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Original Research Article

Identification of Potential Restorers and Maintainers from Newly Developed Parental Lines Based on Morpho-Floral Characters in Rice (*Oryza sativa* L.)

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A B S T R A C T

A study was undertaken to elicit information on the identification of maintainers and restorers for their utilization in hybridization programme as the parental lines. For the development of viable, adoptable rice hybrids through utilization of cytoplasmic genetic male sterility, the processes of identification of maintainers and restorers have become inevitable. A total of 100 CMS lines developed at Zonal Agricultural Research Station, Mandya through backcross breeding were evaluated for their morphological and floral traits besides aroma during summer 2014. Out of which MSN 19-6 and MSN 97-1 were very early to flower (93 days). MSN-68 (143.8) was tallest among all the parental lines and taller restorer lines are preferred for better seed set. The parental lines, MSN 1B had recorded maximum number of tillers per plant (29) and MSN 75 exhibited highest number of panicles per plant (23.2). In general panicle exsertion was good in restorers upto 100 per cent and most of the parental lines exhibited 100 per cent panicle exsertion. The pollen fertility ranged from 64.12 per cent to 97.86 per cent *viz*., MSN 67 (98.79 %) and MSN 43-2-1 (97.86 %) and spikelet fertility from 54.84 per cent to 97.66 per cent *viz*., MSN 20-14 (29.40 cm), MSN 27 (29.20 cm) and MSN 1A3 (28.72 cm). Based on the percent pollen and spikelet fertility, 87 were identified as restorers and 13 as partial restorers. The effective restorers, identified in this study could be used to develop hybrids for commercial purpose.

Keywords

Maintainers, *Oryza sativa*, Pollen fertility, Restorer, Spikelet fertility

Introduction

Rice (*Oryza sativa* L.) is an important staple food crop for more than half of the world population. Over 90 per cent of the rice is produced and consumed in Asia accounting for more than 65 per cent of calorific intake (Khush, 2004). India has the largest area (43.97 million hectares) under rice among the rice growing countries of the world, but ranks second in total production (106.3 million tonnes). In Karnataka, it occupies 1.41 million hectares with a production of 3.35 million tonnes with a productivity of 2897 kg/ha (FAO, 2014). The population in rice consuming countries continues to grow steadily and it is estimated that 40% more have to be produced by 2030. In order to keep pace with the growing population, the dire need of increasing rice production and

productivity encouraged scientists to develop and disseminate innovative rapid improvement technologies. Among the innovative improvement options available, hybrid rice technology is practically feasible and readily adoptable. However, commercial success of hybrid rice technology mainly depends on the extent of heterosis realized (Shivakumar *et al.*, 2010). Successful use of hybrid vigor in rice largely depends on availability of locally developed cytoplasmic genetic male sterile (CMS) and restorer lines. Development of new cytoplasmic male sterile (CMS) lines with better floral traits like stigma exsertion and natural out crossing percentage would therefore be of paramount importance to ensure better seed set and seed yield in large scale seed production and commercial cultivation of the hybrids (Shivakumar *et al.*, 2010). Keep all this points in view, present study was undertaken to evaluate the newly developed CMS lines and to identify potential restorers and maintainers from them.

Materials and Methods

Hundred cytoplasmic male sterile (CMS) lines developed at Zonal Agricultural Research Station (University of Agricultural Sciences, Bangalore), V. C. Farm, Mandya were evaluated for their morphological and floral traits during summer 2014 and the seedlings were transplanted in a single row of 55 seedlings in each row with spacing of 20 x 15 cm. All the recommended package of practices was followed timely to ensure good crop establishment. Observations were recorded on five randomly selected competitive plants on days to 50 per cent flowering, plant height (cm), number of tillers/plant, number of panicles/plant, panicle exsertion (%), panicle length (cm), pollen fertility (%), number of filled grains/panicle, spikelet fertility (%) and L/B ratio of grain.

Estimation of pollen fertility

For pollen fertility (%), three spikelets, one each from top, middle and bottom of main panicle of CMS lines each from two replications were collected and pollen grains were squeezed out from all the anthers on a clean glass slide and stained with 1.0 per cent I-KI (Iodine-Potassium Iodide) stain (which is prepared by dissolving 2 g of potassium iodide and 1g of iodine in 100 ml of distilled water) and examined under microscope at a magnification of 10X.

The pollens were considered to be fertile if they were round, plumpy and deeply stained, while they were considered as sterile if they were shrunken, unstained and irregular in shape. Three microscopic fields were counted for each spikelet and pollen fertility was expressed in percentage.

