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Title: Grain Properties of Indigenous Rice Cultivars from Khagrachari District of Bangladesh

Authors: Md. Sarwar Jahan*, Md. Kaosar Ahemed and Sajib Talukder
Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh

*Corresponding Author: Md. Sarwar Jahan Email: mjahan70@yahoo.com

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ABSTRACT

A study was conducted in the Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Khulna, Bangladesh to find out the variations in grain characters of fifteen local rice cultivars collected from Khagrachari district, Bangladesh. Significant variations were observed in all of the investigated parameter. The highest and lowest length of grain was recorded in the cultivar Chonchonbini (7.1 mm) and Mashlajira (4.12 mm), respectively. Grain width of Badia (2.78 mm) was the highest and the lowest width was recorded in Mashlajira (2.13 mm). Grain thickness varied from 1.6 mm to 1.94 mm. The highest L/W ratio (3.11) was observed in Curi. Most of the variety showed medium grain shape. The highest alkali spreading score was found in Moisanguribini (6). All of the varieties showed soft gel consistency. Variation in grain characters observed among the local rice cultivars in the present study and these characters may be used as valuable resources for future breeding programs.

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INTRODUCTION

The Himalayan foothills including parts of Bangladesh are considered to be at least a center of diversity of the genus *Oryza* (Morishima, 1984). Perhaps for this reason Bangladesh is rich in genetic diversity of cultivated rice. Nearly 10,000 land races of rice are considered to exist in Bangladesh (Haque and Miah, 1990). The promotion of high yielding variety (HYV) rice mono-culture has led to loss of diversity including 7000 traditional rice varieties (Singh et al., 2000). For preserving genetic diversity in order to use for variety improvement programs in future, the threatened rice varieties need to be collected, conserved and evaluated. Effective utilization of germplasm in breeding programs is enhanced if the variations are properly characterized and described (Ouendeba et al., 1995). The rich genetic resources of rice in Bangladesh can be grouped into several ecotypes and so far seven ecotypes have been recorded in Bangladesh: Boro, Aus, Transplanted Aman (T. Aman), Broadcast Aman (B. Aman), Rayada, Ashina and Hill rice (Khush, 1997; Oka, 1998). Besides, there are ethnic or tribal people living in Bangladesh, who have also their special use of rice for their own purposes, e.g. wine making etc. Tribal rice could be considered as primitive type (Uddin, 1994).

Grain characters have been used for the classification of ecospecies and ecotypes of rice (Morishima and Oka, 1981). Rice, unlike most other cereals, is consumed as a whole grain. Therefore, physical properties such as size, shape, uniformity, and general appearance are of utmost importance. Furthermore, as most rice is milled, the important physical properties are determined primarily by the milled endosperm (Mutters, 1998). The quality in rice may, therefore, be considered from the view point of milling quality, grain size, shape and appearance and cooking characteristics (Cruz and Khush, 2000).

Local rice varieties may grow and yield satisfactorily in a wide area but their quality traits are expressed best in their native area of cultivation. Expression of aroma and other quality traits is quite dependent upon environmental factors, which are yet to be properly defined for local rice varieties in Khagrachari district of Bangladesh. The present study was therefore undertaken to determine the variability in grain parameters of fifteen local rice cultivars from Khagrachari district of Bangladesh.

MATERIALS AND METHODS

Plant material

Fifteen local rice cultivars from Khagrachari District were used as plant materials in this experiment. They are Dub bini, Chonchonbini, Longkapora, Bini, Curi, Bora kusum, Tumbas, Lengdacikon, Sonamukhi, Badia, Rangamuni, Kallayajira, Moshlajira, Moisanguribini and Nadinga. All of the fifteen cultivars were collected form Khagrachari hilly areas and experimented in Agronomy Laboratory of Agrotechnology Discipline, Khulna University, Khulna (Table 1).

