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Efficacy and Economics of Urea Spray Technology for a Locally Discovered Rice Cultivar *Haridhan* in Bangladesh

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Abstract: Foliar spray of fertilizer does not only increase the crop yields but also reduce the quantities of fertilizer applied through soil. An attempt was taken to find out the efficacy and economic benefit of urea spray technology for getting higher yield using a local rice cultivar *Haridhan* and a modern rice cultivar BRRI dhan56. The research work was conducted at the Agronomy Field Laboratory, Department of Agronomy, Bangladesh Agricultural University, Mymensingh during the period from July to November 2015. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Results revealed that foliar spray of urea solution had significant effect on several yield contributing characters. It was found that treatment T4 (where 50% of the recommended dose (RD) of urea was applied directly to soil by 2 equal splits and 20% of the RD of urea was applied as foliar spray with three equal splits at 30 DAT, 45 DAT and 60 DAT) gave significantly higher number of effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield, straw yield and biological yield than that of any other treatments. Both the varieties gave significantly higher yield with the treatment T4. In case of cost effectiveness, it was found that treatment T1 (where no urea was applied) exerted lowest cost of production (60,124 BDT ha^{-1}), but, treatment T4 provided highest gross income (122,800 BDT ha^{-1}), net income (60,436 BDT ha^{-1}) and benefit cost ratio (1.97) as well as lowest cost per unit of product (5.27) for the varieties. The highest cost of production was found in case of treatment T6 where traditional method of urea was applied. Therefore, the present study concluded that about 30% recommended dose of urea/ha can be saved in each rice growing season by applying urea as foliar spray.

Keywords: Urea Spray, Local Rice Cultivar, *Haridhan*, Economic Efficiency

1. Introduction

Out of total cropped area in Bangladesh, about 84.67% is used for rice production with an annual production of 34.36 million tons from 11.47 million ha of land (BBS, 2014). The average yield of rice in Bangladesh is quite low (2.91 t ha^{-1}) [1] compared to other leading rice growing countries such as China (6.23 t ha^{-1}), Korea (6.59 t ha^{-1}), Japan (6.7 t ha^{-1}) and USA (7.04 t ha^{-1}) [2].

Haridhan, a new rice variety, recently has been discovered, selected and being cultivated for several years by a local farmer named Haripada kapali of Jhineidah district of Bangladesh [3]. Initially, it was thought that the variety has a similarity with the modern rice cv. BR 11 but research has identified that dissimilarity was found more than that of similarity. However, this rice variety is being extensively cultivated by the local farmers in the southern district of Bangladesh, especially in the Jhineidah district. The main feature of this variety is its high yielding capacity (about 6.0 ton/ha) during aman season (monsoon season) in the farmer's very own field with high dose of urea fertilizer (about 300 kg ha^{-1}). In Bangladesh, the rice yield is usually lower in aman season than that of boro season (winter season) where *Haridhan* is an exception producing higher yield even in aman season.

Generally, the nitrogenous fertilizer (urea) is applied as

basal and as top dressed at different growth stages for rice cultivation [4]. Unfortunately, N use efficiency in the wetland rice culture is very low, rarely exceeding 30-40% [5] and more than 50% of the applied nitrogen is lost through denitrification, volatilization, leaching and runoff [6] and ultimately affect on cash loss of farmers and sometimes causes environmental as well as ground water pollution [7, 8]. High price of urea fertilizer and its availability at the right time jeopardize rice production occasionally [9]. So, it is necessary to improve the efficiency of applied nitrogenous fertilizer utilization by rice plant [10]. All the factors provide an indication of searching an effective alternate N application method for rice cultivation [4].

