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Boro Rice Yield Gap Minimizing Strategies Practiced by the Farmers of Dhamrai Upazila under Dhaka District

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Abstract

Rice yield gap minimizing strategies can boost rice production, ensure our food security, and growth in the agriculture sector. The objectives of this study were to describe the selected characteristics of the boro rice farmers to identify the boro rice yield gap minimizing strategies practiced by the farmers, to determine the extent of practice of boro rice yield gap minimizing strategies by the farmers and to explore the contributing relationship between the selected characteristics of the farmers with their practice of boro rice yield gap minimizing strategies. A validated and well-structured interview schedule was used to collect data. Data analysis was done using simple and inferential statistical tools such as range, number, sum, mean, standard deviation, frequency, and percentage distribution. Multiple Linear Regression was used to test the contributing relationships among the concerned variables. The findings of the study showed that 29.41% of the respondents practiced minimum strategies, 60.78% of the respondents practiced medium strategies and 9.8% of the respondents practiced maximum strategies. The result also showed that farmers' age, education, yield gap of boro rice, training received on rice production, agricultural extension media contact and problems faced in practicing rice yield gap minimizing strategies had a significant contribution to the boro rice yield gap minimizing strategies practiced by them. In addition, the findings of the study showed that farmers' annual family income, land area under boro rice cultivation, profit from boro rice cultivation and knowledge on rice yield gap minimizing strategies had no contribution to boro rice yield gap minimizing strategies practiced by them. It is concluded that farmers can minimize rice yield gap by increasing their knowledge of rice production technology through increasing their participation in pedagogic programs, training on rice cultivation, agricultural extension media, adoption of advanced technologies like crop calendar, quality seed, seed treatment, recommended use of fertilizer and pesticide and recommended post-harvest operation.

Keywords

Boro Rice, Yield Gap, Minimizing, Strategies, Practiced, Farmers, Dhamrai and Dhaka

1. Introduction

The difference between the potential farm yield and the actual average farm yield is termed as the yield gap. In Bangladesh, yield gaps exist in different crops ranging up to 60% [1]. According to the recent study conducted by BRRI, the yield gap in rice was estimated at 1.74 tn/ha. Rice yield must continue to increase at an annual rate of 1.5% compared with the current rate of 0.80% to keep pace with the expected demand [1]. Because of the continuous population growth, rice demand in 2050 is projected to be 56% higher than in 2001 [2].

Bangladesh agriculture involves food production for 163.65 million people from merely 8.75 million hectares of agricultural land. Since independence, there has been a 3-fold increase in rice production in Bangladesh, which jumped from nearly 11 MT (million tons) in 1971-72 to about 34.86 MT in 2014-15 [3]. In the last few years (2009-2014), rice production has increased by 0.34 MT per year [4]. Stagnant national rice yield (tn/ha) is also a constant and the value 3.17 tn/ha was derived from the weighted average of national yield of Aus, T. Aman and Boro during 2009-2013 [5]. Bangladesh produced about 50.1 million tons of rough rice from 11.7 million ha of land in 2010 with a productivity of 4.3 tn/ha [6]. Moreover, around 25% of the production is required for non-consumption uses like seed, feed, waste, and processing [7]. The present productivity is far below the attainable yield of 8 - 10 tn/ha in the dry season (Boro) and 5 - 6 tn/ha in the wet season (T. Aman) in farmers' field experiments. So that, as a small and densely populated environmentally vulnerable country, minimizing the rice yield gap is an urgent necessity in the context of Bangladesh.

The estimated yield gaps of Aus, Aman and Boro rice were 44.44%, 60.00% and 23.42% respectively [8] [9]. Total rice production in the FY 2015-16 was 34.71 MT. In which Aus, Aman and Boro consist of 2.289 MT, 13.483 MT and 18.938 MT respectively. Decreasing resources (e.g., land, labour, soil health and water), and increasing climate vulnerability (e.g., drought, salinity, flood, heat and cold) appeared as great challenges to keep pace with food production in the background of increasing population [10]. In every step of the rice production system, there is a huge difference between the research station and the farmers' field which is the main reason behind the yield gap. To ensure a sufficient level of food production for an ample population, it is important to minimize the yield gap of rice and all other agronomic and horticultural crops. In this fact, the researcher felt it necessary to identify the extent of the rice yield gap by minimizing strategies practiced by the farmers at every step of the rice production system. The researcher suggests that the findings of the study would be helpful to undertake appropriate policies

to mitigate the rice yield gap by policymakers, researchers and extension providers which will enhance rice production in the country. Considering the importance of boro rice yield gap minimizing strategies, the following objectives were formulated in order to give proper direction in the study:

a. To describe the selected characteristics of the boro rice farmers,
b. To identify the boro rice yield gap minimizing strategies practiced by the farmers,
c. To determine the extent of practice of boro rice yield gap minimizing strategies by the farmers,
d. To explore the contributing relationship between the selected characteristics of the farmers and their practice of boro rice yield gap minimizing strategies.