Evaluation of Physical properties

The length of the rice grain is a measure of the rough rice kernel in its greatest dimension (slenderness) while the width of the rice grain is the measure of the rough rice kernel width (breadth) in its maximum dimension (Tokpah, 2010). The thickness is the depth of the rice grain. Measurements for length, width and thickness of de-hulled grains were taken using 20 grains of each cultivar under each of the five replications using a digital Vernier caliper. Moreover, of the de-hulled grains, calculations were done on the ratio of 'length to width' using average values of respective characters. Grain shape was determined based on the length/width (L/W) ratio (Badi, 2013; Xiongsiyee and Prom-U-Thai, 2016).

Based on length, rice grains were grouped into different grain size classes according to the classification by Cruz and Khush (2000). The classes are very long (> 7.50 mm), long (6.61-7.50 mm), medium (5.51-6.60 mm) and short (< 5.50 mm). The ISO Classification was followed for grain shape. Depending on L/W ratios, the rice cultivars tested were classified into shape groups as round (L/W ratio 1.0 or less), bold (L/W ratio 1.1 to 2.0), medium (L/W ratio 2.1-3.0) and slender (L/W over 3.0) (Badi, 2013).

Evaluation of Chemical properties

(a) Alkali digestibility: The alkali spreading for the grains of each of the varieties was determined with three replications according to the method of Little et al. (1958). The disintegration of starch granules was detected by keeping a vertically halved de-hulled grain in petridish with 1 ml of 1.7% (w/v) KOH solution for 24 hours at room temperature. Based on disintegration behavior, rice kernels were classified broadly into 3 groups, i.e. low, intermediate and high alkali digestibility (Cruz and Khush, 2000; Jahan et al., 2006). Kernels with high and intermediate alkali digestibility disintegrate almost completely and partially in 1.7% KOH solution; however, the kernels with low alkali digestibility remain unaffected there. Within individual groups, significant difference can be observed in the degree of spreading (disintegration) for rice kernels. Therefore, each of the alkali digestibility group was divided further for better characterization. Low alkali digestibility consisted of the alkali spreading scores 1 and 2 as determined by the degree of spreading of rice kernels in 1.7% KOH solution after 24 hours of immersion at room temperature. Intermediate alkali digestibility consisted of the alkali spreading scores 3, 4 and 5 and high alkali digestibility consisted of the alkali spreading scores 6 and 7 (Cruz and Khush, 2000). Time needed for cooking is assessed by the gelatinization temperature (GT) of starch. Alkali digestion technique is widely applied for estimating GT. Therefore, in the present study, GT was measured by determining the alkali-spreading value following the method of Badi (2013).

(b) Gel consistency: The gel consistency test is based on the consistency of the rice paste and differentiates among varieties with high amylose content. The test separates high-amylose-rice into three categories: very flaky rice with hard gel consistency (length of gel, 40 mm or less); flaky rice with medium gel consistency (length of gel, 41 to 60 mm) and soft rice with soft gel consistency (length of gel, more than 61 mm). Twenty whole de-husked rice grains were ground with the help of a mortar and pestle to give fine flour (100 meshes). One hundred mg (±1 mg) of powder was weighed and triplicated into the culture tube (13x100mm) and then 0.2 ml of 95% ethyl alcohol containing 0.025% thymol blue was added along with only 2.0 ml of 0.2 N KOH. Contents were mixed well. The test tubes were covered with glass marbles to prevent steam loss and to reflux the samples. The samples were cooked in vigorously boiling water bath for 8 minutes, making sure that the tube contents reach 2/3rd the height of the tube. The test tubes were removed from the water bath and let stand at room temperature for 5 minutes. The tubes were cooled in an ice bath for 20 minutes and laid horizontally on a laboratory table lined with millimeter graphing paper. The total length of the gel was measured in mm from the bottom of the tube to the gel front.

Statistical analysis

The experiment was laid out in a Completely Randomized Design (CRD) with five replications. All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjusted by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using computer operated program MSTAT-C. Standard deviation and coefficient of variation were determined for all the parameters studied.