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

Estimation of panicle exsertion and spikelet fertility

Panicle exsertion, the ratio of number of spikelets outside the flag leaf to the total number of spikelets in the panicle was expressed in per cent. Spikelet fertility percent is the ratio of number of filled grains to total number of spikelets per panicle and expressed as percentage. Number of filled and chaffy spikelets in five main panicles of five selected plants in each replication were pooled together and averaged at the time of harvest to assess the spikelet fertility.

$$\text{Panicle exsertion (\%)} = \frac{\text{Number of spikelets exposed outside the leaf sheath}}{\text{Total number of spikelets in the panicle}} \times 100$$

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

Table.1 Mean values of parental lines for different morphological and floral traits

Sl. No	Genotypes	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
1	MSN – A3	112.00	136.00	22.20	15.20	100.00	28.72	84.89	172.00	72.09	3.45
2	MSN-1B	112.00	92.80	29.00	14.40	85.00	21.28	75.68	124.00	54.84	3.55
3	MSN-2-4	103.00	123.60	24.40	20.40	100.00	25.00	97.58	102.80	94.36	3.03
4	MSN-3	112.00	137.60	23.80	14.60	99.00	25.90	95.58	196.60	91.25	2.68
5	MSN-3-3	112.00	127.20	27.00	17.80	100.00	23.20	84.79	132.40	77.34	2.82
6	MSN-3-4	103.00	126.60	19.20	15.60	92.00	23.00	92.56	161.00	94.41	2.60
7	MSN-10	103.00	104.00	21.80	12.40	98.00	20.80	92.00	144.00	87.50	3.27
8	MSN-15-15	112.00	99.00	23.40	19.80	100.00	23.20	94.68	106.00	86.79	2.66
9	MSN-15-16	110.00	120.80	21.60	12.00	100.00	23.00	92.68	178.20	90.12	2.65
10	MSN-15-18	111.00	100.80	25.40	17.40	100.00	22.45	78.04	110.00	72.73	2.52
11	MSN-19-6	93.00	117.80	19.00	14.20	100.00	21.50	88.64	188.40	80.89	2.83
12	MSN-20	111.00	119.20	17.00	14.40	100.00	28.50	94.25	170.60	95.78	3.24
13	MSN-20a	117.00	120.00	20.20	11.40	99.00	24.30	97.34	138.60	96.54	3.38
14	MSN-20c	105.00	82.80	24.20	19.00	100.00	19.20	80.89	176.20	74.01	3.08
15	MSN-20d	113.00	79.20	25.60	16.80	98.00	20.60	93.49	118.80	91.58	3.34
16	MSN-20h	117.00	122.40	16.60	9.40	100.00	25.40	94.35	167.40	91.04	3.42
17	MSN-20L	105.00	98.00	19.60	12.00	98.00	18.80	91.49	161.00	87.33	3.35
18	MSN-20-2	105.00	122.40	17.20	10.60	100.00	28.20	93.25	175.00	92.69	3.38
19	MSN-20-14	101.00	90.60	17.40	11.40	100.00	29.40	94.77	157.60	90.48	2.93
20	MSN-20-8-1-1	117.00	110.80	23.40	13.80	100.00	24.50	85.53	104.40	79.69	3.58
21	MSN-20-13-1-1	103.00	77.00	20.00	15.40	90.00	19.00	91.29	86.00	86.05	3.59
22	MSN-21-3	101.00	87.20	19.60	14.40	94.00	21.00	97.12	145.20	94.49	3.70
23	MSN-21-3-1	101.00	101.60	14.60	16.00	92.00	19.80	96.58	150.20	94.54	2.77
24	MSN-21-6	108.00	104.60	18.80	12.60	91.00	20.20	93.72	155.00	89.03	2.81
25	MSN-21-8	101.00	92.00	19.40	18.80	100.00	22.80	94.35	145.60	91.21	2.65
26	MSN-22-1	101.00	85.60	21.00	18.40	100.00	21.35	75.89	115.40	66.38	3.18
27	MSN-22-2	117.00	94.00	20.80	19.40	94.00	25.95	80.24	148.00	75.68	4.20

Contd….