2. Methodology

2.1. Locale of the Study

The study was conducted at Bharabia and Dhamrai union of Dhamrai upazila under Dhaka district. Two villages Bharabia and Chandra Para of Bharabia Union and Asulia village of Dhamrai Union were purposively considered as the locale of the study because rice is intensively cultivated in these villages.

2.2. Population and Sampling

BR-29 rice variety cultivated by all farmers in the study area was the population of the study. According to Yamane's [11] formula, the sample size was determined as 102. A reserve list of 10 farmers was prepared in case of their absence in any case. In calculating sample size 5% precision level, 50% degree of variability and value of Z = 2.57 at 99% confidence level were chosen from the following formula:

$$n = \frac{z^2 P(1-P) N}{z^2 P(1-P) + N(e)^2}$$

where:

n = Sample size, N = Population size, e = the level of precision and Z = the value of the standard normal variable at the chosen confidence level and P = the proportion or degree of variability.

Table 1. Distribution of the population and sample size of the farmers.

Name of the Villages	Population size	Sample size	Reserve list
Bhararia	107	45	4
Chandra Para	41	18	2
Asulia	92	39	4
Total	240	102	10

Proportionate random sampling techniques were used to select a sample from

three villages of the study area. According to the appropriate proportion of sample size data were collected from each village of the respective union. A reserve list of 10 farmers (about 10% of the sample) was kept purposively if any respondents were unavailable at the time of data collection. The distribution of population and sample size will be shown in Table 1.

2.3. Development of Data Collecting Instrument

In order to collect valid and reliable information an interview schedule was prepared. It was carefully designed with the objectives of the study in mind. Both open and closed forms of questions were used to collect information. Simple, direct questions and scales were included in the interview schedule for collecting information regarding the focus on boro rice yield gap minimizing strategies. Interview schedules were pre-tested in actual field situations before being used for final data collection among 15 respondents in the study area. A reliability test was done. Necessary corrections, modifications and additions were made in the interview schedule on the basis of the results of the pre-test. The interview schedule was then printed in its final form. Necessary photocopies were then made.

2.4. Collection of Data

Before data collection, the researcher met with the Upazila Agriculture Officer (UAO), Agriculture Extension Officer (AEO) and Sub-Assistant Agriculture Officer (SAAO) of those blocks for necessary help and cooperation. Data was collected in-person by the researcher himself through face to face interviews. The interview was conducted in the respondent's farm and home during their leisure period. Before starting the interview, the researcher took all possible care to establish rapport so that the respondent did not hesitate to furnish proper responses to the questions and statements included in the interview schedule. However, if any respondent had difficulty understanding any questions, the researcher took the utmost care to explain and clarify the question.

2.5. Variables of the Study

In social research, the selection and measurement of variables constitute an important task. In this connection, the researcher looked into the literature to widen his understanding of the nature and scope of the variables involved in research studies. [12] defined a variable as any measurable characteristics which can assume varying of different successive individual cases. The hypothesis of a research, while constructed properly, contains at least two important elements, an independent variable and a dependent variable.

An independent variable is a factor that is manipulated by the researcher in an attempt to ascertain its relationship to an observed phenomenon [13]. A dependent variable is that factor which appears, disappears or varies as the experimenter introduces, removes or varies the independent variables. The dependent variables are often called the criterion or predicted variable, whereas the independent vari-

able is called the treatment, experimental and antecedent variables [14]. Variables are very important for social research on which the statistical analysis will be done by the obtained scores on these variables. The eleven characteristics of the farmers were considered as independent variables of this study.

2.5.1. Age

Age of a respondent is termed as the period of time from his birth to the time of interviewing. It was measured in terms of complete years.

2.5.2. Education

The level of education of a respondent was measured on the basis of classes passed in a formal educational institution. For example, if a respondent passed up to class 4, his education score was taken as 4. If a respondent did not know how to read and write his education score was assigned as zero (0). A score of 0.5 will be given to that respondent who could sign his name only.

2.5.3. Farm Size

The farm size of a respondent was determined as the total area of his farm. It included as an area of the farm owned by him as well as those obtained from others by renting, leasing or other means.

2.5.4. Annual Family Income

Annual family income is referred as the annual gross income of a respondent family from agricultural production, business, service and income from other family members during the last one year. The income was expressed in Thousand Taka ('000' Tk).