Table 1. List of fifteen local rice cultivars collected from Khagrachari District, Bangladesh

Sl. No.	Acc. No.	Name of cultivars	Growing Season
01.	Khag -01	Dub bini	Aman
02.	Khag -02	Chonchonbini	Aman
03.	Khag - 03	Longkapora	Aman
04.	Khag -04	Bini	Aman
05.	Khag -05	Curi	Aman
06.	Khag -06	Bora	Aman
07.	Khag -07	Tumbas	Aman
08.	Khag -08	Lengda	Aman
09.	Khag -09	Sonamuki	Aman
10.	Khag -10	Badia	Aman
11.	Khag -11	Rangamuni	Boro
12.	Khag -12	Kallayajira	Aman
13.	Khag -13	Mashlajira	Boro
14.	Khag -14	Moisanguri	Boro
15.	Khag-15	Nadinga	Boro

RESULTS AND DISCUSSION

Variations in grain length

The length of the grains differed significantly and was found between 4.12 mm and 7.1 mm with an average value of 5.91 mm. The standard deviation of cultivars for grain length was calculated as 0.87 (Table 3). The longest grain (7.1 mm) was found in the variety Chonchonbini which differed significantly from grain length of other cultivars. Variety Mashlajira showed the shortest grain that was also statistically different from grain length of other cultivars. Jahan et al. (2006) reported that grain length of 369 de-hulled rice varieties from Bangladesh ranged between 2.71 to 8.08 mm with an average value of 5.84 mm. Among the fifteen cultivars, apparently longer grains were found in chonchonbini, Longkapora, Bini, Curi and Badia. Dub bini, Tumbas, Lengdacikon, Sonamuki, Rangamuni and Moisanguri, possessed medium grains. Short grain was found in Bora kusum, Kallayajira, Mashlajira and Nadinga (Table 2).

Variations in grain width

Grain width varied from 2.13 mm to 2.78 mm with an average width of 2.44 mm among the rice cultivars tested. The highest grain width was found in Badia (2.78 mm) and the lowest in Mashlajira (2.13 mm). Grain width among the cultivars also differed significantly ($p \leq 0.01$). However, grains of Bora kusum (2.64 mm), Rangamuni (2.63 mm), Dub bini (2.58 mm), Bini (2.57 mm) and Moisanguribini (2.62 mm) showed non-significant variations. Grain width of Sonamuki (2.38 mm) and Tumbas (2.37 mm) was found statistically at par. Cultivars Kallayajira (2.21 mm), Lengdacikon (2.21 mm) and Curi (2.17 mm) exhibited statistically similar grain width also (Table 2). Dipti et al. (2003) reported a mean width of 2.08 mm of 11 Beruin rice varieties of Bangladesh.

Variation in grain thickness

Statistically significant variation was recorded in thickness of the rice grains. Grain thickness varied between 1.6 mm and 1.94 mm with an average value of 1.73 mm. The standard deviation of cultivars for grain thickness was found 0.11 (Table 2). The highest grain thickness (1.94 mm) was observed in Rangamuni which significantly differed from other cultivars and the lowest grain thickness (1.6 mm) was found in Mashlajira which was statistically at par with Sonamuki (1.65 mm), Lengdacikon (1.65 mm), Kallayajira (1.61 mm), Tumbas (1.61 mm), Curi (1.61 mm) and Mashlajira (1.60 mm). Cultivars Moisanguribini (1.85 mm), Chonchonbini (1.85 mm) and Nadinga (1.84 mm) displayed statistically similar grain thikness. Badia (1.79 mm) and Dub bini (1.78 mm) also revealed statistically similar grain thickness. Satoh et al. (1990) reported a mean thickness of 1.88 mm of 99 cultivated rice varieties from Madagascar.