Foliar spray of fertilizer does not only increase the crop yields but also reduce the quantities of fertilizer applied through soil [11]. Foliar application can also reduce the lag time between application and uptake by the plant [12]. Radioisotopes were used to show that foliar-applied fertilizers passed through the leaf cuticle and into the cells [13]. Various studies have shown that a small amount of nutrients (nitrogen, potash, or phosphate) applied by foliar spraying increases significantly the yield of crops [14]. In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application [15] which minimizes N losses to the environment without affecting rice yield [16]. In fact, foliar fertilization does not totally replace soil-applied fertilizer but it does increase the uptake and hence the efficiency of the nutrients applied to the soil. This application technique is especially useful for micronutrients but can also be used for major nutrients like N, P, and K basically because the amount applied at any time is small and thus it requires several applications to meet the needs of a crop. Recently foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants [17]. Hence, it is of interest to assess the lowest amount of urea fertilizer application through foliar spray technique for highest amount of yield of crops, especially for rice crop. Therefore, an attempt was taken to find out the efficacy and comparative cost effectiveness of urea spray over traditional method of rice cultivation in Bangladesh.

2. Materials and Methods

2.1. Experimental Site and Treatments

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU) Mymensingh, Bangladesh.

There were two factors such as- i) varieties (*Haridhan* and BRRI dhan56) and ii) urea spray techniques. There were six treatments for urea spray technique. The details of the treatments have been presented in table 1

Table 1. *Details of experimental treatments.*

Treatments	Description of the treatments
T1= N_0	no urea was applied in the soil for rice cultivation
T2= $N_{65\%}$	In this treatment 65% of total required urea was applied to the soil by 3 splits (21.66% at 15 Days after transplanting (DAT) and 21.66% at 30 DAT and 21.66% at 45 DAT).
T3= $N_{50+US(15\%)}$	In this treatment 50% of total required urea was applied to soil by 2 splits (10% dring final land preparation and 40% at 15 DAT). 15% of the urea was applied as foliar spray with three equal splits of which 1st spray at 30 DAT 2nd spray at 45 DAT and 3rd spray was applied at 60 DAT.
T4= $N_{50+US(20\%)}$	In this treatment 50% of total required urea was applied to soil by 2 splits (10% at the time of final land preparation and 40% at 15 DAT). 20% of the urea was applied as foliar spray with three equal splits of which 1st spray at 30 DAT 2nd spray at 45 DAT and 3rd spray was applied at 60 DAT.
T5= $N_{60+US(15\%)}$	In this treatment 60% of total required urea was applied to soil by 2 splits (10% at the time of final land preparation and 50% at 15 DAT). 15% of the urea was applied as foliar spray with three equal splits of which 1st spray at 30 DAT 2nd spray at 45 DAT and 3rd spray was applied at 60 DAT.
T6= $N_{100\%}$ (Traditional Method)	In this treatment 100% of total required urea was applied to soil by 3 equal splits (33.33% at 15 DAT, 33.33% at 30 DAT and rest 33.33% at 45 DAT).

Note: "US" means "Urea Spray".

2.2. Collection of Seeds

Seeds of *Haridhan* were collected from the local farmers of Jhinaidah district of Bangladesh where this cultivar is extensively cultivated by the farmers. Another rice variety BRRI dhan56 was collected from Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.

2.3. Land Preparation, Fertilizer Application and Transplanting of Rice Seedlings

The experimental land was first opened with a power tiller. The land was thoroughly prepared with the help of country plough and ladder. Weeds and stubble were removed from the field. The bunds around individual plots were made for proper water management between the plots. The individual plots of each block were prepared thoroughly by spading and then levelled just before the specified date of transplanting. The field was fertilized with triple super phosphate, muriate of potash and gypsum @ 52, 82, 60 kg ha^{-1}, respectively. The whole amount of triple super phosphate, muriate of potash and gypsum was applied at final land preparation. Urea fertilizer was applied as per the treatments. Thirty-day old seedlings were uprooted carefully from the nursery bed and transplanted in the individual plot on 18 July 2015 at the rate of 2-3 seedlings $hill^{-1}$ with a spacing of 25 cm x 15 cm.

2.4. Preparation of Urea Solution for Haridhan

In T3 treatment 30g urea was applied in three splits when each splits contained 10g urea mixed with 400 ml water for preparation of spray solution per $10m^2$ plot. In T4 treatment 40g urea was applied in three splits when each splits contained 13.3g urea mixed with 400 ml water for preparation of spray solution per $10m^2$ plot. In T5 treatment 30g urea was applied in three splits when each splits contained 10g urea mixed with 400ml water for preparation of spray solution per 10 m^2 plot.