2.5.5. Land Area under Boro Rice Cultivation

The land area under boro rice cultivation of a respondent was measured by the total land area of his farm under boro cultivation last year. The land area under boro rice cultivation of a respondent was measured in hector.

2.5.6. Profit from Boro Rice

Profit from boro rice cultivation refers to the annual net profit of a respondent from the production of boro rice. The profit from boro rice was expressed in Thousand Taka ('000' Tk). Profit from boro rice cultivation was estimated by subtracting the annual expenditure of boro rice cultivation from the income from boro rice cultivation.

2.5.7. Yield Gap of Boro Rice

The yield gap of boro rice of a respondent was referred to as the difference between the potential farm yield and the actual average farm yield. It was measured in ton/hector.

2.5.8. Training Received on Rice Cultivation

Training received by the respondent on rice cultivation was determined by the total number of days of training received by the respondent from any organization

on rice cultivation. If a respondent took 2 days of training on any aspect of rice cultivation from any GOs, NGOs then his training received score would be 2.

2.5.9. Agricultural Extension Media Contact

Extension contact may be defined as one's extent of exposure to different extension methods. The extent of contact was determined against four (4) point rating scales as not at all, rarely, occasionally and frequently and score was assigned as 0, 1, 2 and 3 respectively. The extension contact of a respondent was, therefore, determined by adding the total responses against 10 selected extension contacts. The extension contact score could range from 0 to 30, where 0 indicating no extension contact and 30 indicating very high contact.

2.5.10. Farmers' Knowledge on Rice Yield Gap Minimizing Strategies

Knowledge on rice yield gap minimizing strategies of a respondent was measured by using 12 different questions in relation to various rice yield gap minimizing strategies. It was measured in scores. A respondent was given full score '2' for correct response. However, partial score was given for partially correct response and a '0' score was given for wrong or no answer. The summation of score obtained by a respondent was the knowledge score of the respondent. The knowledge score of the respondents on rice yield gap minimizing strategies could range from 0 to 24 where '0' indicating no knowledge on rice yield gap minimizing strategies and '24' indicating the highest knowledge on rice yield gap minimizing strategies.

2.5.11. Problem Faced in Practicing Rice Yield Gap Minimizing Strategies

Ten (10) problems were selected and validated by experts to measure the extent of problem faced by the farmers in practicing rice yield gap minimizing strategies. Five (5) point rating scale was used for each problem. Five alternative responses were not at all, low, medium, high and very high problem. The weights were assigned to these responses as 0, 1, 2, 3 and 4 respectively. Extent of problem faced score of the respondents was measured by summing up all the responses to all the problems. The extent of problem faced score could range from 0 - 40 where '0' indicating no problem and '40' indicating very high problem.

2.6. Measurement of Boro Rice Yield Gap Minimizing Strategies

Boro rice yield gap minimizing strategies practiced by the farmers were measured by rank order of the 12 selected boro rice yield gap minimizing strategies. The rank order of the selected boro rice yield gap minimizing strategies was done on the basis of mean value of practicing of each of the 12 strategies by the respondents.

Measurement of Extent of Practice of Boro Rice Yield Gap Minimizing Strategies

"Practice of boro rice yield gap minimizing strategies by the farmers" was the dependent variable of the study. For measuring the boro rice yield gap minimizing

strategies practiced by the farmers, a five (5) point rating scale with 12 strategies were used. The 12 strategies were selected and validated by experts to measure the extent of boro rice yield gap minimizing strategies practiced by the farmers. Five alternative categories to measure the boro rice yield gap minimizing strategies practiced by the farmers were not at all, rarely, occasionally, often, regularly. The score assigned to these responses were 0, 1, 2, 3 and 4 respectively. The extent of boro rice yield gap minimizing strategies practiced by the farmers score ranged from 0 - 48, where '0' indicating no practice and '48' indicating highest level of practice of boro rice yield gap minimizing strategies. On the basis of extent of practice of boro rice yield gap minimizing strategies the respondents were classified into three categories.

2.7. Data Processing

2.7.1. Editing

The collected raw data were examined thoroughly to detect errors and omissions. As a matter of fact, the researcher made a careful scrutiny of the completed interview schedule to make sure that necessary data will be entered as complete as possible and well arranged to facilitate coding and tabulation. Very minor mistake was detected by doing this, which were corrected promptly.

2.7.2. Coding and Tabulation

After completion of field survey, all the data were coded, compiled and tabulated according to the objectives of the study. Local units were converted into standard units. All the individual response to questions of the interview schedule was transferred into a master sheet to facilitate tabulation and categorization.

