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Investigation of Morpho-chemical Characteristics and Yield Potential of Five Local Rice Cultivars

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Authors' contributions

This work was carried out in collaboration between all authors. Author MSI wrote the protocol, conducted the field experiments and wrote the first draft of the manuscript. Author BCS designed the study and supervised the research work. Authors KMMI and SMSA managed the literature searches, collected data from field, analyzed the data of the research and help in manuscript preparation. Author NU overviewed the research and co-supervised the work. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study morpho-chemical, yield and yield contributing characteristics of five local rice cultivars viz. Red Swarna, Jota pari, Pariza, Sugandhi and ShaitaBoro.
Study Design: The experiment was laid out in Randomized Complete Block Design with three replications.
Place and Duration of Study: A field experiment was conducted at the farm laboratory of Agricultural Chemistry Department, Hajee Mohammad Danesh Science and Technology

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University, Dinajpur, Bangladesh during the period from February to May, 2014.
Methodology: The total experimental area was divided into 3 blocks. Each block was then subdivided into 5 plots. The plot unit area was 2 m x 2 m. The replications were separated from one another by one meter border. The border between the individual plot was 0.5 m. All the intercultural operations were done as when necessary. Data on different characteristics were collected at different growth stages.
Results: Results revealed that morphological, physiological; yield and yield attributes were significantly different among the cultivars studied. The Sugandhi produced higher number of grains per panicle and bolder grains which resulted higher grain yield. Further, Sugandhi showed superiority in yield contributing characteristics: total tillers number, filled grain per panicle over other local cultivars and it also produced higher grain yield (4.86 t per ha).
Conclusion: It is revealed that Sugandhi had the higher yielding ability than those of other local cultivars.

Keywords: Investigation; morpho-chemical characteristics; yield potential; local rice cultivars.

1. INTRODUCTION

Bangladesh is an agricultural country and still hard working for rapid development of its economy. Approximately, 22 percent of Gross Domestic Product (GDP) has been derived from agriculture sector while rice contributes 9.5 percent to the agricultural GDP [1]. Rice is the staple food of about 135 million people of Bangladesh which provides nearly 48% of rural employment, about two-thirds of total calorie supply and about one-half of the total protein intakes of an average person in the country. Rice production contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh [2]. Rice provides 20% of the world's dietary energy supply which is also a good source of thiamine, riboflavin, niacin and dietary fibre [3]. Unlike the other major cereals, more than 90% of rice is consumed by humans [4]. More than 95% of population consumes rice and it alone provides 76% of calorie and 66% of total protein requirement of daily food intake [5]. It is necessary to enhance the growth of rice production through increasing land productivity to meet the increasing food demand for the vast population of the country as the country has serious land constraints.

Rice in Bangladesh is grown in three distinct seasons: Boro (January to June), Aus (April to August) and Aman (August to December) [6]. It provides nearly 95 percent of the total food requirements, but there is still a need to increase production to feed the growing population which increases at the rate of 1.32 percent per annum [7].

Two genotypes of rice cultivars namely traditional (local) and modern (high yielding) are cultivated in Bangladesh. Local rice variety has a large contribution to meet the demand of people in Bangladesh. Recently the farmers of Bangladesh produce a huge amount of rice from local cultivars. Though the soil and climate of our country is quite suitable for the production of rice, still it is facing many problems of which the poor yielding inherent capability of our local varieties is the most important one. Poor plant type such as tall plants, long and droopy leaves, weak culms, susceptible to lodging are the main causes of the low yield of the local varieties. Several of local rice landraces are cultivated in different AEZ (Agro Ecological Zone) in different seasons in the country. Among those, there are various types depending on their photosensitivity, crop duration, grain size, aroma, chlorophyll, minerals and vitamins content etc. For the additional food requirement, in these days of alarming population increase in Bangladesh, we cannot afford to grow those local cultivars unless their yield per unit area is improved.