2.5. Preparation of Urea Solution for BRRI dhan56

In T3 treatment 23g urea was applied in two splits when each splits contained 11.5g urea mixed with 400ml water for preparation of spray solution $10m^2$ plot. In T4 treatment 30g urea was applied in two splits when each splits contained 15g urea mixed with 400ml water for preparation of spray solution per $10m^2$ plot. In T5 treatment 23g urea was applied in two splits when each splits contained 11.5g urea mixed with 400ml water for preparation of spray solution per $10m^2$ plot.

2.6. Experimental Design and Statistical Analysis

The experiment was conducted following Randomized Complete Block Design (RCBD) design with replication. The individual plot size was 10 m^2 and there were total 36 plots (2×6×3). After collection all the yield data and cost information, the data were analyzed using the software MSTATC and were tested with Duncan's Multiple Range Test (DMRT).

2.7. Calculation of Benefit Cost Ratio (BCR) and Cost per Unit of Product (CPUP)

The benefit cost ratio (BCR) and the cost per unit of product (CPUP) were calculated to compare cost effectiveness among the urea spray treatments, and the following formulae were used:

1. Benefit Cost Ratio (BCR) = $\frac{\text{Gross Income}}{\text{Total Cost of Production}}$

2. Cost Per Unit of Product (CPUP) = $\frac{\text{Total Cost of Production - Value of By product}}{\text{Yield of Product}}$

3. Results and Discussion

3.1 Yield and Yield Contributing Characteristics of Rice Varieties

Experimental results showed that locally discovered rice cv. *Haridhan* got significantly tallest plant, higher number of effective tillers $hill^{-1}$, panicle length (cm), number of grains $panicle^{-1}$, grain yield and harvest index than that of modern rice cv. BRRI dhan56 (Table 2). This might be due to the genetic makeup for yield contributing characters of *Haridhan* is better than that of BRRI dhan56. The table also shown that the 1000 grain weight did not differ significantly. Foliar spray of urea solution had significant effect on the yield contributing characters of both the rice cultivars (Table 3). Treatment T4, where 50% of total required urea was applied directly to soil by 2 splits and 20% of the urea was applied as foliar spray with three equal splits with 1st spray at 30 days after transplanting (DAT), 2nd spray at 45 DAT and 3rd spray at 60 DAT, gave significantly higher number of effective tillers $hill^{-1}$, number of grains $panicle^{-1}$, and grain yield (t ha^{-1}) than that of any other treatments (Table 3). Both the varieties gave significantly higher yield with the treatment T4. This is might be due to the traditional method of urea application in the rice field of Bangladesh where loss of nitrogen is very much high and recovery of nitrogen by rice plant from soil is low. In traditional method, one-third urea is applied 15 days after transplantation (DAT) and rest of the urea is applied in two equal splits in 25-35 DAT and 45-55 DAT, respectively, depending on the life duration of the respective variety [18]. In this method all the urea fertilizers are directly applied to the soil. Therefore, an amount of urea is lost by several means such as volatilization, leaching loss etc. before completely uptaken by the rice plant. On the other hand, in urea spray, the utilization of nitrogen by rice plant is rather quick and readily absorbed by the plant leaf surface opening [13]. This might be the cause of higher grain yield produced by T4 treatment. Considering interaction effect, it was found that variety *Haridhan* with urea spray treatment of T4 had significant effect on plant height (cm), number of grains panicle-1, and grain yield and exerted a better performance than that of any other urea application treatments.

Table 2. *Effect of variety on yield and yield contributing characters of BRRI dhan56 and Haridhan.*

Varieties	Plant height (cm)	No. of effective tillers $hill^{-1}$	Panicle length (cm)	No. of grains $panicle^{-1}$	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Harvest index (%)
BRRI dhan56	110.47^b	10.53^b	24.89^b	126.82^b	25.19	5.51^b	47.01^b
Haridhan	121.69^a	11.19^a	26.54^a	166.55^a	25.94	6.08^a	48.50^a
CV (%)	3.25	6.66	5.62	3.63	4.77	3.92	4.44
Level of sig.	**	**	**	**	NS	**	**

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.
**= Significant at 1% and NS=Non-significant.
CV= Coefficient of Variation.