2.7.3. Categorization of Data

The collected raw data as well as the respondents were classified into various categories to facilitate the description of the independent and dependent variables. These categories were developed for each of the variable by considering the nature of distribution of the data and extensive literature review. The procedure for categorization has been discussed while describing the variables under consideration in Chapter 3.

2.8. Statistical Procedures

The data was analyzed in accordance with the objectives of the study. Qualitative data was converted into quantitative data by means of suitable scoring techniques wherever necessary. The statistical measures such as range, number, sum, mean, standard deviation, frequency, and percentage distribution were used for categorization and describing the variables. Multiple linear regression analysis was done to explore the contributing relationship between the selected characteristics of the farmers with the dependent variable. Statistical package for social sciences (SPSS) version 25 was used for the analysis of data. Five percent (0.05) level of probability was considered as the basis for rejecting any null hypothesis.

3. Results and Discussion

3.1. Selected Characteristics of the Farmers

Table 2. Salient features of the selected characteristics of the farmers (N = 102).

Characteristics with measuring unit	Range		Categories	Respondents		Mean	S. D.
	Possible	Observed		Number	Percent		
Age (Years)	-	30 - 68	Young aged (up to 35 year)	5	4.90	50.69	8.96
			Middle aged (36 to 50 year)	44	43.14		
			Old aged (>50 year)	53	51.96		
Education (Year of schooling)	-	0 - 14	Illiterate (0)	22	21.60	4.53	2.94
			Primary (1 - 5)	45	44.10		
			Secondary (6 - 10)	31	30.40		
			Higher secondary and above (>10)	4	3.90		
Farm size (Hectare)	-	0.13 - 4.10	Small farm (<1.0 ha)	72	70.59	0.863	0.79
			Medium farm (1 - 3 ha)	22	21.26		
			Large farm (>3.0 ha)	8	7.84		
Annual family income ('000' Tk)	-	40 - 520	Low income (up to 173)	76	74.50	134.85	95.71
			Medium income (174 - 346)	20	19.60		
			High income (>346)	6	5.88		
Land area under boro rice cultivation (Hectare)	-	0.12 - 3.6	Small farmer (up to 0.41 ha)	42	41.17	0.73	0.64
			Medium farmer (0.42 - 1.06 ha)	43	42.16		
			Large boro farmer (>1.11 ha)	15	14.70		
Profit from boro rice ('000' Tk)	-	12 - 300	Low profit (upto 33)	36	35.29	61.64	55.83
			Medium profit (34 - 95)	47	46.07		
			High profit (>95)	19	18.62		
Yield gap of boro rice (Ton/ha)	-	2.46 - 3.72	Medium gap (upto 3.05 tn/ha)	19	18.62	3.36	0.31
			High gap (3.06 - 3.67 tn/ha)	77	75.49		
			Very high gap (>3.67 tn/ha)	6	5.88		
Training received on rice cultivation (Number of days)	-	2 - 4	Low (up to 2 days)	44	43.10	2.63	0.59
			Medium training received (3days)	52	51.00		
			High training received (4 days)	6	5.90		
Agricultural extension media contact (Score)	0 - 30	14 - 24	Low contact (up to 16)	24	23.53	18.94	2.67
			Medium contact (17 - 22)	70	68.63		
			High contact (23 - 30)	8	7.84		
Knowledge on rice yield gap minimizing strategies (Score)	0 - 24	14 - 22	Poor knowledge (up to15)	31	30.40	17.15	2.27
			Moderate knowledge (16 - 19)	50	49.00		
			Good knowledge (20 - 24)	21	20.6		
Problem faced in practicing rice yield gap minimizing strategies (Score)	0 - 40	14 - 21	Low problem (up to16)	21	20.60	17.85	1.64
			Medium problem (17 - 19)	56	54.90		
			High problem (20 - 21)	25	24.50		

Eleven characteristics of the farmers were selected. The selected characteristics were age, educational qualification, farm size, annual family income, land area under boro rice cultivation, profit from boro rice, yield gap of boro rice, training received on rice cultivation, agricultural extension media contact, farmers' knowledge on rice yield gap minimizing strategies and problem faced in practicing rice yield gap minimizing strategies. These characteristics of the farmers are described in this chapter. For ready reference, separate tables are provided while presenting categories, discussion and interpretations of results concerning each of the characteristics in this chapter.

Age

This distribution was supported by [15] and [16] shown in **Table 2**, Data contained in **Table 2**, indicate that an overwhelming majority (95.10%) of the farmers in the study area were middle to old aged. It may due to middle to old aged people have more land ownership than young aged people.

Education

This distribution was supported by [17] shown in **Table 2**, Data presented in **Table 2**, express that almost three fourth (74.50%) of the farmers had primary to secondary education, while 21.60% were illiterate and only 3.90% had above secondary level education. The authors of [17] found almost similar findings. Most of the respondents of the locale had primary to secondary level of education and illiteracy rate was low. It may due to the area was adjacent to Dhaka, as well as primary schools and high school and college are located in the locale.

