Environment & Ecology 35 (4) : 2727—2732, October—December 2017
Website: environmentandecology.com ISSN 0970-0420

Evaluation of Rice Grain Quality of Newly Developed Advanced Rice (*Oryza sativa* L.) CMS Lines and their Respective Maintainer Lines

Gouri Shankar Panda, Indra Deo Pandey, Shoukat Ahmed Rather, Chandan Moharana, Rakesh Sil Sharma

Received 10 December 2016 ; Accepted 12 January 2017 ; Published online 31 January 2017

Abstract Genotypic differences in grain quality and cooking quality of newly developed 8 advanced CMS lines and their respective 8 Maintainer lines were assessed. The data revealed huge variations in grain quality among the lines. All lines tested have milling percentage varied from 55% to 73.62%. Highest head rice recovery was recorded in case of Maintainer-5 (55.7%). Most of the grain of parental lines were found to be long slender types. Cooked kernel length found highest in case Pant CMS-5 (10.6 mm) and Pant CMS-7 recorded highest cooked kernel breadth (3.3 mm). Kernel elongation ratio was highest in case of Pant CMS-8 (1.74). Maintainer-6 had highest hulling recovery (84.7%). Alkali digestion value was highest in Maintainer-6 (7) and Pant CMS-7 (7). Highest gel consistency value found in case of Pant CMS-1 (82 mm). Amylose content was highest in Maintainer-4 (46%).

Keywords Rice grain, Maintainer lines, CMS.

Introduction

Rice as a cereal grain is the most widely consumed staple food for a large part of world's human population, especially in Asia. It is the agricultural commodity with the third highest worldwide production, after sugarcane and maize (FAOSTAT, 2012). Since large portion of maize crops are grown for purpose other than human consumption, rice is the most important grains with regard to human nutrition and caloric intake, providing more than one-fifth of the calories consumed worldwide by humans. In recent decades, as living conditions is improving human demand for high quality rice is continuously on rise, which gives importance in incorporation of desirable grain quality features is the next important objective. Grain quality in rice is very difficult to define with precision because preferences for quality varies from country to country, locality to locality. Grain quality has always been an in the focus considering in rice variety selection and development. As per the survey of 11 major rice growing countries conducted by Juliano and Duff [1] observed that grain quality is next to yield as the important breeding objective.

In case of rice whole grain is cooked and consumed so quality considerations are of greater importance than for any other food crop. Rice is mainly consumed in the milled form, so the physical attributes of the intact endosperm are few of most important feature which determines consumer preference. So, the percentage of head grain, translucency of the grains, grain dimensions, chalkiness, weight, cooking and eating quality should be taken into consideration during the development of hybrid varieties.

G. S. Panda*, I. D. Pandey, S. A. Rather, C. Moharana, R. S. Sharma
G. B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttarakhand, India
e-mail: shankarpanda47@gmail.com
*Correspondence