Table 3. *Effect of foliar spray of urea on the yield and yield contributing characters of BRRI dhan56 and Haridhan.*

Urea application	Plant height (cm)	No. of effective tillers hill^{-1}	Panicle length (cm)	no. of grains panicle^{-1}	Weight of 1000 seeds	Grain yield (t/ha)	Harvest index (%)
T1	112.17c	9.88c	25.29	131.79e	25.47	4.15c	46.90
T2	117.37ab	11.27ab	25.55	152.68b	25.62	5.01b	47.87
T3	118.50a	10.80bc	26.04	139.81d	25.42	5.82b	47.88
T4	115.07bc	12.11a	26.21	156.91a	26.22	6.14a	48.92
T5	117.15ab	10.60bc	25.70	148.33c	25.23	5.87b	47.34
T6	116.23ab	10.51bc	25.52	150.58bc	25.43	5.89b	47.63
CV (%)	4.10	5.53	6.42	2.43	5.72	2.99	5.42
Level of sig.	**	**	NS	**	NS	**	NS

In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.
**= Significant at 1% and NS=Non-significant.
T1 = N_0 (Control), T2 = $N_{65\%}$, T3 = $N_{50\%}$ + US (15%), T4 = $N_{50\%}$ + US (20%), T5 = $N_{60\%}$ + US (15%) and
T6 = $N_{100\%}$ (Traditional method of urea application)

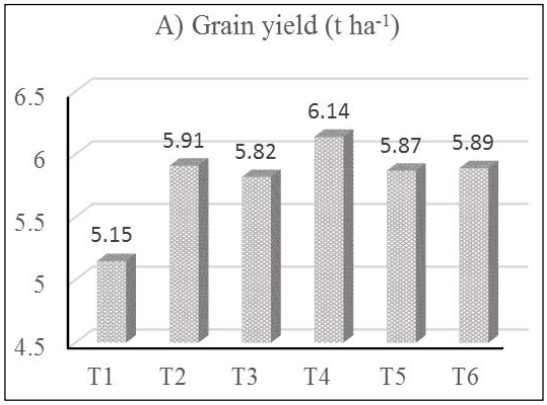
Table 4. *Interaction Effect of foliar spray of urea and varieties on the yield and yield contributing characters of BRRI dhan56 and Haridhan.*

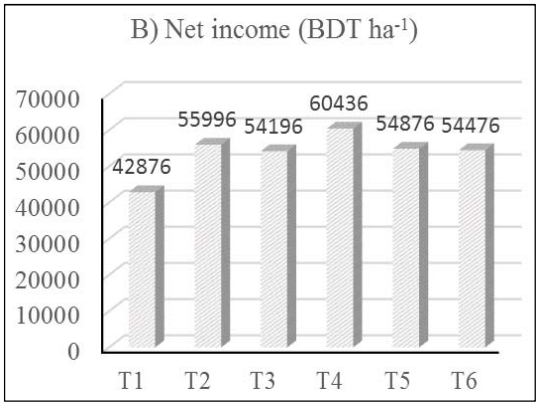
Interaction	Plant height (cm)	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	Weight of 1000 seeds	Grain yield (t ha^{-1})	Harvest index (%)
V1T1	104.13e	9.47	24.23	116.20i	25.40	4.68f	45.64
V1T2	111.73cd	10.80	24.67	127.70g	25.33	5.66cde	47.04
V1T3	114.73bc	10.33	26.35	122.73h	24.80	5.70cde	47.92
V1T4	111.40cd	11.29	24.69	133.28f	26.20	5.84bcd	48.62
V1T5	111.50cd	10.87	24.68	131.35fg	24.53	5.76cde	46.61
V1T6	109.33d	10.42	24.72	129.65fg	24.87	5.45e	46.23
V2T1	120.20a	10.30	26.34	147.37e	25.53	5.63de	48.16
V2T2	123.00a	11.73	26.43	177.65a	25.90	6.16ab	48.69
V2T3	122.27a	11.27	25.73	156.89d	26.03	5.93bcd	47.84
V2T4	118.73ab	12.93	27.72	180.53a	26.23	6.43a	49.22
V2T5	122.80a	10.33	26.71	165.32c	25.93	5.98bc	48.07
V2T6	123.13a	10.60	26.31	171.52b	26.00	6.33a	49.03
CV (%)	2.35	7.16	6.20	2.98	5.80	3.10	5.21
Level of sig.	*	NS	NS	**	NS	**	NS