Farm size

Based on the farm size, the farmers were classified into three categories namely small farm size, medium farm size and high farm size as shown in **Table 2**. Data contained in **Table 2**, reveal that 70.59% of the farmers had small farm size, 21.26% of the farmers had medium farm size and 7.84% of the farmers had large farm size. The average farm size of the farmers of the study area (0.862 hectares) was higher than that of national average (0.60 hectare) of Bangladesh [4].

Annual family income

Data presented in **Table 2**, indicate that 74.50% of the farmers had low family income, 19.69% of the farmers had medium family income and 5.88% of the farmers had high family income. Dominance of low income farmers may due to poor socio-economic condition, small and medium farm size of the majority farmers. As well as mean annual income of the locale was lower than the national average of $1752 USD may due to more involvement of the farm families in business, services, and getting foreign remittance.

Land area under boro rice cultivation

Data presented in **Table 2**, reveals that 41.17% of the farmers in the study area were small boro farmer, 42.16% were medium boro farmer and 14.70% were big boro farmer. Land area under boro rice cultivation shrinks form the total farm size of the respondents. It may due to distribution of farm size for various purpose e.g. homestead area, pond, cultivation of other crops, previous crops, potato, win-

ter vegetables cultivation.

Profit form boro rice

Data contained in Table 2, indicate that 35.29% of the farmers had low profit, 46.07% of the farmers had medium profit and 18.62% of the farmers had high profit. The majority of the farmers had medium to high profit which may be due to the high price of boro rice, availability of rice mills in the locale and good transport facilities with the capital.

Yield gap of boro rice

Data presented in Table 2, revealed that an overwhelming majority (75.49%) of the farmers had a high yield gap and 18.62% of the farmers had a medium yield gap and 5.88% of the farm. High yield gap exists in the locale, which may be due to famer's lack of knowledge, education, and low practices of rice yield gap minimizing strategies.

Training received on rice cultivation

Data contained in Table 2, indicate that 43.10% of the farmers had low training exposure, 51.00% had medium training exposure and 5.90% had high training exposure on rice cultivation. Inadequate applied training facilities for the farmers to achieve high rice production may a reason behind low training exposure by majority of the boro rice farmers. Unwillingness of the farmers to receive and adopt training on modern rice cultivation practices may another reason behind this.

Agricultural extension media contact

Data presented in Table 2, reveal that 23.53% of the farmers had low agricultural extension media contact, 68.63% of the farmers had medium agricultural extension media contact and 7.84% had high agricultural extension media contact. Extension contact of the respondents varied, which may be due to socio-economic conditions of the farmers. It was found that low income farmers had low extension media contact in the locale. Their involvement in day labour, small vendors and reluctance to agricultural extension media may the reasons behind this.

Knowledge on rice yield gap minimizing strategies

Data contained in Table 2, reveal that 30.40% of the farmers had poor knowledge, 49.00% had moderate knowledge and 20.60% had good knowledge on rice yield gap minimizing strategies. Lack of education, agricultural extension media contact and training exposure to rice cultivation may the reason behind this.

Problem faced in practicing rice yield gap minimizing strategies

Data presented in Table 2, reveal that an overwhelming majority (79.40%) of the farmers faced medium to high problem and 20.60% of the farmers faced low problem in practicing rice yield gap minimizing strategies. Farmers stated that high cost and unavailability of inputs, labor shortage, excessive cold during germination and transplanting period, pests and diseases infestation, excessive precipitation at harvesting period were the major problems faced by them.

3.2. Boro Rice Yield Gap Minimizing Strategies Practiced by the Farmers

Identification of boro rice yield gap minimizing strategies practiced by the farmers

and ranking of boro rice yield gap minimizing strategies practiced are discussed in the following sub-sections. Boro rice yield gap minimizing strategies practiced by the farmers are ranked in ascending order on the basis of mean practice value as shown in Table 3.

Table 3. Rank order of boro rice yield gap minimizing strategies practiced by the farmers.