Rice yield is mainly dependent on producing ability of dry matter before heading. [8] Showed that the degree of heterosis in dry matter accumulation was relatively lower at the later growth stage than at the early growth stage. However, photosynthetic rate of the same genotypes showed the marked difference during growth stage [9]. It was also reported that the physiological traits, such as photosynthetic rate [10], nitrogen uptake [11], floret number per unit area [12], which are closely related to the yield, showed wide variation over genotypes and environments. Local rice is superior compared to modern rice. It has a better flavour, is more nutritious, can be grown continuously throughout the year, is easier to plant and more economical, especially if grown organically. Some local

cultivers also have medicinal properties for common diseases such as stomachache, cough, metabolic acceleration, and others. The objective of the research was comparison of local rice cultivars with respect to selected morpho-chemical features and yield potential as well as determination of cultivar which is the most useful for cultivation in Northwest Bangladesh.

2. MATERIALS AND METHODS

The experiment was conducted in the farm laboratory of Agricultural Chemistry Department, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during Boro season, from February to May, 2014. The treatments of this experiment are five rice cultivars *viz.*: *Red Swarna, Jota pari, Pariza, Sugandhi and ShaitaBoro*. These cultivars are well adapted in the environmental condition of the research area and highly practiced by the local farmers. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. A total of 15 plots were prepared. The total experimental area was divided into 3 blocks. Each block was then subdivided into 5 plots. The size of each plot was 2 m x 2 m. The replications were separated from one another by one meter border. The border between the individual plots was 0.5 m. All the intercultural operations were done as when necessary. Observations were recorded on different characteristics such as: 1. Morphological characteristics: plant height (cm), number of leaves per plant, and root weight (gm) 2. yield and yield components: effective tillers per hill, non-effective tillers per hill, total number of tillers per hill, filled grain per panicle, non-filled grain per panicle, 1000-grain weight (gm), grain yield (t per ha), straw yield (t per ha) and harvest index. 3. Leaf chemical constituents: Chlorophyll i. chlorophyll-a ii. chlorophyll-b iii. carotenoids, phosphorus, potassium, calcium and magnesium.

Harvest index is the relationship between economic yield and biological yield [13]. It was calculated by using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

2.1 Determination of Chlorophyll

For measuring chlorophyll exactly 0.1 g fresh leaf tissues of rice flag leaves were taken in a test tube containing 10 mL of 80% acetone. It was then shaken overnight using an electric horizontal shaker. The optical density or absorbance of the supernatant was measured by using UV-visible spectrophotometer at different wavelengths. As 80% acetone was used in this study, the absorbance was measured at 663 nm, 646 nm and 470 nm wavelength for chlorophyll-a, chlorophyll-b, total chlorophyll and carotenoids content. The concentration of chlorophyll-a (Chl-a), chlorophyll-b (Chl-b), total chlorophyll and total carotenoids were measured by using following formula.

Chl-a= 12.21 A_{663}-2.81A_{646} (µg ml of plant extract[1] or mg per g fresh weight)

Chl-b=20.13 A_{646} – 5.03 A_{663}

Total chlorophyll = 17.76 (A_{646}) + 7.34 (A_{663})

Total carotenoids,

$$C_{x+c} = \frac{1000\ A_{470} - 2.05\ C_a - 114.8\ C_b}{245}$$

2.2 Determination of Phosphorus, Potassium, Calcium and Magnesium

For leaf chemical composition the selected leaves during pre-flowering stage different replicated cultivars were collected. The leaves were carefully dried in an oven at 60ºC for 72 hours. The leaves samples were ground and the extract was prepared by wet oxidation method using Di-acid mixture, the extraction was used for chemical nutrient estimation. Calcium and Magnesium were measured by complexometric method. Leaf Phosphorus and Potassium were measured by spectrophotometer using $SnCl_2$ as a reducing agent.

2.3 Statistical Analysis

The data collected on different parameters under the experiment were statistically analyzed to obtain the level of significance using the MSTATC computer software. If the characteristics under study were significant the differences between pairs of means were compared by Duncan's Multiple Range Test (DMRT) [14].

