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Yield Gap of *Aman* Rice at Farmers' Field: Determining Factors

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Abstract

The purpose of this research was to ascertain the factors responsible for yield gaps of *aman* rice (BINA dhan 7, BR-11, BRRI dhan 40, BRRI dhan 41) at farmers' field in two selected districts of Bangladesh. The empirical data for the study were collected from two consecutive years 2011 and 2012; data were also collected through FGDs (Focus Group Discussions) and KIIs (Key Informant Interviews). The findings reveal that in case of *aman* rice the overall yield gap of BR 11 was the highest (20.89 percent) followed by BRRI dhan 40 (17.89 percent), BRRI dhan 41 (16.76 percent) and BINA dhan 7 (10.92 percent). The farmers' practice gap in aman rice was the highest in case of gypsum (68 per cent) followed by TSP (59 per cent) and MoP (55 percent). Six practice gaps, such as seed quality, seedling age, application of urea, TSP, MoP, and gypsum contributed about 62 percent variation in yield gaps of *aman* rice cultivation. The most important constraints in *aman* rice cultivation for the farmers were: lack of high yield potential varieties, rainfed *aman* rice cultivation, and severe attack of rats.

Keywords: Factors, yield gap, aman rice, farmer

Introduction

Bangladesh has experienced a continued annual shortage of about 1.5 million tones of food grains (Karim, 1999). The national average yield of *aman* rice is 2.29 t/ha (BBS, 2014) which is still much lower than the yield potential of modern rice varieties; this indicates the low productivity of rice at farmers' level. The food shortage would continue to exist if the production of food grains cannot be increased significantly. Since rice is the major crop in Bangladesh its production has to be increased by at least 60 per cent to maintain the present level of rice requirements by the year 2020 (Karim, 1999). However, increasing the food grain production, especially rice in Bangladesh is not an easy task since there is hardly any scope for horizontal expansion of the rice area due to the gradual diminishing of cultivated land as a result of diverting its use for houses, roads, industries and urbanization. Hence, the only options available to the policy makers for increasing the rice production are: (i) full exploitation of the present yield potentials of the existing modern varieties, and (ii) bridging the yield gaps of rice. The practical yield gaps in rice that can be addressed are the difference between the research plot yields and the farmers' actual yields as defined below:

- **Research plot yield:** It is the yield of research plots in farmers' fields with almost no physical, biological, and economic constraints and with the best-known management practices at a given time in a given ecology.

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- Farmers' actual yield: It is the average farmers' yield, around the research plots, in a given target area at a given time and in a give ecology without any intervention(s) from the researchers.

Farmers often obtain much lower than the achievable yield of a variety, although the research institutes of Bangladesh and universities have developed and released a good number of rice varieties having high yield potentials (BRRI, 2009). This means that there is a gap between the achievable yield and farmers' actual yield. But the factors behind this yield gap are yet to be identified. Islam, (2007) argued that reducing the yield gap alone could supply additional 15% of the increased annual grain demand by the year 2025. The factors behind the yield gap vary with their management practices and soil conditions. However, identification of these factors would provide a comprehensive idea in minimizing the present yield gaps of *aman* rice. Keeping these facts in mind, the present study has been undertaken to fulfill the following specific objectives:

i. To quantify the yield gaps of *aman* rice between achievable yield at researcher supervised farmers' plot and non-supervised plot;
ii. To identify the management related factors responsible for yield gap of *aman* rice with their relative contribution; and
iii. To ascertain the constraints faced by the farmers in *aman* rice cultivation.

Methodology

In order to compare the yield between maximum attainable yield and farm-level yield, apart from research data, information were also collected from two selected major rice growing areas. The rice growing areas included Muktagacha Upazila of Mymensingh and Nokla Upazila of Sherpur district. A total of 18 research plots were set up at farmers' field in order to assess the achievable yield of the selected *aman* rice varieties. The selected *aman* varieties are Bina dhan 7, BR-11, BRRI dhan40, BRRI dhan41 were set up at farmers' field in order to assess the achievable yield of *aman* rice varieties. The research plots were jointly conducted, monitored and supervised by the concerned farmers, SAAOs from DAE and researchers. Production inputs like seeds, fertilizers, pesticides etc. were provided in advance from the project.