Strategies	Mean	SD	Rank
Sowing seedling within mid- December to mid-January	4.0	0	1
Transplanting 35 - 45 days old seedling	4.0	0	1
Maintaining sowing distance (20 – 25 × 15 – 20 cm)	4.0	0	1
Harvesting during maturity index (80% panicles have about 80% ripened spikelets)	3.93	0.254	2
Use of IPM	3.89	0.312	3
Following recommended steps of post-harvest operation (Using paddle thresher for threshing, sun drying 4 - 5 times, cleaning with winnower/air, store in gunny bags at 10 - 12% moisture content)	3.64	0.541	4
Use of recommended irrigation (AWD, 7 - 10 cm transplanting to maximum tillering stage, from 40 DAT 12 - 15 cm up to late tiller production)	3.49	0.502	5
Use of recommended weeding (15 DAT, 30/35 DAT and 45/50 DAT)	3.2	0.423	6
Use of recommended doses of fertilizer (Urea-40 kg, TSP-13 kg, MoP-22 kg, Zipsum-15 kg, $ZnSO_4$-1.5 kg/ Bigha in 3 installment)	1.36	0.842	7
Seed treatment with recommended fungicides (For funagal disease Agrosan, Bavistin, Vitavax 200, Homai 0.4% seed weight; Hot water treatment 54˚C for 15 min, Agrimycin 0.025% 12 hour before sowing for bacterial disease)	1.13	1.04	8
Use of quality seed (TLS/ registered/ certified/ foundation seed)	1.12	0.978	9
Use of crop calendar	0	0	10

Data presented in Table 3, revealed that strategies *i.e.*, Sowing seedling within mid-December to mid-January; Transplanting 35 - 45 days old seedling; Maintaining sowing distance (20 – 25 × 15 – 20 cm) ranked 1st with the mean of 4.0 and SD of 0. This happens because farmers in the study area are well informed about the impact of those strategies in rice yield gap minimization and they practice those strategies regularly.

Harvesting during maturity index (80% panicles have about 80% ripened spikelets) ranked 2nd with the mean of 3.93 and SD of 0.254. This occurs because farmers of the study area are well aware of the maturity index and harvesting time of boro rice.

Use of IPM ranked 3rd with a mean of 3.89 and SD of 0.312. This may be due to farmers of that area has sufficient knowledge on use of IPM and its impact on boro rice.

Following recommended steps of post-harvest operation (Using paddle thresher for threshing, sun drying 4 - 5 times, cleaning with winnower/air, store in gunny bags at 10 - 12% moisture content) ranked 4th with the mean of 3.64 and SD of 0.541. This may be due to farmers of the study area had adequate knowledge

on post-harvest operations of rice. But, due to lack of equipment for drying, threshing, storing and labour shortage yield gap may exist. Moreover, small farmers of the area do the operations manually by their own, it requires much time and cause grain deterioration.

Use of recommended irrigation (AWD, 7 - 10 cm transplanting to maximum tillering stage, from 40 DAT 12 - 15 cm up to late tiller production) ranked 5th with the mean of 3.49 and SD of 0.502. The locale is under cover of irrigation facility and most of the farmers use AWD method of irrigation. It was found that, farmers having low income and lack of knowledge, awareness do not practice irrigation regularly which may be a reason behind rice yield gap in the study area.

Use of recommended weeding (15 DAT, 30/35 DAT and 45/50 DAT) ranked 6th with the mean of 3.2 and SD of 0.423. Farmers of the study area has medium knowledge on weeding period of rice but due to labour shortage, large and medium farm size farmers sometimes cannot practice weeding operation in time. Moreover, in the present study it was found that most of the low-income farmers practice weeding manually by their own without labour, which requires much time, and it may be another reason behind rice yield gap in the locale.

Use of recommended doses of fertilizer (Urea-40 kg, TSP-13 kg, MoP-22 kg, Zipsum-15 kg, $ZnSO_4$-1.5 kg/ Bigha in 3 installment) ranked 7th with the mean of 1.36 and SD of 0.842. This happened because farmers of the study area have lack of knowledge on fertilizer doses of boro rice to obtain potential yield and high cost of fertilizer. Moreover, residual impact and overdoses of fertilizer can reduce soil fertility and farmers had lack of knowledge regarding this issue.

Seed treatment with recommended fungicides (For funagal disease Agrosan, Bavistin, Vitavax 200, Homai 0.4% seed weight; Hot water treatment 54˚C for 15 min, Agrimycin 0.025% 12 hour before sowing for bacterial disease) ranked 8th with the mean of 1.13 and SD of 1.04. In the present study, it was found that farmers of the study area had lack of knowledge on seed treatment and were unwilling to bear its expense. They often use traditional seed treatment method by boiling and soaking seeds 12 hour before sowing into the seedbed which is ineffective to hinder soil and seed born pathogens, which may ultimately cause outbreak of diseases.

Use of quality seed (TLS/ registered/ certified/ foundation seed) ranked 9th with the mean of 1.12 and SD of 0.978. This may be due to most of the farmers regularly use their own seeds in rice cultivation. During data collection, it was found that, medium and big farmers of the locale occasionally use quality seed for rice production.