Sl. No	Genotypes	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
28	MSN-25	117.00	88.60	22.40	18.00	94.00	21.20	94.58	118.20	93.91	3.16
29	MSN-25-3	103.00	115.20	18.40	21.80	93.00	24.80	93.67	301.00	92.69	4.30
30	MSN-26A	113.00	91.00	18.40	16.20	100.00	23.00	91.86	203.00	93.60	2.93
31	MSN-27	103.00	133.40	15.20	12.80	99.00	29.20	82.12	191.60	80.58	3.23
32	MSN-34	112.00	128.40	16.80	12.00	98.00	24.50	96.87	188.80	95.34	3.58
33	MSN-36	112.00	112.00	19.80	11.20	100.00	24.70	90.37	204.00	92.75	3.23
34	MSN-39-2	98.00	127.00	26.20	14.80	100.00	25.20	91.59	192.60	93.35	3.10
35	MSN-41-2-1	118.00	107.80	19.00	15.20	99.00	23.20	89.58	169.60	91.27	3.95
36	MSN-42-3	112.00	88.20	21.40	13.60	95.00	19.80	75.64	96.00	62.50	4.40
37	MSN-43-1-1	105.00	89.80	23.00	14.60	95.00	20.20	92.42	147.20	91.03	3.70
38	MSN-43-1-2	101.00	81.00	19.20	11.40	94.00	20.80	88.75	162.00	84.57	3.82
39	MSN-43-2	105.00	87.80	20.20	18.20	100.00	20.00	90.74	123.00	87.80	3.46
40	MSN-43-2-1	107.00	94.60	20.40	15.80	94.00	20.60	97.86	202.60	96.45	3.16
41	MSN-43-2-2	117.00	105.40	19.60	14.60	100.00	20.70	93.46	167.80	91.42	3.53
42	MSN-61	107.00	142.00	13.80	15.00	100.00	23.54	82.33	114.80	88.85	3.23
43	MSN-64-1-1	99.00	121.20	19.20	16.20	98.00	23.60	88.58	218.80	85.37	4.30
44	MSN-66	101.00	95.60	21.20	17.80	99.00	22.40	75.68	195.00	71.28	4.25
45	MSN-67	117.00	98.80	12.40	12.40	100.00	20.50	98.79	213.80	97.66	3.16
46	MSN-67-2-1-46	112.00	117.60	15.40	13.20	100.00	20.00	93.35	182.20	90.56	3.34
47	MSN-68	112.00	143.80	24.20	13.40	99.00	27.60	91.03	178.40	92.71	4.24
48	MSN-69	112.00	85.40	22.80	14.80	100.00	23.40	92.74	143.60	90.81	2.98
49	MSN-70	117.00	132.40	13.80	13.00	100.00	27.40	86.80	154.40	86.53	3.36
50	MSN-70-1	112.00	142.00	21.60	17.40	100.00	25.35	92.54	148.00	91.22	3.10
51	MSN – 71	107.00	128.80	24.20	14.20	99.00	22.60	87.80	135.60	84.51	2.93
52	MSN – 72	105.00	114.40	15.20	16.20	92.00	21.40	85.74	137.00	86.86	3.21
53	MSN – 73	105.00	122.60	19.60	12.80	98.00	23.10	95.50	126.00	96.03	3.40
54	MSN – 74	98.00	118.00	24.20	19.80	100.00	22.20	96.44	136.40	95.31	3.52
55	MSN – 75	108.00	95.80	19.40	23.20	100.00	24.76	75.20	174.80	70.25	4.78

Contd….