Materials and Methods

The experiment was being carried out at the N. E. Borlaug, Crop Research Center (CRC) of GB Pant University of Agriculture and Technology, Pantnagar. The research center lies in the tarai belt, 30 km southern end of foothills of Shivalik range of Himalayas at 29 N latitude and 79.29 E longitude and an altitude of 243.83 m above mean sea level. The grain quality analysis work was carried out in rice lab present in N.E. Borlaugh Crop research center and rice lab of department of genetics and plant breeding lab, GBPUA and T, Pantnagar. The experimental materials for present study compromised of 8 cytoplasmic male sterile line and its 8 Maintainer line. The samples were analyzed for different grain quality traits which include kernel length (mm), kernel breadth (mm), length / breadth ratio, volume expansion ratio and amylose content (per cent) as per the standard procedures for each trait. Ten de-husked whole kernels were measured based on the kernel length and L/B ratio, grains were classified into long slender (LS), medium slender (MS), long bold (LB) and short bold (SB) [2]. Hulling was carried out in Satake laboratory huller (type THU 35 A) and the dehusked brown rice was passed through KETT type T-2 miller for 1 minute 30 seconds to obtain uniformly 5–6% polish [3] then total polished kernels were weighed and the milling percentage was calculated (Weight of the polished kernel / Weight of the paddy × 100). The milled samples were passed through rice grader to separate whole kernels from the broken ones. Small proportions of whole kernels which passed along with the broken grains were separated by hand. Full rice and three fourth kernels were considered and weighed and head rice recovery in percentage was calculated (Weight of whole polished grain / weight of paddy × 100) [4]. Alkali spreading value (ASV) and clearing test. Six milled rice grains were taken in petri plates and 10 ml of 1.7% of KOH was added and kept in incubator at 27–30°C for 23 h. Then the alkali spreading value was calculated as low, low-intermediate, intermediate or high [5]. Alkali digestion value was conducted by using the spread of the 6 milled rice kernels in 1.7% KOH solution for a period of 23 h was rated as per Standard Evaluation System for Rice (IRRI, 1996). Six milled kernels were placed in 10 ml of 1.7% KOH solution in petri dish and arranged in a manner so that they do not touch each other and were allowed to stand for 23 h at 30°C to score spreading on 1–7 scale. To determine the amylose content 20—30 grains of milled rice was grinded manually. Then 100 mg rice powder separated and it was kept in oven for 70°C for overnight. Then it was transferred to a volumetric flask of 100 ml. 1 ml of distilled ethyl alcohol was added into the flask and mixed throughly. Ten ml of NAOH added in the sample and left overnight at room temperature. Then solution was shaken vigorously and volume was made up 100 ml by using coiled and cooled distilled water. 5 ml of solution was transferred into another 100 ml volumetric flask from the original solution. Add 45 ml of boiled and cooled distilled water. Few drops of phenopthalin (0.25%) indicator added which resulted into development of pink color. Then it was titrated with 1N HCl which result into disappearance of pink color ; 2 ml of IKI (2.2% solution) was added which is called color preparation. Absorbance of the blue color was measured in terms of percentage at 590 nm in spectrophotometer then it was compared with the value of potato starch solution.

$$\text{Amylose content} = \frac{\text{Absorbance value of the known solution}}{\text{Absorbance of known solution}} \times \frac{\text{Mg dry amylos in 1 ml standard}}{5 \times \text{dry solid in sample } \frac{g}{g}} \times 100$$

Presence and absence of aroma in rice was determined by taking rice sample in 14 cm long plastic tube. Half of the tube is filled with rice kernel and rest amount is filled up with 1.7% KOH. Then its lid was closed and it was kept in this stat for 30 minutes. Then the lid was opened to test the presence of aroma in the kernel. It can be classified into 3 groups according to presence of aroma i.e. strongly scented (SS), mild scented (MS) and absence of aroma (A) [6, 7].

Results and Discussion

Kernel length : Kernel length across the genotype range from 5.6 to 6.6 mm. Average length of kernel

Table 1. Rice cooking quality parameters of CMS and maintainer lines.

Sl. No.	Rice variety	Kernel length	Kernel breadth	1/b	Cooked kernel length	Cooked kernel breadth	Alkali diges-tion
1	cms-1	6.4	1,7	3.764	9.4	3.1	2
2	m-1	6.1	1.7	3.58	9.2	2.5	2.33
3	cms-2	6.6	1.8	3.666	10.4	2.7	4
4	m-2	5.9	1.7	3.47	9.7	2.8	2.33
5	cms-3	6.2	1.9	3.263	10.5	2.7	2.33
6	m-3	6.4	1.6	4	8.4	2.6	2.33
7	cms-4	6	1.8	3.33	10.3	2.6	6.5
8	m-4	6.3	1.6	3.937	10.5	3.1	6.33
9	cms-5	6.5	1.8	3.611	10.6	2.5	5.83
10	m-5	6	1.6	3.75	10.4	2.6	5
11	cms-6	6.2	1.7	3.647	10.2	2.6	5.66
12	m-6	6	1.6	3.75	9.2	3.2	7
13	cms-7	5.9	1.8	3.277	9.8	3.3	7
14	m-7	5.6	1.6	3.5	9.5	2.5	5
15	cms-8	6.2	1.7	3.647	10.8	2.1	4
16	m-8	6.5	1.7	3.823	10.6	2.8	4.16
Average		6.175	1.70	3.62	9.96	2.73	4.4875
Range		5.6-6.5	1.6-1.9	3.33-4	8.4-10.6	2.1-3.3	02-7

Table 1. Rice cooking quality parameters of CMS and maintainer lines.