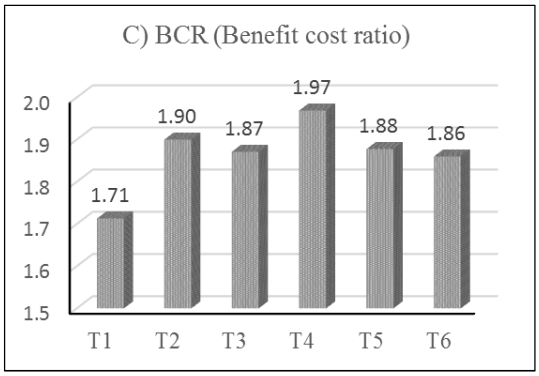
In a column, figures with same letter or without letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT.
*= Significant at 5% **= Significant at 1% NS=Non-significant.
V1= BRRI dhan56 and V2= *Haridhan.*
T1 = N_0 (Control), T2 = $N_{65\%}$, T3 = $N_{50\%}$ + US (15%), T4 = $N_{50\%}$ + US (20%), T5 = $N_{60\%}$ + US (15%) and T6 = $N_{100\%}$ (Traditional method of urea application).

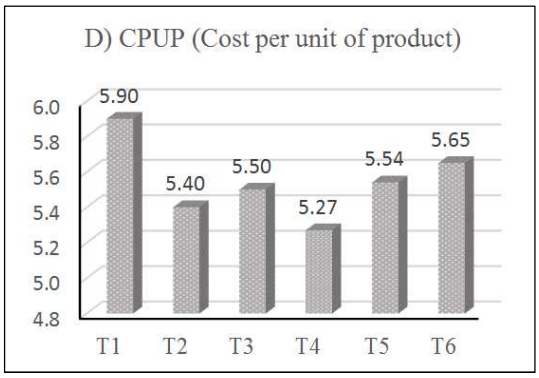
3.2. Cost Effectiveness of Urea Spray Technique

Cost of production is the most important aspect for the cultivation of any crops. Based on the production cost of a particular crop, farmers decide to continue that crop to be continued for cultivation or not. However, the cost of production depends on several factors including input costs like seeds, fertilizers, water etc. In the present study, attempt has been taken to reduce the cost of production of rice crop by applying the urea fertilizer with spray technique. It has been found that treatment T1 (where no urea fertilizer was applied) exerted lowest cost of production (60,124 BDT ha^{-1}) with a lowest net income (42876 BDT ha^{-1}), whereas treatment T4 gave significantly highest gross income (122,800 BDT ha^{-1}), net income (60,436 BDT ha^{-1}) and benefit cost ratio (1.97) as well as lowest cost per unit of product (5.27) in the case of both the varieties. The highest cost of production was found in case of treatment T6 where traditional method of urea application was done. Different heads on cost effectiveness are shown in the Figure 1 (A-D).









Note: 1 USD= 82 BDT.

Figure 1. *Cost effectiveness of urea spray technique over traditional method- A) Grain yield, B) Net income, C) Benefit cost ratio and D) Cost per unit of product.*

4. Conclusion

Among several plant nutrients, presence of nitrogen in the soil of most rice field of Bangladesh is very low. Therefore, a great deal of nitrogen fertilizer, mainly urea is applied to the rice field to supplement this nutrient in every rice growing season. Hence, every year a lots of urea fertilizer needs to import with an exchange of handsome amount of foreign currency. However, the present study tried to find a way to reduce the amount of urea fertilizer to the rice field without sacrificing rice yield, moreover, to increase the rice yield to some extent. The findings of this study revealed that an application of 50% of recommended dose (RD) of urea through soil and 20% of the RD of urea as spray in three equal splits can produce higher grain yield in rice varieties and hence can save an amount of 30% of RD of urea per hectare per rice growing season. This could be of a significant help to national economy by reducing import of urea fertilizer from abroad.