Sl. No	Genotypes	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
56	MSN – 75-1	112.00	102.80	21.60	18.20	99.00	20.20	85.85	189.40	79.94	4.60
57	MSN – 75-2	117.00	129.40	18.80	16.20	98.00	24.60	87.52	160.00	81.25	4.00
58	MSN – 77	101.00	114.00	18.60	15.80	99.00	22.60	86.78	154.00	83.77	3.02
59	MSN – 78	103.00	103.20	16.80	13.00	99.00	23.90	90.24	127.40	88.23	2.87
60	MSN – 83	108.00	98.60	22.20	16.00	99.00	22.20	78.93	121.20	71.95	4.50
61	MSN – 85	98.00	99.00	16.60	17.00	100.00	23.70	75.93	234.00	69.23	4.25
62	MSN – 85-1	98.00	99.00	20.00	14.20	99.00	21.60	81.37	262.80	77.25	3.58
63	MSN – 86	107.00	129.00	16.40	15.00	99.00	19.80	84.67	166.00	78.31	3.04
64	MSN – 87	111.00	100.40	25.80	18.00	99.00	23.00	69.83	205.20	63.94	3.52
65	MSN – 88	107.00	98.00	19.00	13.40	100.00	23.20	95.40	144.00	96.53	3.36
66	MSN – 88-1	100.00	87.00	21.20	14.40	94.00	20.00	71.24	119.00	65.21	3.85
67	MSN – 89	111.00	120.20	25.40	12.40	95.00	22.20	93.52	192.60	92.63	4.50
68	MSN – 90	108.00	127.60	21.80	13.80	100.00	22.30	65.89	230.40	61.63	4.40
69	MSN – 90-1	111.00	123.60	21.80	11.40	95.00	22.80	94.86	183.60	92.92	4.15
70	MSN – 91	108.00	120.00	19.60	15.00	93.00	23.20	62.00	128.40	76.64	4.35
71	MSN – 92	108.00	126.40	24.40	14.20	90.00	23.80	93.52	140.00	95.00	4.17
72	MSN – 93	105.00	121.40	18.40	15.60	95.00	22.80	83.63	175.20	81.05	4.30
73	MSN – 94	105.00	87.00	19.40	14.20	95.00	19.80	94.31	150.80	92.04	3.07
74	MSN – 95	96.00	128.00	14.60	11.40	90.00	20.40	88.56	164.00	85.98	2.88
75	MSN – 96	108.00	109.80	17.40	11.40	100.00	24.20	81.07	126.00	84.76	4.19
76	MSN – 97	95.00	99.80	22.80	15.20	100.00	21.40	92.54	120.60	89.55	3.25
77	MSN – 97-1	93.00	90.20	23.00	6.80	98.00	21.00	90.55	92.20	85.68	3.50
78	MSN – 98	111.00	123.20	19.60	17.80	99.00	22.20	88.63	172.20	90.13	2.41
79	MSN – 99	96.00	103.20	24.80	15.40	100.00	21.10	68.91	239.20	63.55	3.41
80	MSN – 100	101.00	97.60	19.80	12.80	100.00	23.90	91.78	115.80	92.23	2.80
81	KMR-3	103.00	117.80	14.20	12.00	100.00	23.60	85.86	178.60	79.84	3.09
82	KMR-4	108.00	119.00	19.80	13.60	90.00	22.60	76.23	159.00	69.81	2.88

Contd….

Sl. No	Genotypes	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
83	KMR-12	105.00	136.40	19.40	16.00	100.00	25.90	89.68	150.80	83.16	4.19
84	PBK 093-1-4-4-2-1	105.00	118.80	19.80	16.00	100.00	21.60	92.50	205.60	88.33	3.14
85	PBK 093-1-5-1-1	101.00	122.60	20.60	14.20	100.00	20.40	80.07	188.40	75.58	3.10
86	PBK 093-1-6-4-1	95.00	82.60	23.20	11.80	100.00	21.20	93.25	113.20	89.40	3.25
87	PBK 093-1-8-2-1-1	111.00	123.40	20.80	12.40	100.00	21.70	76.84	192.20	70.24	3.09
88	PBK 093-1-9-4-2-1	107.00	128.80	18.80	14.00	100.00	20.20	71.68	152.80	65.97	3.25
89	PBK 093-1-16-2-1	111.00	132.60	22.60	12.60	100.00	18.20	91.45	178.60	87.57	3.15
90	PBK 092-2-3-1-1	111.00	125.20	19.80	11.20	98.00	20.80	70.97	96.40	65.56	3.25
91	PBK 091-3-3-1-1	111.00	82.00	20.60	12.60	88.00	22.00	89.60	150.20	83.22	3.15
92	PBK 095-5-4-5-1	108.00	133.60	17.80	14.00	100.00	25.20	74.12	194.60	70.61	2.84
93	PBK 091-3-7-1-1	108.00	123.60	15.00	12.20	100.00	22.20	86.78	185.40	81.34	3.14
94	PBK 091-3-8-1-1	108.00	128.20	15.20	13.20	99.00	24.20	74.32	163.60	66.99	3.50
95	PBK 091-5-7-4-1	103.00	107.20	17.60	18.00	100.00	23.60	90.56	211.00	88.15	3.25
96	PBK 091-5-10-4-3-1	103.00	132.00	15.20	15.40	98.00	23.40	91.76	217.20	85.82	2.84
97	PBK 091-5-4-6-2-1	111.00	84.00	17.20	11.80	100.00	20.10	64.12	101.00	68.32	3.05
98	PBK 091-5-12-3-1	111.00	140.00	19.80	13.60	100.00	22.00	92.60	151.60	94.33	3.15
99	PBK 091-5-13-6-1	111.00	76.60	22.60	14.40	90.00	21.80	84.39	158.00	78.48	3.25
100	PBK 091-5-14-1-1-3	117.00	136.20	17.20	16.40	100.00	23.00	95.84	201.00	93.53	3.05