In order to compare the yield between the research plots and farmers' actual yield, field data were collected from the *aman* rice growers of the selected Upazilas. Random sampling procedures were used for determining the proportionate samples from the population. Data were collected from the two consecutive years 2011 and 2012.

For validation of information on different causes of yield gaps, 4 Focus Group Discussions (FGDs) were conducted with the farmers. In addition, in order to make the findings more authentic 20 Key Informants Interviews (KIIs) were conducted personally by the researchers with the extension personnel, input dealers, and development workers. Apart from this 4 Field Days (FDs) were also conducted.

Measurement of yield gap

Yield gap of a variety was measured on the basis of the difference between the achievable yield (kg/ha) of research plot yield and a farmer's actual yield (kg/ha) obtained at the farmers' plot and then

compared it to the percentage of achievable yield. Thus, the yield gap of a variety could vary from 0 to 100%. The following formula was used in this regards was as follows:

$$\text{Yield gap of a farmer} = \frac{\sum_{i=1}^{n}(P_i - Y_i)}{P_i} \times 100$$

Where, P_i = Achievable yield (obtained at research plots) of a particular variety

Y_i = Actual yield the same variety harvested by a farmer

Determining the practice gap in aman rice cultivation

Seed rate, seed quality, seedling age, application of urea, TSP, MoP and gypsum are considered to be yield determining factors. Practice gap for each yield determining factor however was measured on the basis of difference between recommendation and actual application. The formula used in this regard was as follows:

$$\text{Deviation proportion G} = \frac{R - A}{R}$$

Where,

G= gap

R= Recommended practices for the variety

A= Actual practices done for the same variety by the respondents at research station

For example, the recommended dose of seed rate of a *aman* rice variety was 30 kg/ha. Hence, the practice gap index for seed rate of a farmer in *aman* rice was measured by using the following formula:

Practice gap index for seed rate of *aman* rice

$$= \frac{\sum_{i=1}^{n} A_i \times G_i}{\sum_{i=1}^{n} A_i} \times 100$$

Where,

A_1 = Actual seed rate of a particular variety sowing in the first plot

A_2 = Actual seed rate of a particular variety sowing in the second plot

A_3 = Actual seed rate of a particular variety sowing in the third plot

G_1 = Deviation proportion for the first plot

G_2 = Deviation proportion for the second plot

G_3 = Deviation proportion for the third plot

The same formulae were followed in computing different practice gap indices of *aman* rice. The following recommendations of *aman* rice varieties were used as the basis of deviation during calculation of practice gap.

Variety	Yield determinant practices					
	Seed rate (kg/ha)	Seedling age (days)	Urea (kg/ha)	TSP (kg/ha	MoP (kg/ha)	Gypsum (kg/ha)
Binadhan 7	30	25	180	120	70	50
BR-11	30	30	180	120	70	50
BRRI dhan 40	30	30	180	120	70	50
BRRI dhan 41	30	30	180	120	70	50

Source: DAE, 2003

Constraints in aman rice cultivation leading to yield gap

The respondents were asked to indicate the extent of their constraints during the cultivation of Bina dhan 7, BR-11, BRRI dhan 40, BRRI dhan 41 in a four point rating scale - high, medium, low and not all with the weightage of 3, 2, 1 and 0 respectively. The constraints facing index (CFI) was computed by using the following formula:

$$CFI = P_h X3 + P_m X\ 2 + P_l X\ 1 + P_n X0$$

where,

P_h = Number of farmers facing the constraint as high

P_m = Number of farmers facing the constraint as medium

P_l = Number of farmers facing the constraint as low

P_n = Number of farmers facing the constraint as not at all

Findings and Discussion

Yield gap of a*man* rice

There were 18 research plots of *aman* rice (09 in Muktagacha Upazila of Mymensingh district and 09 in Nokla Upazila of Sherpur district). The varieties were BINA dhan 7, BR 11, BRRI dhan 40 and BRRI dhan 41. The variety wise yield gaps and mean yield gaps of the selected rice varieties in *aman* season at Muktagacha and Nokla along with standard deviation have been presented in Table 1.

The finding at Table 1 shows that the overall yield gap of BR 11 was the highest (20.89 percent) followed by BRRI dhan 40 (17.89 percent), BRRI dhan 41 (16.76 percent) and BINA dhan 7 (10.92 percent). The yield gap of BRRI dhan40 was also higher than BINA dhan 7 and BRRI dhan41. Further, the yield gaps in Nokla site was higher than Muktagacha site in case of all the varieties.