3. RESULTS AND DISCUSSION

3.1 Morphological Characteristics

Plant height of different rice cultivars varied markedly amongst themselves. Among the five cultivars studied, the plant height 86.44 cm was

recorded in Sugandhi at seedling stage and 95.33 cm at the harvesting stage. Lowest plant height was recorded in Red Swarna (42.66 cm) at seedling stage and the highest plant height ShaitaBoro (107.3 cm) at harvesting stage which is similar to Red swarna (104.0 cm). Among these five cultivars, the highest leaf number (7.1) at vegetative stage and (8.4) at harvesting stage was recorded in Sugandhi which is similar to Jotapari (6.5) and (6.7).The lowest leaves number was recorded in ShaitaBoro (3.7) at vegetative stage and (4.3) at harvesting stage. The highest dry root weight was observed in Red Swarna (5.20 g) followed by Jotapari (4.91 g), while the lowest root weight was found in ShaitaBoro (1.20 g) after harvest. Considering root weight of examined cultivars, their variability could be attributed to its genetic potential (Table 1).

3.2 Yield and Yield Attributes

Results revealed that in general high yielding cultivars produced higher number of effective tillers per hill than low yielding ones. The highest effective tillers per hill were observed in Sugandhi (10.00), while the differences among the other cultivars Red Swarna, Jota pari, Pariza and ShaitaBoro were not significant. The highest non-effective tillers per hill (2.00) were produced in Jota pari and Pariza cultivars, while the lowest (0.33) was produced with Sugandhi cultivar. The highest number of tillers was produced by Sugandhi (11.33) and Jota pari and Pariza showed statistically same (10.67, 10.00). In contrast, both Red Swarna and ShaitaBoro produced the lowest number (9.33) of tillers per hill at harvesting stage. The highest filled grain number per panicle was recorded in Sugandhi (137.0) while the lowest filled grain number per panicle was in Pariza (76.67). The highest non-filled grain number per panicle was recorded in ShaitaBoro (40.67) while the lowest non- filled grain number per panicle was in Pariza and Jota pari (25.67) (Table 2).

The research also revealed that the highest 1000-grain weight was recorded in Pariza (20.57 g) followed by Sugandhi (20.13 g), and Jota pari (19.67 g), but the differences between them were not significant. The highest grain weight was recorded in Sugandhi (4.86 t per ha) followed by Jota pari (4.73 t per ha) and Red Swarna (4.63 t per ha), but there were insignificant differences between the three cultivars. The lowest grain weight was recorded in ShaitaBoro (2.31 t per ha). The higher yield in Sugandhi might be due to the production of higher number of effective tillers per hill and higher number of filled grain per panicle. Similar results were also reported by [15].

The highest straw yield was recorded in Jota pari cultivar (15.42 t per ha), followed by Sugandhi cultivar (15.13). The lowest straw yield was recorded in ShaitaBoro (7.5 t per ha). [16] reported that grain yield was positively correlated with biological yield in rice. Similar result was also reported by [17] in rice. The highest harvest index was recorded for Red Swarna (27.49%) and the lowest harvest index was recorded in ShaitaBoro (8.93%). The other variety showed intermediate values. HI is the measure of the efficiency of conversion of photosynthate into economic yield of a crop plant (Table 2).

3.3 Leaf Chemical Constituents

3.3.1 Chlorophyll

Leaf chlorophyll content is one of the important physiological traits closely related to photosynthetic ability in rice. Undoubtedly, understanding the genetic mechanisms underlying the leaf chlorophyll content across different developmental stages of rice has significant implications for improving photosynthetic ability in rice.

3.3.1.1 Chlorophyll-a content

Chlorophyll-a is the primary photosynthetic pigment. It absorbs most energy from wavelengths of violet-blue and orange-red light. Chlorophyll-a is essential for photosynthesis in eukaryotes, cyanobacteria and pro-chlorophytes because of its role as primary electron donor in the electron transport chain. In this study, a significant difference in chlorophyll-a content was found amongst the booting stage of selected five local rice cultivars as shown in Table 3. The highest chlorophyll-a content was found in Pariza (24.69 mg per g), while the lowest chlorophyll-a content was observed in Jota pari (18.32 mg per g).