Use of crop calendar ranked 10th the mean of 0 and SD of 0 because farmers of the study area had very few knowledge on rice crop calendar and its impact on minimizing rice yield gap Farmers of the locale do not use crop calendar.

3.3. Extent of Practice of Boro Rice Yield Gap Minimizing Strategies

Boro Rice yield gap minimizing strategies practiced by the farmers varied from 28

to 42 against the possible range of 0 - 48 with the mean of 33.75 and standard deviation of 2.996. Based on the extent of practice of boro rice yield gap minimizing strategies, farmers are classified into three categories (Mean ± SD) namely, "minimum strategies practiced", "medium strategies practiced", maximum strategies practiced" as shown in Table 4.

Table 4. Distribution of the farmers according to practice of boro rice yield gap minimizing strategies.

Categories	Farmers		Mean	SD
	Number	Percent		
Minimum strategies practice (up to 31)	30	29.41	33.85	3.253
Medium strategies practice (32 - 37)	62	60.78		
Maximum strategies practice (38 - 48)	10	9.8		
Total	102	100		

Data contained in Table 4, indicate that an overwhelming majority (90.19%) of the farmer practice low and medium level of boro rice yield gap minimizing strategies. Low annual income, low profit, small farm land, low training exposure, low agricultural extension media contact, lack of knowledge on rice yield gap minimizing strategies, high problem faced in rice cultivation and poor socio-economic conditions of the farmers may be the reasons behind minimum and medium level of strategies practiced by them.

3.4. Contributing Relationship between the Selected Characteristics of the Farmers with Their Practice of Boro Rice Yield Gap Minimizing Strategies

This section deals with the findings exploring the contributing relationship between the selected characteristics of the farmers with their practice of boro rice yield gap minimizing strategies. The contributing factors were age, educational qualification, farm size, annual family income, land area under boro rice cultivation, profit from boro rice cultivation, yield gap of boro rice, training received on rice production, agricultural extension media contact, knowledge on rice yield gap minimizing strategies, problem faced in practicing rice yield gap minimizing strategies. The main focus of the study was, "Practice of boro rice yield gap minimizing strategies by the farmers".

To assess the contributing relationship between selected characteristics of the farmers with their practice of boro rice yield gap minimizing strategies, a multiple linear regression analysis was done. The multiple linear regressions results have been shown in Table 5.

The null hypothesis was, "Each of the eleven selected characteristics (age, educational qualification, farm size, annual family income, land area under boro rice cultivation, profit from boro rice, yield gap of boro rice, training received on rice cultivation, agricultural extension media contact, knowledge on boro rice yield

gap minimizing strategies and problems faced in practicing boro rice yield gap minimizing strategies) of the farmers has no contributing factor with their practice of boro rice yield gap minimizing strategies."

Table 5. Multiple linear regression coefficients of contributing variables of practice of boro rice yield gap minimizing strategies by the farmers.

Dependent variable	Independent variables	β	p	R^2	Adjusted R^2
Boro rice yield gap minimizing strategies practiced by the farmers	Age	0.086	0.031*	0.838	0.825
	Education	0.217	0.001**		
	Farm size	−0.320	0.133		
	Annual family income	0.118	0.341		
	Land area under boro rice cultivation	0.357	0.190		
	Profit from boro rice cultivation	−0.082	0.592		
	Yield gap of boro rice	−0.588	0.000**		
	Training received on rice cultivation	0.104	0.017*		
	Agricultural extension media contact	0.121	0.048*		
	Knowledge on rice yield gap minimizing strategies	−0.096	0.191		
	Problem faced in practicing rice yield gap minimizing strategies	−0.120	0.044*		

** Significant at $p < 0.01$, * Significant at $p < 0.05$.

The findings of the study revealed that, the eleven (11) characteristics of the farmers were taken as independent variables together were effective in predicting boro rice yield gap minimizing strategies practiced by the farmers. The observed F ratio was 68.861. Which was significant at 0.01 level of probability and indicated that the combination of the independent variables in boro rice yield gap minimizing strategies practiced by the farmers was effective? 83.8 percent (%) ($R^2 = 0.838$) of the variation in the respondents' practice of boro rice yield gap minimizing strategies can be attributed to their age, educational qualification, farm size, annual family income, land area under boro rice cultivation, profit from boro rice cultivation, yield gap of boro rice, training received on rice production, agricultural extension media contact, knowledge on rice yield gap minimizing strategies, problem faced in practicing rice yield gap minimizing strategies making contribution on boro rice yield gap minimizing strategies practiced by the farmers.

