IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
e ISSN-0976-593X Volume **11** | Issue 2 | July, 2016 | 148-155

DOI: 10.15740/HAS/IJPS/11.2/148-155
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RESEARCH ARTICLE

Browsing for improved grain quality characteristics in rice hybrids developed from *indica* CMS lines and aerobic rice cultures

■ **D. MALARVIZHI, A. THANGA HEMAVATHY AND K. THIYAGARAJAN**

SUMMARY

In the present study, 88 hybrids were evaluated under aerobic and flooded conditions, out of which 35 hybrids were identified for grain quality analysis based on single plant yield, grain type, and parental line flowering synchronization. The grains of 35 high yielding hybrids and their respective parents were subjected to grain quality analysis as per the procedures given in the standard evaluation system. The released rice hybrids ADTRH 1 and CORH 2 and the popular fine grain varieties ADT 43 and BPT 5204 were used as standard checks for effective comparison. Data were recorded for the following quality characters like milling quality traits, physical grain quality traits and cooking quality traits. The hybrid COMS 14A × IR 62161-184-3-1-3-2 was identified as the best hybrid since it recorded the highest total score followed by IR 68888A × IR 69715-72-1-3, IR 68888A × WGL 32100, IR 68897A × IR 72875-94-3-3-2, COMS 14A × IR 69715-72-1-3 and COMS 14A × WGL 14, COMS 14 A × IR55838-B2-2-3-2-3 and IR 68897 A × IR 71604-4-1-4-7-10-2-1-3. These hybrids had good scores for more number of quality traits such as milling per cent, head rice recovery, chalkiness, volume expansion, intermediate GT, soft gel consistency and amylose content. The parents of these hybrids also had higher total score for most of the quality traits. These hybrids with higher yield and good grain quality, can be exploited commercially for grain yield and quality improvement. The male parents *viz.*, WGL 14, IR 71604-4-7-10-2-1-3, IR 62161-184-3-1-3-2, IR55838-B2-2-3-2-3, IR 62030-54-1-2-2, PSBRC 82, IR 36,and female parents *viz.*, IR 68888A, IR 68897A and COMS 14A, with desirable grain quality had produced hybrids with superior grain quality. These parents could also be exploited further for developing heterotic rice hybrids with improved grain quality.

Key Words : Grain quality, CMS lines, Restorers, Rice hybrids

How to cite this article : Malarvizhi, D., Hemavathy, A. Thanga and Thiyagarajan, K. (2016). Browsing for improved grain quality characteristics in rice hybrids developed from *indica* CMS lines and aerobic rice cultures. *Internat. J. Plant Sci.*, **11** (2): 148-155, **DOI: 10.15740/HAS/IJPS/11.2/148-155**.

Article chronicle : Received : 28.01.2016; **Revised :** 01.04.2016; **Accepted :** 15.05.2016

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Development of rice hybrids with higher yield advantage over pureline conventional varieties though received more attention initially, it could not meet the requirements of the consumers later. The hybrids developed during the early phase had only higher yield potential lacking all other desirable grain quality characteristics. Several rice hybrids introduced from

China into other countries did not meet the grain quality standards of local commercial inbred rice varieties due to their larger grain size, excessive chalkiness and low milling yield (Virmani and Zaman, 1998). In the recent years, consumer's preference and market price in domestic as well as international market are much in favour of good quality rice. The quality of rice assures importance because much of the rice produced in the world is consumed as cooked whole kernel, and the percentage converted into flour being relatively small. In India the qualities sought in rice are the fineness of the kernel, attractive colour and flavour, moderate water absorption, high volume expansion, retention of kernel shapes, absence of kernel splitting during cooking and dry and fluffy nature of cooked rice. The cooking quality preferences vary within the ethnic groups and from one country to another within different geographical regions. Though high yielding varieties have been developed and released, for the acceptance and spread of varieties, grain quality has became an important criteria after yield. As good quality of rice fetches higher returns to the farmers, it has now become imperative to incorporate quality features in desirable range into the conventionally bred varieties as well as in the hybrids for their adoption on large scale.

The price which the farmers get for their produce is determined only by the desirable and preferable quality traits. Hence, breeding for higher yield is of prime importance in rice and at the same time, rice grain quality should be improved in order to meet the requirements of the rice market and to raise the living standards.