3.3.1.2 Chlorophyll-b content

In this study, a significant variation in chlorophyll-b synthesis was evident in the booting stage of selected local rice cultivars during the study period. The cultivar Pariza was found to have more chlorophyll-b content during the experimental period. The highest chlorophyll-b

content was found in Pariza (7.90 mg per g) and the lowest chlorophyll-b content was found in Jota pari (4.08). Chlorophyll-b contents in flag leaf of five local rice cultivars (Table 3). There is a strong relationship between temperature and plant chlorophyll synthesis.

3.3.1.3 Total chlorophyll content

In this study, the total chlorophyll content of selected rice cultivars did not varied significantly during the experimental period as shown in Table 3. At the booting stage, the highest total chlorophyll content was found in Pariza (32.59 mg per g) which is statistically similar with Sugandhi (28.05 mg per g), ShaitaBoro (27.82 mg per g). The lowest total chlorophyll content was observed in Jota pari (22.40 mg per g) which is statistically similar with Red Swarna (24.52 mg per g).

3.3.2 Total carotenoids content

The highest carotenoids content was found in Pariza (10.07 mg per g) which is statistically similar with other varieties. Carotenoids are multifunctional compounds serving as structural components of light-harvesting complexes, accessory pigments for light harvesting, substrates for abscisic acid synthesis, and components of photo protection and scavengers of oxygen. Carotenoids contents in flag leaf of five local rice cultivars were not significant (Table 3).

3.3.3 Nutrient contents in leaves of different rice cultivars

Nutrient elements present in leaf samples of five local rice cultivars were presented in the following Figs.1-4.

3.3.3.1 Phosphorus

The highest Phosphorus (P) content was observed in Sugandhi (0.73 ppm) followed by Jota Pari (0.52 ppm) and Red Swarna (0.51 ppm). On the other hand, the lowest P content was recorded in ShaitaBoro (0.37 ppm) followed by Pariza (0.39 ppm) (Fig. 1).

Table 1. Morphological parameters of five local rice cultivars

Cultivars	Plant height		Leaf number per plant		Root weight per plant
	Vegetative growth stage	Harvesting stage	Vegetative growth stage	Harvesting stage	
Red swarna	42.66c	104.0a	4.0b	5.3b	5.20a
Jota pari	60.22b	98.03ab	6.5a	6.7a	4.91a
Pariza	44.37c	75.33c	5.7b	5.2b	2.34b
Sugandhi	86.44a	95.33ab	7.1a	8.4a	1.81b
ShaitaBoro	65.4b	107.3a	3.7c	4.3c	1.20b
LSD	7.997	12.11	5.767	4.72	2.04
CV	7.10	6.73	8.19	6.63	34.98