X1-Days to 50 per cent flowering X2- Plant height (cm) X3- Number of tillers/plant X4- Number of panicles/plant X5- Panicle exsertion (%) X6- Panicle length (cm) X7- Pollen fertility (%) X8- Number of grains/panicle X9- Spikelet fertility (%) X10-Grain L/B ratio

Table.2 Classification of genotypes based on pollen fertility into Restorer (R), Partial restorer (PR), Partial maintainer (PM) and Maintainer (M)

Sl. No	Genotypes	Pollen fertility		Sl. No	Genotypes	Pollen fertility		Sl. No	Genotypes	Pollen fertility		Sl. No	Genotypes	Pollen fertility	
		Per cent	Class			Per cent	Class			Per cent	Class			Per cent	Class
1	MSN – A3	84.89	R	26	MSN-22-1	75.89	PR	51	MSN -71	87.80	R	76	MSN - 97	92.54	R
2	MSN-1B	75.68	PR	27	MSN-22-2	80.24	R	52	MSN - 72	85.74	R	77	MSN - 97-1	90.55	R
3	MSN-2-4	97.58	R	28	MSN-25	94.58	R	53	MSN - 73	95.50	R	78	MSN - 98	88.63	R
4	MSN-3	95.58	R	29	MSN-25-3	93.67	R	54	MSN - 74	96.44	R	79	MSN - 99	68.91	PR
5	MSN-3-3	84.79	R	30	MSN-26A	91.86	R	55	MSN - 75	75.20	PR	80	MSN - 100	91.78	R
6	MSN-3-4	92.56	R	31	MSN-27	82.12	R	56	MSN - 75-1	85.85	R	81	KMR-3	85.86	R
7	MSN-10	92.00	R	32	MSN-34	96.87	R	57	MSN - 75-2	87.52	R	82	KMR-4	76.23	PR
8	MSN-15-15	94.68	R	33	MSN-36	90.37	R	58	MSN - 77	86.78	R	83	KMR-12	89.68	R
9	MSN-15-16	92.68	R	34	MSN-39-2	91.59	R	59	MSN - 78	90.24	R	84	PBK 093-1-4-4-2-1	92.50	R
10	MSN-15-18	78.04	PR	35	MSN-41-2-1	89.58	R	60	MSN - 83	78.93	PR	85	PBK 093-1-5-1-1	80.07	R
11	MSN-19-6	88.64	R	36	MSN-42-3	75.64	PR	61	MSN - 85	75.93	PR	86	PBK 093-1-6-4-1	93.25	R
12	MSN-20	94.25	R	37	MSN-43-1-1	92.42	R	62	MSN - 85-1	81.37	R	87	PBK 093-1-8-2-1-1	76.84	PR
13	MSN-20a	97.34	R	38	MSN-43-1-2	88.75	R	63	MSN - 86	84.67	R	88	PBK 093-1-9-4-2-1	71.68	PR
14	MSN-20c	80.89	R	39	MSN-43-2	90.74	R	64	MSN - 87	69.83	PR	89	PBK 093-1-16-2-1	91.45	R
15	MSN-20d	93.49	R	40	MSN-43-2-1	97.86	R	65	MSN - 88	95.40	R	90	PBK 092-2-3-1-1	70.97	PR
16	MSN-20h	94.35	R	41	MSN-43-2-2	93.46	R	66	MSN - 88-1	71.24	PR	91	PBK 091-3-3-1-1	89.60	R
17	MSN-20L	91.49	R	42	MSN-61	82.33	R	67	MSN - 89	93.52	R	92	PBK 095-5-4-5-1	74.12	PR
18	MSN-20-2	93.25	R	43	MSN-64-1-1	88.58	R	68	MSN - 90	65.89	PR	93	PBK 091-3-7-1-1	86.78	R
19	MSN-20-14	94.77	R	44	MSN-66	75.68	PR	69	MSN - 90-1	94.86	R	94	PBK 091-3-8-1-1	74.32	PR
20	MSN-20-8-1-1	85.53	R	45	MSN-67	98.79	R	70	MSN - 91	62.00	PR	95	PBK 091-5-7-4-1	90.56	R
21	MSN-20-13-1-1	91.29	R	46	MSN-67-2-1-46	93.35	R	71	MSN - 92	93.52	R	96	PBK 091-5-10-4-3-1	91.76	R
22	MSN-21-3	97.12	R	47	MSN-68	91.03	R	72	MSN - 93	83.63	R	97	PBK 091-5-4-6-2-1	64.12	PR
23	MSN-21-3-1	96.58	R	48	MSN-69	92.74	R	73	MSN - 94	94.31	R	98	PBK 091-5-12-3-1	92.60	R
24	MSN-21-6	93.72	R	49	MSN-70	86.80	R	74	MSN - 95	88.56	R	99	PBK 091-5-13-6-1	84.39	R
25	MSN-21-8	94.35	R	50	MSN-70-1	92.54	R	75	MSN - 96	81.07	R	100	PBK 091-5-14-1-1-3	95.84	R