MATERIAL AND METHODS

In the present study, 88 hybrids were evaluated under aerobic and flooded conditions, at Paddy Breeding Station, Coimbatore out of which 35 hybrids were identified for grain quality analysis based on single plant yield, grain type, and parental line flowering synchronization. The grains of 35 hybrids and their respective parents were subjected to grain quality analysis as per the procedures given in the IRRI standard evaluation system. The hybrids ADTRH 1 and CORH 2 and the popular fine grain varieties ADT 43 and BPT 5204 were used as standard checks for effective comparison.

Data were recorded for the following quality characters like milling quality traits which includes hulling percentage, milling percentage and head rice recovery, physical grain quality traits like kernel length, kernel breadth and kernel length/breadth ratio, cooking and eating quality traits like kernel length after cooking (KLAC), kernel breadth after cooking (KBAC), linear elongation ratio, breadth wise expansion ratio, length/ breadth ratio after cooking, gelatinization temperature (GT), amylose content, gel consistency and volume expansion ratio.

Grains of individual single plants of each hybrid along with their parents were hulled in rice husker. The physical characters *viz.*, kernel length, kernel breadth and kernel length/breadth ratio were measured. The brown rice was milled in rice polisher uniformly for 30 seconds and scored for chalkiness based on standard scale. The length and breadth of milled rice before and after cooking were measured. The ratio of mean length of cooked rice to mean length of milled rice was computed as linear elongation ratio (Juliano and Perez, 1984). Breadth wise expansion ratio was computed as the ratio of mean breadth of cooked rice to mean breadth of milled rice. Gelatinization temperature (GT) was estimated based on alkali spreading score (ASS) of milled rice (Little *et al*., 1958). Kernels with a score of 5.5-7.0 was classified as low GT (55-69^{o}C); 5-5.4 as intermediate GT (69-74^{o} C); 2.6 to 3.4 as intermediate to high GT and 1.0-2.5 as high GT (74.5^{o}- 80^{o} C) types. The simplified procedure of Juliano (1971) was used for the estimation of amylose content. Gel consistency was analysed based on the method described by Cagampang *et al*. (1973). The test classified the rice into three categories as hard gel consistency (length of gel - <40 mm), medium gel consistency (length of gel - 40-60 mm) and soft gel consistency (length of gel - > 60 mm) types. The ratio of the volume of cooked rice to the volume of milled rice was expressed as volume expansion (VE).

RESULTS AND DISCUSSION

Rice grain quality includes milling, physical, cooking and eating, organoleptic and nutritional quality traits. The appearance of milled rice is important to the consumer, producer and miller. Thus, grain size and shape are the first criteria for rice quality that breeders consider in developing new varieties for commercial cultivation. Preferences for grain size and shape vary from one group of consumer to another. There is a strong demand in the international market for long grain rice. Length of grain is more important than width and thickness or shape. Bold grains have low head rice recovery because of high breakage. Grains with short to medium long grains break less than long grains during milling. Thus, grain size and shape affect directly on yield of head rice. Consumers prefer white, translucent grain and pay more price for it. Further, grain quality has become an important issue affecting domestic consumption and possibility in international trade of rice (Cagampang *et al*., 1973).

The results of the study are presented in Table 1, 2 and 3. The hybrids IR 68886A × IR 59624-34-2-2 had higher milling per cent followed by IR 68886A × IR 62030-54-1-2-2, IR 68886A × IR 59624-34-2-2, IR 68888A × IR 62161-184-3-1-3-2 and IR 68888A × IR 72875-94-3-3-2. Both the parents of these hybrids had high milling per cent and head rice recovery. The hybrids IR 68886A × IR 62030-54-1-2-2, IR 68886A × IR 59624-34-2-2 and IR 68888A × IR 72875-94-3-3-2 also had higher milling per cent. Earlier, it was reported that choosing parents with high milling yield will produce hybrids with high milling quality (Shobha Rani *et al.*, 2002).