Sl. No.	Hulling (%)	Milling (%)	Head rice (%)	Gel consis-tency	Aroma	Amy-lose	Kernel elonga-tion ratio
1	81.25	68.75	52.31	82	MS	20	1.47
2	81.9	68.57	48.26	73	MS	16	1.51
3	81.08	68.91	47.56	78	A	16	1.58
4	76.25	66.25	46.53	73	MS	34	1.64
5	81.11	72.22	51.23	59	A	41	1.69
6	80	55	39.47	64	MS	25	1.31
7	83.33	75	53.21	68	MS	21	1.72
8	79.54	69.31	49.33	54	MS	46	1.67
9	82.6	69.56	51.39	69	MS	32	1.63
10	82.41	73.62	55.75	71	A	24	1.73
11	78.88	67.77	51.23	72	MS	28	1.65
12	84.7	65.88	46.78	64	SS	31	1.53
13	77.777	66.66	49.24	62	MS	37	1.66
14	71.01	63.63	43.31	81	A	12	1.70
15	77.27	61.36	45.32	74	MS	19	1.74
16	78.49	67.74	49.62	72	MS	28	1.63
Average	79.84	67.51	48.78	69.75		26.87	1.62
Range	71.01-82.6	55-73.62	39.47-55.75	54-82		12.46	5.6-6.5

across genotype was 6.175. Highest kernel length was found in case of Pant CMS-2 (6.6 mm) and followed by Pant CMS-5 (6.5 mm) and Maintainer - 8 (6.5 mm). Lowest kernel length observed in case of Maintainer -7 (5.6 mm) (Table 1). Similar result also found in case of Joshi et al. [8].

Kernel breadth : Kernel breadh across the genotype range from 1.6 to 1.9 mm. Average length of kernel across genotype was 1.706. Highest kernel breadth was found in case on Pant CMS-3 (1.9 mm) followed by Pant CMS-2, Pant CMS-4, Pant CMS-5, and Pant CMS-7. Lowest kernel breadth observed in case of

Maintainer-7 (1.6 mm).

Kernel length, breadth ratio : Kernel length, breadth ratio across the genotype range from 3.33 to 4. Average ratio of across genotype was 3.625. Highest ratio was found in case on Maintainer-3 (4), followed by Maintainer-4 (3.937) and Maintainer-8 (3.824).Lowest ratio observed in case of Pant CMS-4.

Cooked kernel length : Cooked kernel length across the genotype range from 8.4 to 10.6 mm. Average length of kernel across genotype was 9.968 mm. Highest cooked kernel length was found in case of Pant CMS-5 (10.6) and followed by Pant CMS-3 (10.5 mm) and Maintainer-5 (10.5 mm). Lowest cooked kernel length observed in case of Maintainer-3 (8.4 mm).

Cooked kernel breadth : Cooked kernel breadth across the genotype range from 2.1 to 3.3 mm. Average length of kernel across genotype was 2.73 mm. Highest cooked kernel breadth was found in case of Pant CMS-7 (3.3) and followed by Maintainer-6 (3.2 mm). Lowest cooked kernel breadth observed in case of Pant CMS-8.

Kernel elongation ratio : Kernel elongation ratio across the genotype ranged from 1.31 to 1.74. Average kernel elongation ratio across genotype was 1.62. Highest kernel elongation ratio was found in case of Pant CMS-8 (1.74) and followed by Maintainer-5 (1.73) and Pant CMS-4 (1.72). Lowest kernel elongation ratio was observed in case of Maintainer-3 (1.31) of Pant CMS-8 (1.74) and followed by Maintainer-5 (1.73) and Pant CMS-4 (1.72). Lowest kernel elongation ratio was observed in case of Maintainer-3 (1.31). Similar experiment was also conducted by Srivastava and Jaiswal [9] and they obtained 1.3 to 1.9 for lengthwise elongation ratio. Kernel elongation ratio are one of the important character during selection of a variety as it gives a finer look. In our experiment Pant CMS-8 (1.74), Maintainer-5 (1.73) and Pant CMS-4 (1.72) are more suitable as it had better Kernel elongation ratio.