** Values marked by the same letter do not differ significantly*

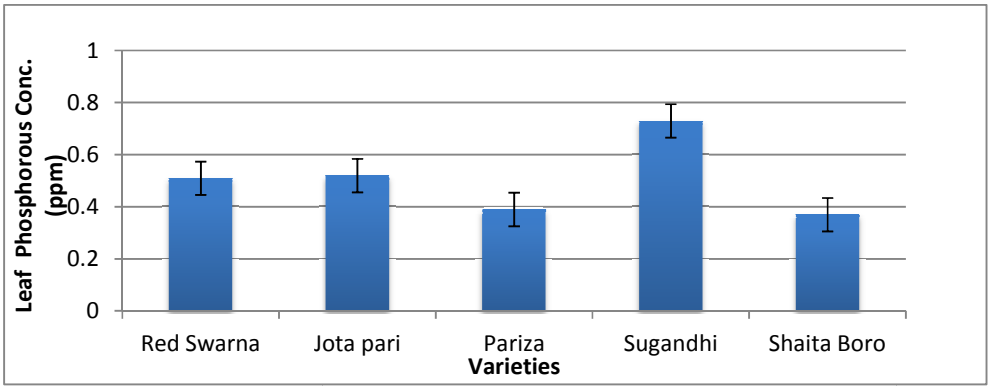

Fig. 1. Leaf phosphorus concentration of different rice varieties

Table 2. Yield and yield attributes of five rice cultivars

Cultivar	Number of effective tillers per hill	Number of non-effective tillers per hill	Total number of tillers per hill	Filled grain Per panicle	Non-filled grain per panicle	1000-grain weight (gm)	Grain yield (t per ha)	Straw yield (t per ha)	Harvest Index
Red Swarna	8.00b	1.33ab	9.33bc	130.0a	39.33a	16.73b	4.63a	12.29ab	27.36a
Jota pari	8.66b	2.00a	10.67a	123.3ab	25.67c	19.67a	4.73a	15.42a	23.47c
Pariza	8.00b	2.00a	10.00ab	76.67d	25.67c	20.57a	4.30ab	11.88ab	26.58a
Sugandhi	10.00a	0.33c	11.33a	137.0a	29.67b	20.13a	4.86a	15.13a	24.31b
ShaitaBoro	8.33b	1.00ab	9.33bc	112.3b	40.67a	16.60b	2.31c	7.50b	23.55c
LSD	2.20	1.57	0.47	56.71	16.18	9.17	1.57	4.80	5.61
CV	13.28	62.7	7.75	26.00	26.68	9.60	18.03	20.51	16.98

** Values marked by the same letter do not differ significantly*

Table 3. Flag leaf chlorophyll content of five local rice cultivars

Cultivar	Chlorophyll-a	Chlorophyll-b	Total chlorophyll	Carotenoids
Red swarna	19.21a	5.31ab	24.52b	7.207a
Jota pari	18.32a	4.08b	22.40b	7.213a
Pariza	24.69a	7.90a	32.59a	10.07a
Sugandhi	21.72a	6.33ab	28.05a	8.727a
ShaitaBoro	22.56a	5.26ab	27.82a	10.01a
LSD	10.01	4.14	12.86	3.509
CV	24.95	36.68	25.01	21.51