Eighteen hybrids had long kernels and 17 hybrids had short kernels. Among the hybrids IR 68888A × IR 69715-72-1-3, IR 68897A × IR 72875-94-3-3-2 and IR 68886A × IR 62161-184-3-1-3-2 had very long kernels. Two hybrids *viz.*, COMS 14A × WGL 14, COMS 14A × WGL 32100 had very short kernels. Lesser kernel breadth is generally preferred to have desirable shape of the kernel. The hybrid COMS 14A × WGL 14 and COMS 14A × WGL 32100 had low kernel breadth. Interestingly, both the parents of these hybrids had low kernel breadth. However, high kernel breadth is a desirable character in regions where consumers prefer bold grains. Hybrids with medium, long and short kernel types can be exploited based on region specific consumer preferences. Therefore, for developing medium grain hybrids, parents possessing long and short grains can be used as suggested by Shobha Rani (2003). Parents with similar endosperm appearance should be selected to avoid segregation for physical appearance among the grains (Li and Yuan, 2000). Hybrids identified with medium, long and short kernel type can be exploited based on region specific consumer preferences. Lesser kernel breadth, is generally preferred to have desirable shape of the kernel. However, high kernel breadth is a desirable trait in regions where consumers prefer bold grains for their daily consumption.

Length breadth ratio decides the shape of the kernel. For this trait, the hybrid IR 68886A × IR69715-72-1-3 had long slender grain type which resulted from the parents with long slender grain type. A total of 12 hybrids displayed long slender grain type and eight hybrids *viz.*, IR 68888A × IR 62030-54-1-2-2, IR 68888A × PSBRC

Table 1 : Mean performance of parents for different cooking and eating quality traits

Sr. No.	Parents	SP	MP	HRR	KL	KB	L/B ratio	KLAC (mm)	KBAC (mm)	LER	BER	L/B AC	VER	ASV	GC (mm)	AC (%)
1.	IR 68886 B	76.06	64.70	59.23	6.61	2.00	3.29	10.70	3.09	1.66	1.50	3.47	3.44	1.42	88.50	17.90
2.	IR 68888 B	74.53	67.38	61.38	6.06	1.90	3.18	10.82	2.50	1.86	1.28	4.34	3.06	1.31	109.74	21.67
3.	IR 68897 B	71.52	69.52	63.36	6.81	2.02	3.36	10.42	2.50	1.59	1.23	4.16	2.90	6.43	55.15	20.69
4.	COMS 14 B	78.33	70.01	64.72	5.81	1.82	3.19	9.06	2.44	1.66	1.31	3.72	3.04	5.11	120.78	24.70
5.	IR 36	72.53	64.13	59.17	6.62	2.03	3.26	10.05	2.75	1.63	1.28	3.67	3.13	3.15	90.22	22.91
6.	IR55838-B2-2-3-2-3	70.05	64.08	60.64	5.61	2.41	2.33	8.81	3.22	1.56	1.37	2.74	3.04	5.24	102.83	22.64
7.	IR 59624 –34-2-2	69.41	67.13	64.13	6.06	1.89	3.20	10.44	3.04	1.73	1.60	3.44	2.74	6.84	78.26	17.91
8.	IR 62030-54-1-2	79.33	70.46	65.51	6.42	2.11	3.04	9.82	3.04	1.52	1.44	3.23	3.23	3.25	97.96	19.70
9.	IR 62161-184-3-1-3-2	77.10	63.38	60.16	6.61	2.02	3.26	10.63	3.11	1.61	1.54	3.41	2.63	5.14	96.74	22.00
10.	IR69715-72-1-3	66.08	64.38	61.20	6.42	2.19	2.94	9.04	2.83	1.50	1.38	3.19	2.62	5.33	95.76	22.78
11.	IR 71604-4-1-4-7-10-2-1-3	80.53	74.83	69.23	6.61	2.11	3.13	8.63	2.61	1.40	1.24	3.30	2.68	6.84	95.75	22.39
12.	IR 72875-94-3-3-2	70.51	65.51	64.22	6.64	2.41	2.75	9.63	3.23	1.46	1.34	2.99	3.14	5.23	111.35	20.74
13.	PSBRC 80	72.58	72.53	59.64	6.40	2.06	3.11	9.87	3.01	1.54	1.46	3.27	2.66	6.56	101.80	25.53
14.	PSBRC 82	75.92	65.63	61.24	7.21	2.21	3.27	10.28	3.10	1.42	1.45	3.31	3.02	5.77	96.95	25.99
15.	WGL 14	72.08	62.13	60.31	5.82	1.80	3.22	7.67	2.35	1.42	1.30	3.25	3.31	5.14	100.87	20.16
16.	WGL 32100	68.54	61.51	59.77	5.22	1.76	2.90	7.84	2.57	1.50	1.46	3.05	3.14	5.23	96.01	20.26
	Mean	73.44	66.70	62.12	6.31	2.05	3.09	9.61	2.84	1.55	1.39	3.41	2.99	4.75	98.38	21.49
	C.D. (P=0.01)	0.114	0.531	0.277	0.070	0.069	0.149	0.028	0.040	0.189	0.144	0.049	0.041	0.051	4.892	1.222