Practice gap in *aman* rice cultivation

The findings in respect of the practice gaps in *aman* rice at farmers' field have been presented in Table 2. The findings presented in Table 2 demonstrated that the highest practice gap was in case of using gypsum by the farmers. The mean practice gap in gypsum application was considerably high (68 percent) followed by TSP (59 percent) and MoP (55 percent). The practice gap in seed quality was considerably high, 38 per cent. The practice gap in case of the application of urea was the lowest, only 9 percent. This indicates that farmers only apply urea in recommended doses during *aman* rice cultivation.

Correlation between different practice gaps in *aman* rice and its yield gaps

For determining the relationships between the practice gaps *aman* rice cultivation and yield gaps Pearson correlation co-efficients were computed. The findings have been presented in Table 3.

Table 1 Yield gaps of *aman* rice varieties at different locations

Research site	Yield of *Aman* rice	Variety wise achievable yield and farmers actual average yield											
		BINA dhan 7			**BR 11**			**BRRI dhan40**			**BRRI dhan41**		
		1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean	1st Year	2nd Year	Mean
Muktagacha site	Achievable yield (Research polt yield)	4570	4598	4584	4240	4256	4248	4475	4485	4480	4382	4420	4401
	Farmers' actual yield	4055	4181	4118	3330	3404	3367	3667	3778	3723	3617	3745	3681
	Yield gap (%)	11.26	9.07	**10.17**	21.46	20.01	**20.73**	18.05	15.76	**16.90**	17.45	15.27	**16.36**
Nokla site	Achievable yield (Research plot yield)	4552	4575	4564	4260	4254	4257	4455	4472	4464	4365	4395	4380
	Farmers' actual yield	3982	4080	4031	3335	3387	3361	3605	3642	3624	3569	3688	3629
	Yield gap (%)	12.52	10.81	**11.67**	21.71	20.38	**21.04**	19.08	18.55	**18.81**	18.23	16.08	**17.15**
	Overall yield gap (%)			**10.92**			**20.89**			**17.89**			**16.76**

Table 2 Farmers' practice gaps in *aman* rice cultivation

Gaps in practices	Categories	Muktagacha site		Nokla site		Total no. and % farmers	Mean (%)	Standard deviation
		% farmers	Mean (%)	% farmers	Mean (%)			
1. Seed rate	No gap (0 %)	36	22.40	20	25.60	28	24.00	18.85
	Low gap (1-27 %)	12		30		21		
	Medium gap (28-54%)	42		34		38		
	High gap (55 % and above)	10		16		13		
2. Seed quality	No gap (0 %)	26	37.00	18	38.50	26	37.75	27.17
	Low gap (1-25 %)	38		36		24		
	Medium gap (26-50 %)	18		20		32		
	High gap (51 % and above)	18		26		18		
3. Seedling age	No gap (0 %)	18	14.80	4	19.80	15	17.30	14.62
	Low gap (1-20 %)	66		64		58		
	Medium gap (21-40 %)	14		24		21		
	High gap (41 % and above)	2		8		6		
4. Urea top dressing	No gap (0 %)	26	7.04	12	10.08	19	8.56	5.50
	Low gap (1-5 %)	20		6		13		
	Medium gap (5.01-10 %)	54		82		68		
	High gap (10.01 % and above)	0		0		0		
5. TSP application	No gap (0 %)	8	56.79	4	60.78	6	58.79	12.04
	Low gap (1-20 %)	46		44		45		
	Medium gap (20.01-40 %)	46		52		49		
	High gap (40.01 % and above)	0		0		0		
6. MoP application	Low gap (13.80-40 %)	20	50.79	16	59.79	18	55.29	23.97
	Medium gap (40.01-70 %)	58		46		52		
	High gap (70.01 % and above)	22		34		30		
7. Gypsum application	No gap (0 %)	6	61.96	0	3.57	3	67.77	29.60
	Low gap (1-33 %)	14		10		12		
	Medium gap (33.01-66 %)	32		30		31		
	High gap (66.011 % and above)	48		60		54		

Table 3 Correlation co-efficients showing relationships between the practice gaps of farmers and their yield gaps in *aman* rice cultivation

Practice gaps in *aman* rice	**Correlation co-efficients (r)**
1. Seed quality	.439**
2. Seedling age	.531**
3. Urea top dressing	.289**
4. TSP application	.305**
5. MoP application	.689**
6. Gypsum application	.348**

*** Significant at P<0.001 level of probability

The findings of Table 3 showed that all the practice gaps in *aman* rice cultivation by the farmers had significant relationships with the yield gaps of *aman* rice. This means that the higher was the practice gaps, the higher was the yield gaps in *aman* rice at farmers' fields.