M- Maintainer, R- Restorer, PR- Partial restorer, PM- Partial maintainer

The genotypes were grouped into four different classes based on pollen fertility per cent (Virmani *et al.*, 1997)

Sl. No	Class		Range
1	Maintainer (M)	:	0 to 1.00 per cent
2	Partial maintainer (PM)	:	1.1 to 20.00 per cent
3	Partial restorer (PR)	:	20.1 to 80.00 per cent
4	Effective restorer (R)	:	80.1 to 100. 00 per cent

The genotypes were grouped into four different classes based on spikelet fertility per cent as shown under (Virmani *et al.*, 1997)

Sl. No	Class		Range
1	Effective maintainer (M)	:	0 to 5.00 per cent
2	Partial maintainer (PM)	:	5.1 to 20.00 per cent
3	Partial restorer (PR)	:	20.1 to 70.00 per cent
4	Effective restorer (R)	:	70.1 to 100. 00 per cent

Results and Discussion

The morphological and floral characters studied in 100 parental lines are listed in the Table 1. Among 100 parental lines studied MSN 19-6 and MSN 97-1 were very early to flower (93 days), which is desirable as reported by Rudresh (2003). MSN-68 (143.8) was tallest among all the parental lines and taller restorer lines are preferred for better seed set. It is also desirable to have more number of tillers per plant and number of panicles per plant as these are the important yield attributing traits. The parental lines, MSN 1B had recorded maximum number of tillers per plant (29) and MSN 75 exhibited highest number of panicles per plant (23.2). In general panicle exsertion was good in restorers upto 100 per cent and most of the parental lines exhibited 100 per cent panicle exsertion. Panicle length is one of the important yield components as it accommodates more number of spikelets per panicles. Panicle length ranged from 18.2 cm to 29.40 cm (Rudresh, 2003). All the above floral traits offer better scope for effective pollination as they expose more stigmatic surface area for pollen to drop on stigma which in turn helps in better seed set.

Pollen fertility and spikelet fertility are the important characters based on which restorers were classified. The pollen fertility ranged from 64.12 per cent to 97.86 per cent *viz*., MSN 67 (98.79 %) and MSN 43-2-1 (97.86 %) and spikelet fertility from 54.84 per cent to 97.66 per cent *viz*., MSN 20-14 (29.40 cm), MSN 27 (29.20 cm) and MSN 1A3 (28.72 cm). Number of grains per panicle is one of the important yield components which are positively correlated with yield. The parental line MSN 25-3 produced more number of grains per panicle (301) followed by MSN 85-1 (262.8) and MSN 99 (239.2). The parental lines manifested more variability for L/B ratio which ranged from 2.41 to 4.78. Also these lines could be efficiently used in the development of heterotic hybrids. Out of 100 parental lines evaluated, 87 were identified as restorers and 13 as partial restorers based on pollen fertility (Table 2). The genotypes were classified as maintainer, restorer, partial maintainer and partial restorer based on pollen and spikelet

fertility. The effective restorers, identified in this study could be used to develop hybrids for commercial purpose. However, problem of partial restoration need to be solved and similar opinion was given by Rosamma and Vijaykumar, 2005.

This variation may be due to the pollen fertility–restoring genes differ or their penetrance or expressivity differed with genotypes (Umadevi *et al.*, 2010) or due to existence of modifiers genes or which could be due to differential interaction between cytoplasm of different male sterile lines with individual pollinator variety. The identified restorer lines can be used as pollen parent in developing new commercial hybrid varieties. New restorer may also be developed through crossing programme which can expand the genetic base of restorer by pyramiding complementary traits from diverse sources according to breeding objectives.

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