82, IR 68888A × WGL 32100, IR 68897A × IR 71604-4-1-4-7-10-2-1-3, IR 68897A × WGL 32100, COMS 14A × IR 62161-184-3-1-3-2, COMS 14A × WGL 14 and COMS 14A × WGL 32100 and the parents IR 68888B, COMS14B, IR 59624-34-2-2, IR 62030-54-1-2-2 and WGL 14 had medium slender grain type which is highly preferable.

Higher kernel length after cooking is a desirable trait as it decides the market acceptance and consumer preference. The hybrid IR 68886A × PSBRC 80 had

Table 2 : Mean performance of selected hybrids for different cooking and eating quality traits

Sr. No.	Hybrids/checks	Shelling per cent	Milling per cent	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	Length/ breadth ratio
1.	IR 68886 A × IR 36	74.40	66.42	60.39	6.79	2.41	2.82
2.	IR 68886 A × IR 59624 –34-2-2	87.17	82.58	79.22	7.06	2.21	3.20
3.	IR 68886 A × IR 62030-54-1-2	87.76	80.23	74.13	6.41	2.41	2.67
4.	IR 68886 A × IR 62161-184-3-1-3-2	85.27	79.33	65.63	7.11	2.11	3.37
5.	IR 68886 A × IR69715-72-1-3	75.10	70.24	65.43	7.40	2.01	3.68
6.	IR 68886 A × IR 72875-94-3-3-2	82.44	77.10	73.63	6.81	2.21	3.09
7.	IR 68886 A × PSBRC 80	72.62	65.81	58.63	7.03	2.21	3.19
8.	IR 68888 A × IR 36	72.56	65.38	62.14	6.81	2.21	3.08
9.	IR 68888 A × IR55838-B2-2-3-2-3	76.13	70.24	66.49	6.01	2.30	2.61
10.	IR 68888 A × IR 62030-54-1-2-2	74.86	66.23	60.24	6.11	2.10	3.03
11.	IR 68888 A × IR 69715-72-1-3	79.31	73.23	69.17	6.70	1.91	3.51
12.	IR 68888 A × IR 71604-4-7-10-2-1-3	81.17	75.67	71.63	6.61	2.41	2.75
13.	IR 68888 A × IR 72875-94-3-3-2	85.22	79.60	74.17	6.81	2.21	3.09
14.	IR 68888 A × PSBRC 82	84.47	79.25	70.61	6.51	2.11	3.09
15.	IR 68888 A × WGL 14	79.13	74.42	68.84	5.81	2.00	2.90
16.	IR 68888 A × WGL 32100	78.66	71.51	69.57	5.91	1.96	3.01
17.	IR 68897 A × IR 36	82.63	76.20	68.13	6.61	2.41	2.75
18.	IR 68897 A × IR55838-B2-2-3-2-3	72.57	66.92	59.40	5.81	2.31	2.51
19.	IR 68897 A × IR 62030-54-1-2-2	80.22	74.31	66.79	6.62	2.11	3.14
20.	IR 68897 A × IR 62161-184-3-1-3-2	80.00	71.20	66.38	6.40	2.21	2.91
21.	IR 68897 A × IR 69715-72-1-3	80.63	75.42	67.71	6.81	2.21	3.09
22.	IR 68897 A × IR 71604-4-7-10-2-1-3	79.38	71.33	65.90	6.11	1.91	3.20
23.	IR 68897 A × IR 72875-94-3-3-2	81.20	74.63	69.40	7.21	2.11	3.42
24.	IR 68897 A × PSBRC 82	79.17	70.83	64.13	6.81	2.21	3.08
25.	IR 68897 A × WGL 14	67.81	64.29	60.46	5.82	2.01	2.88
26.	IR 68897 A × WGL 32100	73.15	66.43	62.85	5.82	1.91	3.04
27.	COMS 14 A × IR 36	89.13	78.17	73.63	5.83	2.00	2.91
28.	COMS 14 A × IR55838-B2-2-3-2-3	77.15	68.83	61.53	6.01	2.01	2.99
29.	COMS 14 A × IR 62030-54-1-2-2	84.28	76.58	72.63	6.03	2.11	2.85
30.	COMS 14 A × IR 62161-184-3-1-3-2	81.89	75.17	70.80	6.11	2.00	3.04
31.	COMS 14 A × IR 69715-72-1-3	67.88	63.58	59.13	6.09	2.05	2.98
32.	COMS 14 A × IR 72875-94-3-3-2	79.66	69.33	65.90	6.19	2.10	2.94
33.	COMS 14 A × PSBRC 82	81.08	71.54	66.67	6.03	2.02	2.98
34.	COMS 14 A × WGL 14	72.61	65.63	63.36	5.61	1.80	3.10
35.	COMS 14 A × WGL 32100				5.61	1.85	3.03
1.	ADTRH 1	77.38	67.26	64.45	7.10	2.01	3.53
2.	CORH 2	74.83	65.33	56.38	6.21	2.23	2.79
3.	ADT 43	77.28	67.25	64.33	5.79	1.81	3.20
4.	BPT 5204	73.28	63.08	60.58	5.40	1.80	3.00
	Mean	78.50	71.46	66.27	6.36	2.11	3.02
	C.D. (P=0.01)	0.195	0.141	0.499	0.046	0.048	0.097