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References

[1] BBS (Bangladesh Bureau of Statistics). 2014. Estimates of Aman Rice (Husked), 2013-14, at the Website: www.bbs.gov.bd.

[2] FAO (Food and Agricultural Organization). 2004. Selected indicators of Food and Agricultural Organization in Asia-Pacific region corporate document Repository, 87-91.

[3] The Daily Sun, 2010. Available at: http://www.daily-sun.com/old_version/details_yes_23-12-2010_Hari-dhan:-Reality-or-myth---a-response_75__5_1_1.html#sthash.xzBV5LJI.dpuf.

[4] BRRI (Bangladesh Rice Research Institute). 2011. BRRI Annual Report 2008-2009. Publication no.187, 79-83.

[5] S. S. Alam, A. Z. M. Moslehuddin, M. R. Islam, and A. M. Kamal, "Soil and foliar application of nitrogen for Boro rice (BRRI dhan29)", Journal of Bangladesh Agricultural University 8(2), 199-202, 2010.

[6] P. Khan, M. Y. Memon, M. Imtiaz, and M. Aslam, "Response of wheat to foliar and soil application of urea at different growth stage", Pakistan Journal of Botany, 41(3), 1197-1204, 2009.

[7] D. Datta, "Principles and practices of rice production" Intl. Rice Res. Inst. Los Banos, Philippines. 9, 185-186, 313-396, 535, 1981.

[8] IRRI (International Rice Research Institute), "Rice Almanac", 2nd Ed.; IRRI in association with the West Africa Rice Development Association and the Centro Internacional de Agricultura Tropical: Manila, Philippines, 1997.

[9] BRRI (Bangladesh Rice Research Institute), "Annual Research Review Workshop 2008- 2009", BRRI, Agronomy Division, Gazipur, 490-492, 2009.

[10] M. A. M. Miah, and G. M. Panaullah, "Effect of water regimes and N-levels on soil available N, its uptake and use efficiency by transplanted rice", Bangladesh J. Agril. Res. 24(2), 343-353, 1999.

[11] M. I. M. Akhand, B. C. Roy, J. C. Biswas, N. Parvin and S. Paul, " Urea spraying as an effective alternate method of nitrogen management", Eco-friendly Agril. J. 6 (9), 188-192, 2013.

[12] BBS (Bangladesh Bureau of Statistics), "The Yearbook of Agricultural Statistics of Bangladesh", Statistics Div., Minis. Plan. Govt. peoples Repub., Bangladesh, Dhaka, 54, 2014.

[13] R. Ahmad, and R. Jabeen, "Foliar spray of mineral elements antagonistic to sodium- A technique to induce salt tolerance in plant growing under saline conditions", Pak. J. Bot., 37(4), 913-920, 2005.

[14] E. P. Brasher, J. R. Wheatley, and W. L. Ogle, "Foliar Nutrition sprays on vegetable crops. Delaware Experiment Station Bull. No. 295, 1953.

[15] M. U. Haq, and A. P. Mallarino, "Soybean yield and nutrient composition as affected by early season foliar fertilization", Agron. J. 92, 16-24, 2000.

[16] Z. Jamal, M. Hamayun, N. Ahmad, and M. F. Chaudhary, "Effect of soil and foliar application of different concentrations of NPK and foliar application of $(NH_4)_2SO_4$ on different parameters in wheat". J. Agron. 5(2), 251-256, 2006.

[17] I. H. Manik, M. A. Abedin. M. R. Rahman, T. Chakrobarty, S. B. Jaman, M. A. Noor and R. Sultana, "Reducing urea demand for rice crop through foliar application of urea in boro season". Res. Agric. Livest. Fish. 3 (1), 79-85, 2016.

[18] BRRI (Bangladesh Rice Research Institute), "Adhunik Dhaner chas (in Bengali)", Bangladesh Rice Research Institure, Gazipur, Bangladesh, 1-80, 2016.