Yield Gap Influencing Factors in *Aman* Rice

Linear multiple regression co-efficients were computed in order to determine the influential factors leading to yield gaps in *aman* rice. The findings have been presented in Table 4. The findings reveal that only three factors (Mop application gap, seedling age and seed quality) contributed about 62 percent variation of the yield gaps in *aman* rice cultivation.

Table 4 Linear multiple regression coefficients of yield gap influencing factors of *Aman* rice production

Yield gap influencing factors in *aman* rice	Unstandardized Coefficients		Standardized Coefficients	t – Value	Level of significance
	B	Std. Error	Beta		
(Constant)	7.809	1.552		5.032	.000
1. MoP application gap	.083	.015	.455	5.524	.000
2. Seedling age	.064	.022	.214	2.867	.005
3. Seed quality	.029	.012	.184	2.550	.012
R^2 **Value = 0.616**		F= 21.06		P = 0.000	

Constraints in *Aman* Rice Cultivation

The Constraints Facing Index (CFI) was calculated and the findings are presented in Table 5. The top 05 constraints as per PFI in descending order are: lack of high yield potential varieties, rainfed *aman* rice cultivation, drought/scarcity of rain during panicle initiation stage, severe attack of rats and high cost of labour. The number of high yield potential rice varieties in *aman* season is relatively less than *boro* season. Probably farmers indicated about the less number of high yield potential rice varieties in *aman* season. Further *aman* rice almost in cases is cultivated in rainfed conditions, but sometimes it becomes problem of water scarcity in *aman* season. In many areas it has been observed that rat's attack is a serious problem during *aman* rice cultivation, especially where there are many fish ponds in around the *aman* rice fields. The godowns/stores of the fish ponds act as the harvour of rats from where they attack the rice fields beginning from the panicle

stage until harvesting. High cost labour has appeared as one of the constraints although there is little scope to address this issue by the policy makers. In order to address inadequate technical knowledge of the farmers arrangements may be made for training, organizing motivational tours, supplying leaflets, booklets, and other written materials. Further, telecasting the modern rice cultivation techniques through television frequently may help to increase farmers' knowledge on modern rice cultivation since almost all the farmers now possess television in their houses.

Table 5 Constraints faced by the farmers in *aman* rice cultivation

Sl. No.	Statement of constraints	High	Medium	Low	Not at all	CFI
1.	Lack of high yield potential varieties	52	34	14	0	238
2.	Rainfed *aman* rice cultivation	45	34	14	0	238
3	Drought/scarcity of rain panicle initiation stage	36	38	12	14	196
4	Severe attack of rats	32	35	29	4	195
5	High cost of labour	29	42	20	9	191
6	Inadequate technical advice from field extension personnel	32	36	15	17	183

Conclusions

The yield gap has been revealed as a complex issue, as it varies from crop to crop, time to time and even location to location. Through this study, a comprehensive idea about yield gaps of selected varieties of *aman* rice has been identified. Yield gap occurs mainly due to deviation of recommended practices by the farmers. The deviation usually happened due to technological, socio-economic and situational factors. It was revealed that most of the farmers applied only one third doses of the recommended chemical fertilizers, delayed transplanting, and planted over aged seedlings. These factors had significant influence on the yield gap. The average yield gap of *aman* rice was about 18% compared to the achievable yield. The practice of low quality seeds and over aged seedlings with inadequate application of MoP fertilizers in the field were identified as the root causes behind this gap. Rainfed *aman* culture often delayed transplanting time that decreased the yield of *aman* rice to a greater extent. Further, yield was also decreased by the severe attack of pest, especially rats in some locations (Muktagacha). However, farmers also opined that lack of high yield potential stable varieties often caused yield gap in *aman* cultivation.

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