98	95	79.77	90.34	20.91	22.14	9.37	10.56	172.2	169	32.45	132.9	4.46	78.25	9.99	5.28	14.37	
	S.E. ±	0.22	0.32	0.33	0.28	0.11	0.16	0.24	0.08	1.3	1.8	0.56	1.24	0.12	0.4	0.04	0.09	0.26	
	C.D. (P=0.05)	2.76	3.1	4.13	3.56	1.41	1.97	2.1	1.02	16.52	22.41	7.05	15.74	1.55	5.08	0.49	1.18	1.12	
	CV (%)	1.34	2	2.61	1.7	3.02	4.3	11.11	5.13	4.16	6.28	10.3	5.61	16.51	3.1	2.51	10.59	3.34	

Table 3 : Mean performance of new CMS lines and maintainer lines for floral characters

Sr. No.	CMS lines	Panicle exertion (%)		Pollen fertility (%)		Stigma length (mm)	Style length (mm)	Angle between Stigma lobes (θ)	Anther length (mm)	Anther breadth (mm)	Filament length (mm)
		A	B	A	B	A	A	A	B	B	B
1.	RTN 10	70.95	88.79	8.3	99.9	0.63	1.02	47.02	1.72	0.33	1.15
2.	IR 68888	77.72	117.93	0	97.4	0.97	0.96	37.56	2.17	0.33	1.79
3.	IR 70369	77.27	129.57	0	81	1.27	0.92	40.49	2.09	0.39	1.84
4.	CRMS 32	73.13	91.33	0	99.31	1.17	0.97	51.19	1.38	0.27	1.45
5.	CRMS 6	73.82	85.29	0	100	0.82	0.94	41.45	1.81	0.3	1.25
6.	CRMS 31	69.85	116.36	0	99.1	0.64	0.67	38.25	1.7	0.24	1.28
7.	KCMS 10	76.24	91.2	4.5	75	0.96	0.74	44.41	2.07	0.4	2.01
8.	KCMS 11	83.32	114.6	0	99.6	0.87	0.83	33.32	1.99	0.33	1.99
9.	KCMS 12	74.23	85.64	1.29	99.73	1.06	0.87	44.61	1.77	0.34	1.26
10.	KCMS 13	74.69	80.1	0	99.72	0.88	0.93	32.51	1.81	0.36	1.79
11.	KCMS 15	74.03	89.9	0	100	0.84	0.88	40.57	1.63	0.34	1.25
12.	KCMS 16	74.72	85.15	0	98	0.68	0.87	43.55	1.66	0.26	0.88
13.	KCMS 17	75.39	114.26	0.5	99.95	1.54	0.87	38.02	2.1	0.31	1.61
14.	KCMS 21	73.65	115.92	0.91	98.74	1.06	0.82	42.68	1.85	0.29	1.51
15.	KCMS 22	71.21	92.21	0	98.49	1	0.89	34.41	1.81	0.24	1.39
16.	KCMS 25	73.44	111.45	0	99.85	1.04	0.8	50.34	1.84	0.31	1.51
17.	KCMS 26	76.44	93	0	100	0.84	0.9	33.95	2.17	0.33	1.2
18.	IR 58025	77.7	87.5	0	98.3	1.09	0.89	41.55	1.63	0.31	1.89
	GM	74.87	99.45	0.861	96.89	0.9656	0.8764	40.88	1.84	0.317	1.503
	S.E. ±	0.326	0.28	0.144	0.28	0.0171	0.007	0.5252	0.027	0.005	0.027
	C.D. (P=0.05)	4.130	3.557	0.182	3.62	0.2174	0.0973	6.44	0.3445	0.069	0.345
	CV (%)	2.614	1.695	14.67	1.77	10.67	5.264	7.465	8.852	10.385	10.88

spikelets per panicle in B lines. The results are in agreement with the findings of Rudresh (2003), Ingale *et al*. (2004) and Gopinath and Raghava Reddy (2005).