high kernel length after cooking compared to the check varieties and the hybrids IR 68897A × IR55838-B2-2-3-2-3, COMS 14A × IR 62161-184-3-1-3-2 and COMS 14A × PSBRC 82 were at par with the check variety ADT 43. The restorer line PSBRC 80 with medium KLAC in combination with the CMS line IR 68886A having medium KLAC had produced the hybrid with high KLAC. The female parent COMS 14A with low KLAC had produced many hybrids with high KLAC in combination with high KLAC restorer lines IR 72875-94-3-3-2 and low KLAC restorers IR69715-72-1-3 and WGL 32100 indicating transgressive segregation for this

Table 3 : Mean performance of hybrids for different cooking and eating quality traits

Sr. No.	Hybrids/checks	KLAC (mm)	KBAC (mm)	LER	BER	L/B AC	VER	ASV	GC (mm)	AC(%)
1.	IR 68886 A × IR 36	10.45	3.55	1.54	1.48	2.95	4.11	5.24	96.65	21.90
2.	IR 68886 A × IR 59624 –34-2-2	10.81	3.25	1.53	1.47	3.32	3.87	6.14	85.27	20.68
3.	IR 68886 A × IR 62030-54-1-2	9.13	3.33	1.43	1.39	2.74	4.23	3.25	98.24	20.90
4.	IR 68886 A × IR 62161-184-3-1-3-2	10.66	2.81	1.50	1.33	3.79	4.12	5.15	96.28	22.94
5.	IR 68886 A × IR69715-72-1-3	10.91	2.85	1.48	1.41	3.82	3.84	5.11	100.17	22.25
6.	IR 68886 A × IR 72875-94-3-3-2	9.79	2.99	1.44	1.36	3.27	4.82	5.32	112.66	22.87
7.	IR 68886 A × PSBRC 80	11.22	2.80	1.60	1.27	4.00	3.73	5.57	80.69	23.60
8.	IR 68888 A × IR 36	10.23	3.00	1.50	1.37	3.41	3.85	5.11	98.26	21.63
9.	IR 68888 A × IR55838-B2-2-3-2-3	10.03	2.42	1.67	1.04	4.15	3.96	3.22	127.92	21.36
10.	IR 68888 A × IR 62030-54-1-2-2	10.07	2.62	1.65	1.25	3.84	3.86	3.42	100.13	22.90
11.	IR 68888 A × IR 69715-72-1-3	10.21	2.41	1.52	1.26	4.24	4.21	5.21	102.85	23.93
12.	IR 68888 A × IR 71604-4-7-10-2-1-3	9.63	2.83	1.46	1.17	3.41	4.04	6.13	88.05	22.55
13.	IR 68888 A × IR 72875-94-3-3-2	10.67	3.01	1.57	1.37	3.54	4.84	5.24	120.88	23.12
14.	IR 68888 A × PSBRC 82	10.66	3.04	1.63	1.44	3.60	4.09	6.23	85.73	23.53
15.	IR 68888 A × WGL 14	9.44	2.85	1.63	1.42	3.30	4.23	5.24	115.85	21.35