Hulling recovery : Hulling recovery across the genotype ranged from 71.01% to 84.6%. Average hulling recovery across genotype was 79.84%. Highest hulling recovery was found in case of Maintainer-6 (84.7%) and followed by Pant CMS-4 (83.33%) and Pant CMS-5 (82.6%). Lowest hulling recovery observed in case of Maintainer-7 (71.01%).

Milling recovery : Milling recovery across the genotype ranged from 55% to 73.62%. Average milling recovery across genotype was 67.51%. Highest milling recovery was found in case of Pant CMS-4 (75%) and followed by Maintainer-5 (73.62%) and Pant CMS-3 (72.22%). Lowest milling recovery observed in case of Maintainer-3 (55%).

Head rice recovery : Head rice recovery across the genotype ranged from 39.47% to 55.7%. Average head rice recovery across genotype was 48.78%. Highest head rice recovery was found in case of Maintainer-5 (55.7%) and followed by Pant CMS-4 (53.21%) and Pant CMS-1 (52.31%). Lowest head rice recovery observed in case of Maintainer-3 (39.47%). Curvas et al. [10] on their research found effect broken grains, head rice recovery and gel consistency on pricing and performance of the consumer. So the percentage of head rice recovery should be use during selection of variety because variety with higher head rice recovery generally more preferred by the consumer.

Alkali digestion value : The sample are rated from 1 (sample not effected) to 7 (sample completely dispersed and intermingled). Alkali digestion value across the genotype ranged from 2 to 7. Average alkali digestion across genotype was 4.16. Highest alkali digestion value was found in case of Maintainer-6 (7) and Pant CMS-7 (7) followed by Pant CMS-4 (6.5) and Maintainer-4 (6.33). Lowest alkali digestion observed in case of Pant CMS-1 (2). In this experiment it was observed that alkali digestion value correlated with differences in solubilisation. Similar result also found in experiment conducted by Bhattacharya and Sowbhagya [6].

Gel consistency : Gel consistency value across the genotype ranged from 54 mm to 82 mm. Average gel consistency across genotype was 69.75 mm. Highest gel consistency was found in case of Pant (CMS-1 (82 mm) and followed by Maintainer-7 (81 mm) and Pant CMS-2 (78 mm). Lowest gel consistency value observed in case of Maintainer-4 (54 mm). Cagampang [4] during gel consistency test found that rice with a hard texture, the gel is short, travelling only a small distance, but for those with soft texture, the gel is viscous and travels up to 10 cm within the hour. So in this experiment the rice travelling short distance were of hard texture and short distance travelling rice were soft textured.

Amylose content : Amylose content across the genotype ranged from 12% to 46%. Average amylose content across genotype was 26.875%. Highest amylose content was found in case of Maintainer-4 (46%) and followed by Pant CMS-3 (41%) and Pant CMS-7 (38%). Lowest amylose content observed in case of Maintainer-7 (12%). In case of milled rice, based on amylose content it is classified into 1–2% waxy, waxy amylose (2–9%), low amylose (9–20%) and med amylose (20–30%) and more than 30% high amylose rice. Rice having high amylose are hard and flaky. Rice having 10–20% amylose are soft and flaky. In this experiment most of the research material were having amylose content between 9–20% which is a desirable traits [11]. Amylose content important determinant of eating quality as it reflects the functionality of rice grain's starch i.e. flakiness and stickiness which were also found in these varieties [12]. There is also liner correlation present between hardness and amylose content of rice [13].

Aroma : Out of 16 line taken in experiment Maintainer-6 line found to be super scented. While Pant CMS-2, Pant CMS-3, Maintainer-5 and Maintainer-7 found without aroma rest variety used are medium or faintly scented.