Number of grains per panicles ranged from 10.15 to 51.69 grains per panicle in A lines and 177.93 to 90.55 grains per panicle in B lines. Among A lines RTN 10A (270.4) recorded maximum number of spikelets per panicle followed by IR 68888A (240.2) and KCMS 26A (236.25) (Ingale *et al*., 2004 and Gopinath and Raghava Reddy, 2005).

Zero spikelet fertility of CMS lines and maximum spikelet fertility of B lines are ideal characters of good CMS lines. Most of A lines had spikelet fertility of less than three per cent and B lines had more than 70 per cent. Among A lines CRMS 32A recorded lowest spikelet fertility (0.00%) followed by KCMS 11A (0.13%)and CRMS 31A (0.2%). Similar observation was also reported by Sawanth *et al*. (2003)

High natural out crossing is highly desirable in CMS lines as it results in higher seed yield in seed production plot, so, it would result in reduced cost of hybrid seed production in seed production plot. KCMS 11 A and KCMS 16 A exhibited out crossing rate more than standard check IR58025 A (22.28 per cent). Besides, CRMS 31 A, KCMS 11 A, KCMS 12 A and KCMS 16 A noticed more than 15.00 per cent of out crossing rate and were found promising for this character. Similar results were also reported by Rudresh (2003) and Gopinath and Raghava Reddy (2005).

The seed yield in CMS lines on natural out crossing is an indication of the final seed yield obtained in the seed production plot. Therefore, CMS lines with better yield are desirable. Among the CMS lines studied, KCMS 16A, KCMS 17A and KCMS 21A yielded seed yield more than check IR 58025 A (7.09g). However, The CMS lines, IR 68888A, CRMS 6A, CRMS 31A, KCMS 10A, KCMS 11A, KCMS 12A, KCMS 13A, KCMS 15A, KCMS 16A KCMS 17A and KCMS 21A recorded seed yield of more than 4g per plant. The maximum seed yield in B lines recorded by KCMS 21B (20.36g) followed by CRMS 6B (20.32g) and IR 70369B (19.05g). Therefore, these lines were found promising for this trait.

The hybrids, which are developed by using IR 58025A, are slightly scented, mainly because of slight scented nature of IR 58025A CMS lines. Therefore, it is necessary to develop other new non-scented CMS lines in rice. In the present study all the CMS lines were non-scented in nature.

Generally, panicle exsertion was more in B lines compared to A lines indicating that the influence of sterile cytoplasm on panicle exsertion. Among A lines, KCMS 11A exhibited high per cent of panicle exsertion of 83.32 per cent, followed by IR 68888A (77.72 per cent) and IR 58025A (77.70 per cent). Among B lines only IR 68888B, IR 70369B, CRMS 31 B, KCMS 11B, KCMS 21B, KCMS 17B and KCMS 25B expressed more than 100 per cent of panicle expression, while IR 70369 expressed maximum of 129.57 per cent panicle exsertion. The findings of present study with respect to panicle exsertion are in agreement with the reports published by Ingale *et al*. (2004) and Gopinath and Raghava Reddy (2005).

The CMS lines with more than 3.41 per cent pollen fertility are not desirable for use in hybrid production. However, all CMS lines except two lines (RTN 10A and KCMS 10A) showed less than 3.4 per cent pollen fertility (Hemareddy, 1996; Sawanth *et al*., 2003 and Rudresh, 2003). Among B lines, the pollen fertility ranges from 80.10 per cent to 100 per cent. Therefore, B lines with maximum pollen fertility are ideal, in the present study CRMS 6B, KCMS 15B and KCMS 26B showed 100 per cent pollen fertility.