16.	IR 68888 A × WGL 32100	9.16	2.21	1.55	1.13	4.15	4.14	5.11	120.67	21.57
17.	IR 68897 A × IR 36	9.63	2.85	1.46	1.19	3.38	4.20	2.60	101.38	21.31
18.	IR 68897 A × IR55838-B2-2-3-2-3	8.63	2.91	1.49	1.26	2.98	3.85	2.86	100.35	20.70
19.	IR 68897 A × IR 62030-54-1-2-2	9.63	2.84	1.46	1.35	3.39	3.65	2.75	98.74	21.49
20.	IR 68897 A × IR 62161-184-3-1-3-2	10.67	3.04	1.66	1.38	3.61	4.09	3.11	94.76	19.30
21.	IR 68897 A × IR 69715-72-1-3	10.46	2.22	1.54	1.00	4.72	3.91	3.24	82.83	17.82
22.	IR 68897 A × IR 71604-4-7-10-2-1-3	11.05	2.63	1.81	1.38	4.21	4.15	2.87	95.85	19.38
23.	IR 68897 A × IR 72875-94-3-3-2	11.14	2.44	1.54	1.16	4.56	4.63	2.76	118.22	22.94
24.	IR 68897 A × PSBRC 82	10.42	2.63	1.53	1.19	3.98	4.94	6.40	102.85	23.05
25.	IR 68897 A × WGL 14	9.44	2.85	1.63	1.42	3.30	4.03	5.13	114.00	21.89
26.	IR 68897 A × WGL 32100	9.63	2.64	1.65	1.38	3.65	4.64	5.31	112.88	21.91
27.	COMS 14 A × IR 36	8.11	2.50	1.42	1.32	3.24	4.54	3.37	94.75	21.25
28.	COMS 14 A × IR55838-B2-2-3-2-3	8.11	2.02	1.45	1.06	4.01	4.95	5.13	101.72	21.35
29.	COMS 14 A × IR 62030-54-1-2-2	9.14	2.20	1.55	1.06	4.16	3.93	3.24	98.90	22.09
30.	COMS 14 A × IR 62161-184-3-1-3-2	9.01	2.09	1.53	1.10	4.31	4.38	5.13	83.74	21.18
31.	COMS 14 A × IR 69715-72-1-3	10.13	2.11	1.68	1.09	4.80	4.31	5.57	94.38	20.28
32.	COMS 14 A × IR 72875-94-3-3-2	10.11	2.10	1.41	1.02	4.81	4.51	5.24	105.95	21.51
33.	COMS 14 A × PSBRC 82	9.01	2.49	1.52	1.27	3.62	4.14	6.41	80.70	21.73
34.	COMS 14 A × WGL 14	8.01	2.09	1.45	1.23	3.82	4.15	5.22	110.74	21.29
35.	COMS 14 A × WGL 32100	9.81	2.60	1.60	1.33	3.76	4.15	5.20	101.75	22.09
1.	ADTRH 1	9.57	2.81	1.35	1.33	3.41	4.33	4.13	87.35	23.51
2.	CORH 2	9.46	2.91	1.60	1.39	3.04	4.83	4.55	103.34	22.72
3.	ADT 43	8.96	2.55	1.64	1.38	3.51	3.83	3.53	118.17	23.48
4.	BPT 5204	7.27	2.33	1.38	1.22	3.10	4.13	5.14	119.01	20.79
	Mean	9.76	2.67	1.54	1.28	3.72	4.04	4.59	101.35	21.46
	C.D. (P=0.01)	0.092	0.043	0.201	0.096	0.110	0.116	0.053	3.163	8.340