Cooking quality analysis revealed that Pant CMS-2 had highest Kernel length. Kernel breadth was highest in Pant CMS-3 whereas 1/b ratio maximum in Maintainer-3. Cooked Kernel length found highest in Pant CMS-5. Pant CMS-7 had highest cooked kernel breadth. Kernel elongation ratio was highest in case of Pant CMS-8. Maintainer-6 had highest hulling recovery. Milling recovery highest in Pant CMS-4. Head rice recovery highest in Maintainer-5. Alkali digestion value was highest in Maintainer-6. Highest gel consistency value found in case of Pant CMS-1. Amylose content was highest in Maintainer-4. Superior aroma was found in Maintainer-6. And considering all of the characters Maintainer-5 and Pant CMS-4 found superior and mores desirable then rest lines. Considering overall result it was concluded selecting lines for panicle initiation, 50% panicle emergence, 100% panicle emergence, panicle per plant, no. of tillers and days of maturity will give us better grain yield per plant. Cooking quality analysis showed that in terms of quality Maintainer-5 and Pant CMS-4 were superior then rest of the lines.

Conclusion

The potential for improving quality through genetics is quite high. There should be no conflict between breeding for better appearance i.e. rice grain qualities and cooking qualities [14]. Also there is an effect of head rice recovery and gel consistency on pricing and performance of the consumer. So the percentage of head rice recovery should be use during selection of variety because variety with higher head rice recovery generally more preferred by the consumer. In the short term, the additional selection characters may slow breeding this study will guide the utilization of popular rice hybrids in plant improvement programs and provides a basis for further studies into how the nutritional and grain quality parameters could be enhanced.

References

1. Juliano BO, Duff B (1991) Rice grain quality as an emerging priority in national breeding programs. In: Rice grain marketing and quality issues. Int Rice Res Inst, Los Banos, Philippines, pp 55—64.
2. Cruz DN, Khush GS (2004) Rice grain quality evaluation procedures. In: Singh RK, Singh US, Khush GS (eds) aromatic rices. Kalyani, New Delhi, pp 15—28.
3. Ghosh AK, Nanda BB, Swami SG, Nayak BB (1971) Influence of nitrogen on the physico-chemical characteristics of rice grain. Oryza 891 87—97.
4. Cagampang GB, Perez CM, Juliano BO (1973) A gel consistency test for eating quality in rice. J Sci Food and Agric 24 : 1589—1594.
5. Juliano BO, Perez CM, Cuevas-Perez F (1993) Screening for stable high head rice yields in rough rice. Cereal Chem J 70 : 650—655.
6. Bhattacharya KR, Sowbhagya CM (1972) An improved alkali reaction test for rice quality. J Food Technol 7 : 323—331.
7. Bhonsle SJ (2010) Grain quality evaluation and organoleptic analysis of aromatic rice varieties of Goa. India J Agric Sci 2 : 99—107.
8. Joshi RK, Subudhi E, Kar B, Nayak (2013) Comparative genetic analysis of lowland aromatic rice culti-

vars of India using microsatellite markers. Biores Bull 4 : 213—223.
9. Srivastava AK, Jaiswal HK (2013) Grain characteristics and cooking quality of indigenous aromatic and non-aromatic genotypes of rice (*Oryza sativa* L.). IJSRR 2 : 36—41.
10. Cuevas RP, Pede VO, McKinley J, Velarde O, Demont M (2016) Rice grain quality and consumer preferences : A case study of two rural towns in the philippines. PLoS one, pp 11.
11. Bansal UK, Kaur N, Sani RG (2006) Donors for quality characteristics in aromatic rice. Oryza 43 : 197—202.
12. Latha R, Senthilvel K, Thiyagaraja K (2005) Grain and cooking quality characteristics of two line hybrids in rice (*Oryza sativa* L.). Ind J Genet 65 : 45—46.
13. González, Livore A, Pons B (2004) Physico-chemical and cooking characteristics of some rice varieties. Brazil Arch Biol Technol, pp 47.
14. Bhattacharya KR (1980) Breakage of rice during milling : A Review Tropical Sci 22 : 255—276.