Large stigma with feathery is desirable character of CMS lines, since the large stigma can receive more pollen efficiently resulting in better seed set on natural out crossing in seed production plots. The stigma length of more than 0.8 mm is desirable. 8 Out of 18 genotypes showed more than 0.8mm stigma length. Three genotypes *viz*., IR 70369A, CRMS 32A and KCMS 17A had stigma length more than standard check IR 58025A (1.09mm). The genotypes IR 70369A, CRMS 32A, KCMS 17A, KCMS 2A, KCMS 22A and KCMS 25A had longer stigma length (>1,0mm) and were found promising for this character. The present result is in agreement with the findings of Uday Shetty (1999) Rudresh (2003), Gopinath and Raghava Reddy (2005).

Larger style length is desirable in CMS lines as it helps in better stigma exsertion and thus improves the chance of receiving more pollen grains for fertilization, which in tern improves the seed set and seed yield (Vidyachandra *et al.*, 1997). In the present investigation style length varied from 0.67mm to 1.02mm. Style length of more than 5.0mm is desirable. In the present study all the CMS lines had style length of more than 5.0mm, 8 out of 18 genotypes had longer style length than check IR 58025A (0.89mm). These CMS lines were found promising for this character. Similar variation in style length was reported by various workers Uday Shetty (1999), Rudresh (2003), Gopinath and Raghava Reddy (2005).

Higher angle between stigma lobes helps to increase the area of stigma that receives more pollen grains, which in turn increases the chance of getting more pollen grains for fertilization and thus, improves seed set in seed production plots (Vidyachandra *et al.,* 1997).

In the present study angle between stigma lobes ranged from 32.5^0 to 50.34^0. All CMS lines showed more than 24^o angle between stigma lobes and 7 out of 18 CMS lines showed more than standard check IR58025A (41.55). The KCMS 25A had maximum stigma angle of 50.34^0 followed RTN 10A (47.02^0) and KCMS 12A (44.61^0). Similar result has been reported by Rudresh (2003), Gopinath and Raghava Reddy (2005).

Higher anther length and breadth in maintainer and restorer lines are desired as these would result in increase the size of the anthers and thus the quantity of pollen produced is more, thus ensuring effective pollination of CMS lines (Vidyachandra *et al.*, 1997). The length of anther varied from 2.17mm to 1.38mm. The maximum anther length of 2.17 mm was noticed in IR 68888B and KCMS 25B followed by IR 70369B (2.09mm). The anther breadth ranged from 0.40mm to 0.24mm. The anther breadth was maximum in KCMS 10B (0.40mm) followed y IR 70369B (0.39mm) and KCMS 13B (0.36mm),

Longer filament helps in better anther exsertion and thus helps in better dispersal of pollen in CMS lines (Vidyachandra *et al.*, 1997). The filament length ranged from 1.15mm to 2.01 mm, The B lines KCMS 10B and KCMS 11B have expressed longer filament length and were found to be promising for this character. Similar result in filament length was reported by Virmani *et al.* (1981) and Gopinath and Raghava Reddy (2005).

Seed yield in hybrid seed production plots depends on floral traits of CMS lines and pollen parents and all other agronomic and seed production packages to facilitate higher out crossing. The desirable traits of CMS lines are complete and stable male sterility, good panicle exsertion and high number of spikelets per panicles, wider angle and longer duration of glumes opening, large and feathery stigma with higher percentage of exserted stigma, erect plant type with short and narrow flag leaf, strong and synchronized flowering ability, high receptivity of stigma, early initiation of flowering and concentrated blooming and good combining ability for yield and yield contributing traits (Ramesha *et al.*, 2003).

The most important criteria to be considered while selecting promising CMS lines are pollen sterility, spikelets fertility and out crossing rate of CMS lines. Generally, CMS lines with less than 3.4 per cent pollen fertility, zero per cent spikelet fertility and more than 15 per cent out crossing rate are most ideal characters of good CMS lines. Based on the performance of 17 CMS lines by comparing with standard check IR 58025A, two CMS lines *viz*., KCMS 16A and CRMS 31A were identified as promising ones as they showed high out crossing rate, low pollen fertility and low spikelet fertility. Therefore, these are suitable for hybrids development.

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