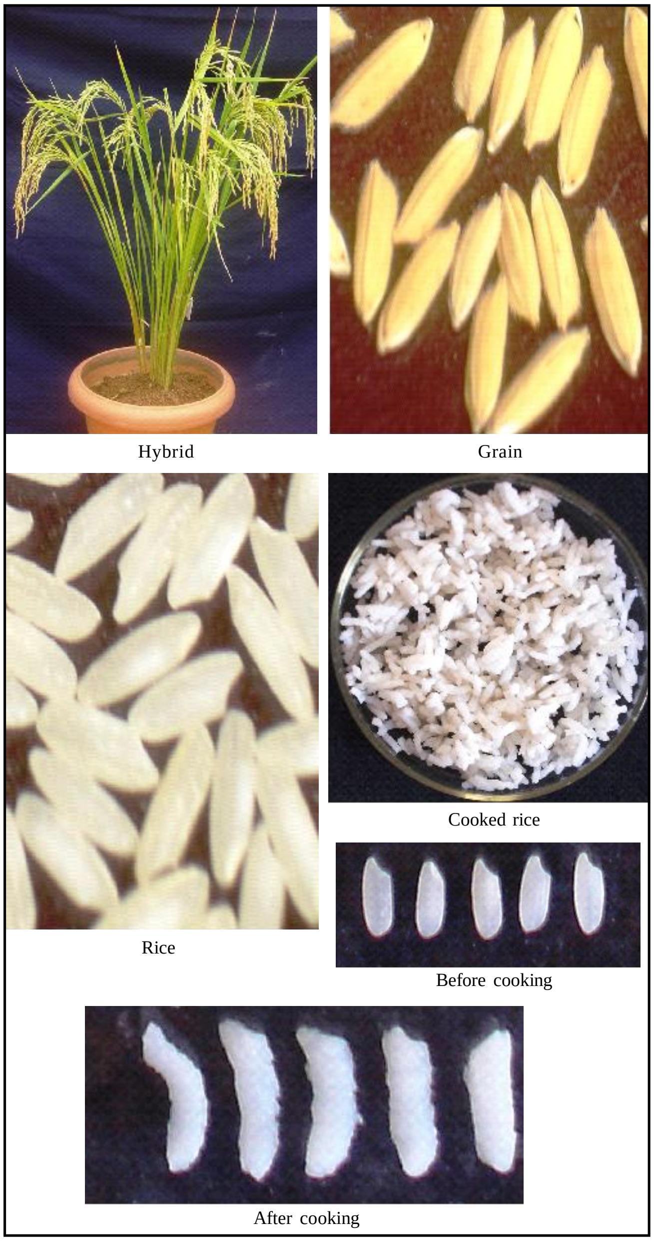

Fig. 1: Quality hybrid IR 68897A × IR 72875-94-3-3-2

trait.

In general, minimum breadth wise expansion on cooking is preferred by the consumers. In the study, the lines IR 68888A, IR68897A and COMS 14A and two testers *viz*., WGL 14 and WGL 32100 and 18 hybrids exhibited low kernel breadth after cooking which may be due to the involvement of maternal parents with low breadth wise expansion. Lower breadth wise expansion ratio was found in 12 hybrids IR 68888A × IR55838-B2-2-3-2-3, IR 68888A × IR 71604-4-7-10-2-1-3, IR 68888A × WGL 32100, IR 68897A × IR 36, IR 68897A × IR 62161-184-1-3-2, IR 68897A × IR 71604-4-1-4-7-10-2-1-3, IR 68897A × IR 72875-94-3-3-2, COMS 14A × IR55838-B2-2-3-2-3, COMS 14A × IR 62030-54-1-2-2, COMS 14A × IR 62161-184-3-1-3-2, COMS 14A × IR 69715-72-1-3 and COMS 14A × IR 72875-94-3-3-2 over check varieties/hybrids in the present study. The lines IR 68888A, IR68897A and COMS 14A and six testers IR 36, IR55838-B2-2-3-2-3, IR69715-72-1-3, IR 71604-4-1-4-7-10-2-1-3, IR 72875-94-3-3-2 and WGL 14 also registered lower breadth wise expansion ratio. These hybrids resulted from the parents with low × low, low × medium, low × high and medium × medium combinations. Low L/B ratio, higher KLAC and low KLBC in hybrids was reported by Munhot *et al*. (2000); Banumathy (2001) and Banumathy and Thiyagarajan (2004). Also, kernel elongation is influenced both by genetic and environmental factors, especially by the temperature at the time of grain ripening (Banumathy and Thiyagarajan, 2004 and Cruz *et al*., 1989).