Length width (L/W) ratio

Ratio of grain length to grain width differed significantly among cultivars. The highest L/W ratio (3.11) was observed in Curi which differed significantly from others. Lowest L/W ratio (1.86) was found in Bora kusum which is statistically similar with L/W ratios of Kallayajira (1.94) and Mashlajira (1.94). Statistically similar L/W ratio was also found in Bini (2.6), Lengdacikon (2.58), Dub bini (2.56) and Sonamuki (2.55). Rangamuni (2.15) and Nadinga (2.06) had statistically similar L/W ratio. Average value of L/W ratio was found to be 2.43 (Table 2).

Table 2. Length, width, L/W ratio and thickness of fifteen local rice cultivars from Khagrachari district of Bangladesh

Acc. no.	Length (mm)	Width (mm)	Thickness (mm)	Length width ratio
Khag-01	6.58 c	2.58 bcd	1.78 bc	2.55 d
Khag-02	7.1 a	2.52 d	1.85 b	2.82 c
Khag-03	6.82 b	2.29 f	1.74 cd	2.98 b
Khag-04	6.69 bc	2.57 bcd	1.76 c	2.6 d
Khag-05	6.74 bc	2.17 gh	1.61 e	3.11 a
Khag-06	4.91 g	2.64 b	1.68 de	1.86 h
Khag-07	5.99 d	2.37 e	1.61 e	2.53 de
Khag-08	5.7 e	2.21 g	1.65 e	2.58 d
Khag-09	6.07 d	2.38 e	1.65 e	2.55 d
Khag-10	6.78 b	2.78 a	1.79 bc	2.44 e
Khag-11	5.66 e	2.63 b	1.94 a	2.15 g
Khag-12	4.3 h	2.21 g	1.61 e	1.95 h
Khag-13	4.12 i	2.13 h	1.6 e	1.93 h
Khag-14	5.97 d	2.62 bc	1.85 b	2.28 f
Khag-15	5.26 f	2.55 cd	1.84 b	2.06 g
Mean	5.91	2.44	1.73	2.43
SD	0.87	0.20	0.11	0.37
CV (%)	1.15	1.25	1.96	1.77

Khag-01 = Dub bini, Khag-02= Chonchon b ini, Khag-03= Longkapora, Khag-04= Bini, Khag-05= Curi, Khag-06= Bora kusum, Khag-07= Tumbas, Khag-08= Lengdacikon, Khag-09= Sonamuki, Khag-10= Badia, Khag-11= Rangamuni, Khag-12= Kallayajira, Khag-13= Mashlajira, Khag-14= Moisanguribini, Khag-15= Nadinga.

Table 3. Grain size and grain shape variation of fifteen local rice cultivars from Khagrachari district of Bangladesh

Acc. No.	Grain size	Grain shape
Khag - 01	Medium	Medium
Khag - 02	Long	Medium
Khag -03	Long	Medium
Khag -04	Long	Medium
Khag -05	Long	Slender
Khag -06	Short	Bold
Khag -07	Medium	Medium
Khag -08	Medium	Medium
Khag -09	Medium	Medium
Khag -10	Long	Medium
Khag -11	Medium	Medium
Khag -12	Short	Bold
Khag -13	Short	Bold
Khag -14	Medium	Medium
Khag-15	Short	Bold

Khag-01 = Dub bini, Khag-02= Chonchon b ini, Khag-03= Longkapora, Khag-04= Bini, Khag-05= Curi, Khag-06= Bora kusum, Khag-07= Tumbas, Khag-08= Lengdacikon, Khag-09= Sonamuki, Khag-10= Badia, Khag-11= Rangamuni, Khag-12= Kallayajira, Khag-13= Mashlajira, Khag-14= Moisanguribini, Khag-15= Nadinga.

Slender shaped grain was found in Curi. Medium shaped grains were found in Dub bini, chonchonbini, Longkapora, Bini, Rangamuni, Tumbas, Lengdacikon, Sonamuki, Badia and Moisanguribini whereas the grains were found as bold in Nadinga, Kallayajira, Mashlajira and Bora kusum (Table 3). Round shape of grains was not recorded in any of the varieties in the current study. Islam et al. (2009) studied six aromatic local rice varieties and found a mean value of L/W ratio as 2.17 with a standard deviation of 0.13.