** Values marked by the same letter do not differ significantly*

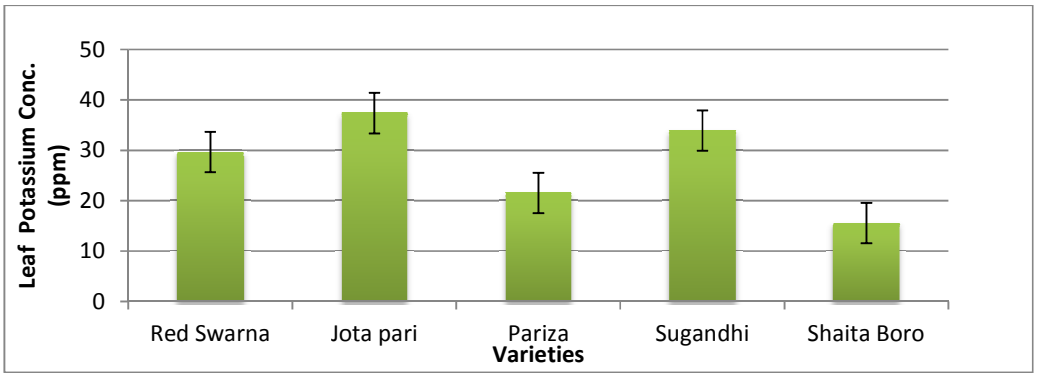

Fig. 2. Leaf potassium concentration of different rice varieties

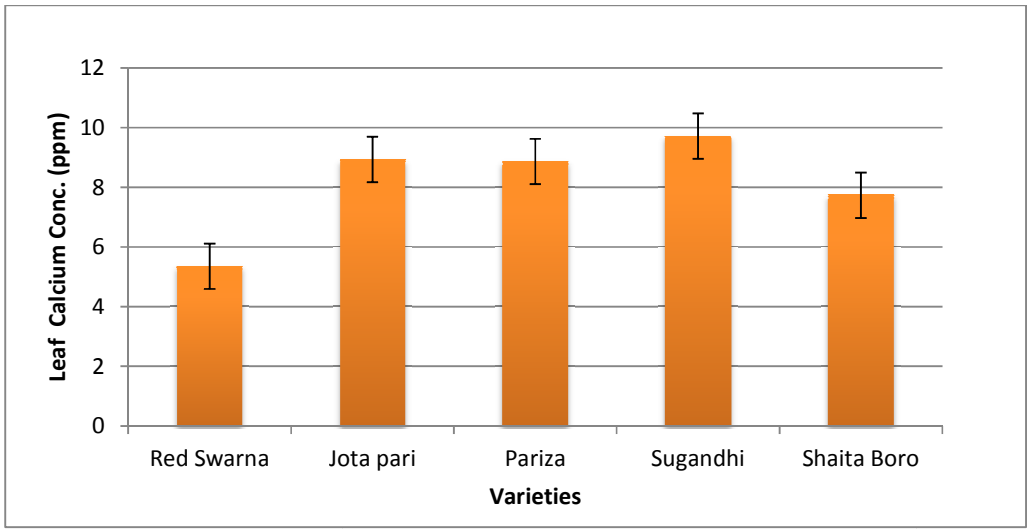

Fig. 3. Leaf calcium concentration of different rice varieties

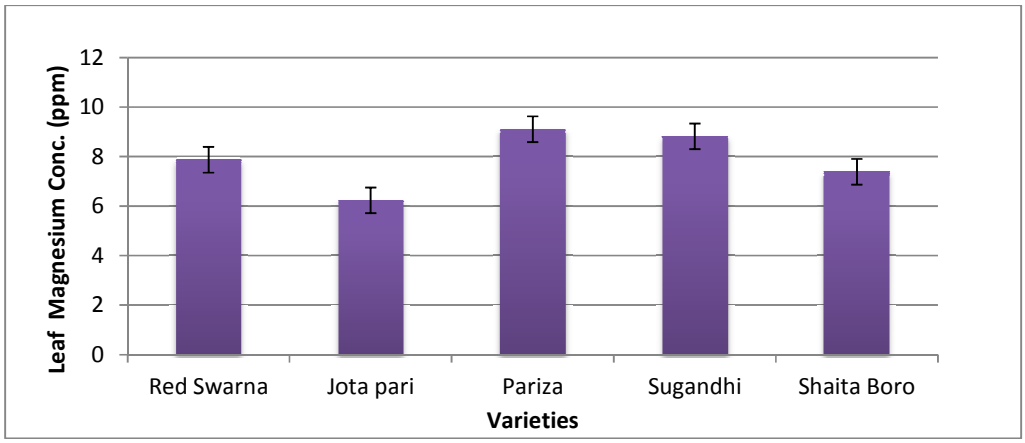

Fig. 4. Leaf magnesium concentration of different rice varieties

3.3.3.2 Potassium

The variation in potassium (K) content in leaves among the cultivars was recorded in Fig. 2. The highest K content was found in Jota pari (37.38 ppm) followed by Sugandhi (33.92 ppm). On the other hand, the lowest K content was recorded in ShaitaBoro (15.54 ppm). The status of K improved the rice straw quality.

3.3.3.3 Calcium

The variation in calcium (Ca) content in leaves among the cultivars was recorded in Fig. 3. The highest Ca content was recorded in Sugandhi (9.72 mg%) which was statistically similar with Jota pari (8.94 mg%) and Pariza (8.87 mg%). On the other hand, the lowest Ca content was recorded in Red Swarna (5.36 mg %). Secondary nutrient plays an important role in the plant life. Calcium is an essential part of cell structure and plays its role in cell division. It is absorbed by the plants in the form of Ca ion i.e. Ca^{2+}.