Amylose content is considered as the most important character for predicting rice cooking quality. Many of the cooking and eating quality characteristics are influenced by the ratio of two kinds of starches, amylose and amylopectin in the rice grain (Juliano *et al*., 1964 and Ravindra Babu *et al*., 2013). Intermediate amylose rice cook moist and tender and do not become hard on cooling. Intermediate amylose rice is preferred in most of the rice growing areas of the world. The study on cooking quality revealed that 32 hybrids had intermediate amylose content as that of the check varieties *viz*., ADTRH 1, ADT 43 and BPT 5204 except three hybrids IR 68897A × IR 62030-54-1-2-2, IR 68897A × IR 62161-184-3-1-3-2,, IR 68897A × IR 71604-4-1-4-7-10-2-1-3. Most of the parents, involved in these hybrids had intermediate amylose content may be the reason that resulted in hybrids with intermediate amylose content.

Gelatinization temperature is measured by the alkali spreading value. In the present study, 16 hybrids displayed intermediate alkali spreading value and 12 hybrids showed intermediate to high alkali spreading value. A high ambient temperature during grain ripening, results in starch with higher GT (Ravindra Babu *et al*., 2013). To isolate hybrids with intermediate GT, it is important to select especially male parent to have intermediate GT (Shivani *et al*., 2007 and Ravindra Babu *et al*., 2013).

Gel consistency is the main factor that determines the texture namely softness or hardness of cooked rice. Medium and soft gel consistency types of rice varieties/ hybrids are generally preferred. In the present study, all the hybrids showed soft gel consistency of more than 60 mm with values ranging from 80.69 mm to 127.92 mm. Fifteen hybrids recorded very high gel consistency over the hybrid check ADTRH 1 (87.35mm) and three hybrids IR 68888A × IR55838-B2-2-3-2-3, IR 68888A × IR 72875-94-3-3-2 and IR 68888 A × WGL 32100 over the check BPT 5204. Except IR68897A, all the three CMS lines IR 68888A, IR68886A, COMS 14A and four testers *viz.*, WGL 14, PSBRC 80, IR 55838-B2-2-3-2-3 and IR 72875-94-3-3-2 recorded very soft gel consistency.

Volume expansion is another important cooking parameter of consumer preference. Twenty hybrids had higher volume expansion after cooking over the checks ADTRH 1, CORH 2 and ADT 43 and 16 hybrids over the check BPT 5204. Higher volume expansion after cooking was recorded by the hybrid COMS 14A × IR55838-B2-2-3-2-3, IR 68897A × IR 72875-94-3-3-2, IR 68888A × IR 72875-94-3-3-2, IR 68886A × IR 72875-94-3-3-2, COMS 14A × IR 69715-72-1-3 and IR 68897A × WGL 14. The parents involved in these hybrids were of low × low and low × intermediate types for volume expansion (Mahalingam and Nadarajan, 2010).

The hybrid COMS 14A × IR 62161-184-3-1-3-2 was identified as the best hybrid since it recorded the highest total score followed by IR 68888A × IR 69715-72-1-3, IR 68888A × WGL 32100, IR 68897A × IR 72875-94-3-3-2, COMS 14A × IR 69715-72-1-3 and COMS 14A × WGL 14, COMS 14 A × IR55838-B2-2-3-2-3 and IR 68897 A × IR 71604-4-1-4-7-10-2-1-3. These hybrids had good scores for milling per cent, head rice recovery, chalkiness, volume expansion, intermediate GT, soft gel consistency and amylose content. The parents of these hybrids also had higher total score for quality traits. These hybrids also showed higher yield performance coupled with good grain quality under aerobic conditions and can be exploited commercially for grain yield and quality improvement.

The parents *viz.*, WGL 14, IR 71604-4-7-10-2-1-3, IR 62161-184-3-1-3-2, IR55838-B2-2-3-2-3, IR 62030-54-1-2-2, PSBRC 82, IR 36, IR 68888A, IR 68897A and COMS 14A, with desirable grain quality had produced hybrids with superior grain quality. Since development heterotic rice hybrids with good grain quality is a major challenge in rice breeding, the identified parents possessing desirable quality traits can be further exploited for developing rice hybrids with improved quality characteristics suitable for specific regions.

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