Table 4. Alkali digestibility and gel consistency of local rice cultivars from Khagrachari district of Bangladesh

Acc. No.	Alkali spreading score	Alkali digestion	Gelatilization temperature	Gel length (mm)	Gel consistency
Khag-01	02	Low	High	87	Soft
Khag-02	02	Low	High	93	Soft
Khag-03	02	Low	High	92	Soft
Khag-04	02	Low	High	94	Soft
Khag-05	01	Low	High	93	Soft
Khag-06	03	Intermediate	Intermediate	97	Soft
Khag-07	01	Low	High	90	Soft
Khag-08	01	Low	High	99	Soft
Khag-09	01	Low	High	95	Soft
Khag-10	02	Low	High	97	Soft
Khag-11	01	Low	High	90	Soft
Khag-12	01	Low	High	78	Soft
Khag-13	02	Low	High	97	Soft
Khag-14	04	Intermediate	Intermediate	91	Soft
Khag-15	02	Low	High	96	Soft

Khag-01 = Dub bini, Khag-02= Chonchon b ini, Khag-03= Longkapora, Khag-04= Bini, Khag-05= Curi, Khag-06= Bora kusum, Khag-07= Tumbas, Khag-08= Lengdacikon, Khag-09= Sonamuki, Khag-10= Badia, Khag-11= Rangamuni, Khag-12= Kallayajira, Khag-13= Mashlajira, Khag-14= Moisanguribini, Khag-15= Nadinga.

Disintegration of rice kernels in 1.7% KOH solution

Among the studied varieties Dub bini, Chonchonbini, Longkaporabini, Bini, Curi, Tumbas, Lengdacikon, Sonamuki, Badia, Rangamuni, Kallayajira, Mashlajira and Nadinga exhibited low alkali digestibility i.e. scored 1 or 2 only for alkali spreading. Intermediate alkali digestibility was found in Bora Kusumand Moisanguribini (Plate 1 and Table 4). The findings from this experiment are in line with the findings of Jahan et al. (2002) who analyzed more than 500 indigenous rice cultivars from Bangladesh and reported that more than 90% of Bangladeshi rice cultivars contain low alkali digestibility with alkali spreading score between 1 and 2. Varieties with low alkali digestion possess high gelatinization temperature while the varieties with intermediate alkali digestion reveal to intermediate gelatinization temperature as suggested by others (Badi, 2013; Cruz and Khush, 2000).

Gel consistency behavior

In the present study, gel length indicated a range from 78 mm to 99 mm. The minimum length of the starch gel was recorded in Kallayajira while the maximum was found in Lengdacikon. It is notable that 13 cultivars showed starch gel length exceeding 90 mm. All of the 15 cultivars exhibited soft gel consistency (Table 4). The findings of the present study indicate that Khagrachari rice is soft rice. Varietal difference in gel consistency exits among varieties of similar amylose content (Cruz and Kush, 2000). Jahan et al. (2006) studied 276 local varieties of Bangladesh and found 73 varieties having soft gel consistency.