3.3.3.4 Magnesium

The test of Magnesium (Mg) content in leaves among the rice cultivars was presented in Fig. 4. The highest Mg content was recorded in Pariza (9.11 mg%) which is statistically similar with Sugandhi (8.82 mg%). On the other hand, the lowest Mg content was recorded in Jota pari (6.23 mg%). Magnesium is a integral part of chlorophyll and thus, linked with photosynthesis.

4. CONCLUSION

From the results it can be concluded that Sugandhi showed the highest yield potential than those of other four local cultivars. Among the local rice cultivars, Sugandhi had the best yielding ability than those of others. Therefore, it can be suggested that, Sugandhi may be selected for cultivation in Bangladesh using modern agronomic practices due to its high genetic yield potential among the other local cultivars studied.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. BBS (Bangladesh Bureau of Statistics). Yearbook of agricultural statistics of Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh; 2008.
2. BRRI (Bangladesh Rice Research Institute). Bangladesh rice knowledge bank. Bangladesh Rice Research Institute, Joydebpur, Gazipur, Bangladesh; 2011.
3. FAO. Paper presented by the Director in 'International year of rice 2004'. Food and Nutrition Division, Food and Agriculture Organization of the United Nations, Rome, Italy; 2004.
4. Tuteja N, Gill SS, Tiburcio AF, Tuteja R. Improving crop resistance to abiotic stress. Wiley Online Library. 2012;1 and 2.
5. Bhuiyan NI, Paul DNR, Jabber MA. Feeding the extra millions by 2025. Challenges for rice research and extension in Bangladesh, National Workshop on Rice Research and Extension in Bangladesh, Bangladesh Rice Research Institute, Gazipur; 2002.
6. David C, Otsuka K. Modern rice technology and income distribution in Asia. Lynne Rienner Publishers; 1994.
7. MoF (Ministry of Finance). Bangladesh economic survey 2010. Economic Division, Ministry of Finance, Government of the People's Republic of Bangladesh, Dhaka; 2010.
8. Sarker MAZ, Murayama S, Ishimine Y, Tsuzuki E. Physio-morphological characters of F1 hybrids of rice (*Oryza sativa L*.) in Japonica-Indica crosses. Plant Production Science. 2001;4(3):196-201.
9. Tang JJ, Chen X, Katsuyoshi S. Varietal differences in photosynthetic characters and chlorophyll fluorescence induction kinetics parameters among intergeneric progeny derived from *Oryza×Sorghum*, its parents and hybrid rice. Journal of Zhejiang University Science. 2002;3(1): 113–117.
10. Sheng T, Qian Q, Dali Z, Yasufumi K, Kan F, Danian H, Lihuang Z. QTL analysis of leaf photosynthetic rate and related physiological traits in rice (*Oryza sativa* L.). Acta Agronomica Sinica. 2004;135(1):1-7.

11. Shan YH, Wang YL, Pan XB. Mapping of QTLs for nitrogen use efficiency and related traits in rice (*Oryza sativa* L.). Agricultural Sciences in China. 2005; 4(10):721–727.
12. Yoshida H, Horie T, Shiraiwa T. A model explaining genotypic and environmental variation of rice spikelet number per unit area measured by cross-locational experiments in Asia. Field Crops Research. 2006;97(2-3):337–343.
13. Gardner FP, Pearce RB, Mistecell RI. Physiology of crop plants. Iowa State University. Press, Iowa. 1985;66.
14. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd edition. John Wiley and Sons, New York. 1984;680.
15. Dutta RK, Mia MAB, Khanam S. Plant architecture and growth characteristics of fine grain and aromatic rice and their relations with yield. Crop Physiology Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh; 2002.
16. Chowdhury SA, Majid MA, Haque KS, Islam M, Rahman MM. Effect of variety on yield and nutritive value of rice straw. Asian-Australasian Journal of Animal Sciences. 1995;8(4):329-335.
17. Munshi RU. A comparative morpho-physiological study between two local and two modern rice cultivars. M.S. Thesis, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh; 2005.

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