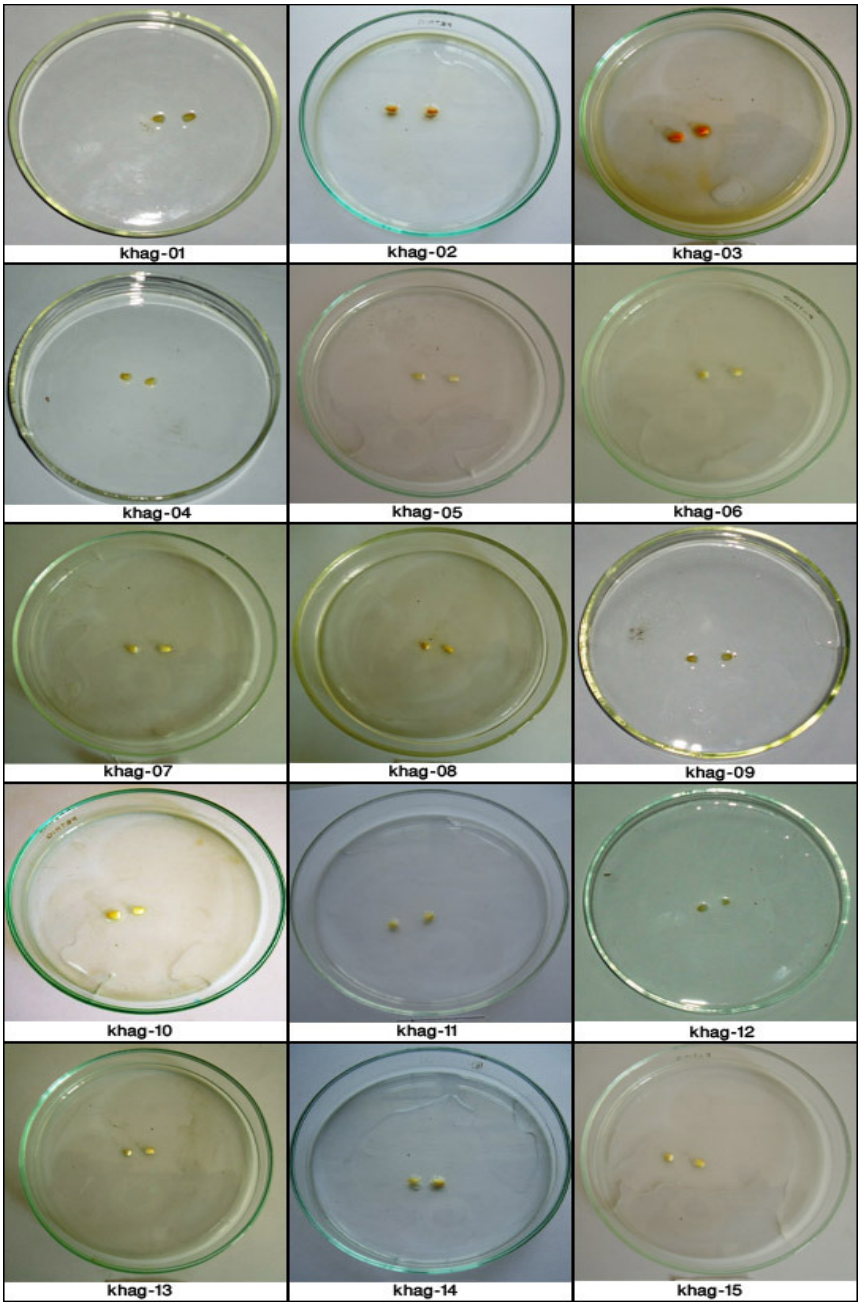
CONCLUSION

This study demonstrated the variation in grain characteristics of the local rice cultivars from Khagrachari district, Bangladesh. Garin size (length) of the rice cultivars exhibited a mixed pattern of long, medium and short types. However, most of the rice samples are medium in grain shape. Moreover, most of the cultivars showed low alkali digestion with high gelatilization temperatures. Consistency of the starch gels of the tested varieties were considered soft.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this article.

Plate 1. Alkali digestibility in fifteen local rice cultivars from Khagrachari district of Bangladesh. Khag-01 = Dub bini, Khag-02= Chonchonbini, Khag-03= Longkapora, Khag-04= Bini, Khag-05= Curi, Khag-06= Bora kusum, Khag-07= Tumbas, Khag-08= Lengdacikon, Khag-09= Sonamuki, Khag-10= Badia, Khag-11= Rangamuni, Khag-12= Kallayajira, Khag-13= Mashlajira, Khag-14= Moisanguribini, Khag-15= Nadinga.



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