However, each predictor may expound some of the variance in respondents' practice of boro rice yield gap minimizing strategies. The adjusted R-square value penalizes the addition of external predictors in the model, but values of 0.825 still show that the variance in farmers' practice of boro rice yield gap minimizing strategies attributed to the predictor variables rather than by chance and the F value indicate that the model was significant ($p < 0.01$).

From Table 5, it was observed that farmers age, educational qualification, yield gap of boro rice, training received on rice production, agricultural extension me-

dia contact and problem faced in practicing rice yield gap minimizing strategies had significant contributing factor on boro rice yield gap minimizing strategies practiced by them. Data also showed that here educational qualification and yield gap of boro rice had most significant contributing factor at 1% ($p < 0.01$) level of significance on boro rice yield gap minimizing strategies practiced by the farmers. Moreover, the data showed that farmer's age, training received on rice production, agricultural extension media contact and problems faced in practicing rice yield gap minimizing strategies had also significant contributing factors at ($p < 0.05$) 5% level of significance on boro rice yield gap minimizing strategies practiced by the farmers.

In summary, the model suggests that the respective authority should consider farmers age, educational qualification, yield gap of boro rice, training received on rice cultivation, agricultural extension media contact and problems faced in practicing boro rice yield gap minimizing strategies when made policy for their extent of adaptation strategies towards salinity effects in agriculture to be improved.

Data furnished from Table 5, revealed that, farmers age had a positive influence on their practice of boro rice yield gap minimizing strategies. Data also showed that farmers age had a significant contributing factor ($p < 0.05$) on their practice of boro rice yield gap minimizing strategies. It could be said that middle and old aged farmers were given more preference to rice cultivation than the young aged. It might because the old aged farmers had land ownership, comparative experience in farming activities and were more involved in rice cultivation than the young and middle aged farmers.

Data revealed from Table 5, showed that, farmers educational qualification had positive influence on their practice of boro rice yield gap minimizing strategies. Farmers educational qualification had the most significant ($p < 0.01$) contributing factor on their practice of boro rice yield gap minimizing strategies. It seemed that educated farmers had more knowledge and greater ability to understand and respond to anticipated changes, had greater access to information and opportunities than others, which might drive them to adopt advanced strategies to minimize rice yield gap.

Data revealed from Table 5, showed that, yield gap of boro rice had a negative influence on farmers practice of boro rice yield gap minimizing strategies. Data also showed that yield gap of boro rice had the most significant ($p < 0.01$) contributing factor on farmers practice of boro rice yield gap minimizing strategies. It was found that farmers practicing medium and maximum level of strategies had low yield gap in the study area. In the study area it seemed that low yield gap inspired farmers to follow more advance strategies to get higher yield in future.

Data furnished from Table 5, showed that, training received on rice cultivation had positive influence on farmers practice of boro rice yield gap minimizing strategies. Training received on rice cultivation had significant contributing factor ($p < 0.05$) on boro rice yield gap minimizing strategies practiced by the farmers. It seemed that when farmers receive different types of training their knowledge and

skill increase, they become more aware of adopting different boro rice yield gap minimizing strategies to get higher yield.

Data revealed from Table 5, showed that, agricultural extension media contact had a positive influence on farmers practice of boro rice yield gap minimizing strategies. Agricultural extension media contact had a significant contributing factor ($p < 0.05$) on farmers practice of boro rice yield gap minimizing strategies. It seemed that agricultural extension media contact helps farmers to get proper and advance techniques of rice cultivation, the guidance of production activities, provide up to date advice on what to do in every stage of rice cultivation and forecast in outbreak of diseases, pests and in natural calamities. Due to those factors farmers having well agriculture extension media contact might have low yield gap.

Data furnished from Table 5, showed that, problem faced in practicing rice yield gap minimizing strategies had negative influence on farmers practice of rice yield gap minimizing strategies. Problem faced in practicing rice yield gap minimizing strategies had significant ($p < 0.05$) contributing factor on farmers practice of boro rice yield gap minimizing strategies. In the present study, it was found that farmers facing less problems in rice production got higher yield than the farmers facing more problem in rice production. It may because, low problem in rice cultivation enhances higher production and minimize yield gap.

4. Conclusions and Recommendations

Conclusions

On the basis of findings, discussion and logical interpretations, the following conclusions have been drawn:

a) Age of the farmers was a significant contributing factor to the boro rice yield gap, minimizing strategies practiced by them. So it could be concluded that farmers' age played an important role in their strategies for minimizing the boro rice yield gap.

b) The educational qualifications of the farmers were the most significant contributing factors to their practice of minimizing the boro rice yield gap. So it could be concluded that education increased the knowledge and ability of farmers to understand and respond to advanced agricultural practices which drove them to adopt advanced strategies to minimize the rice yield gap.

c) Yield gap of boro rice had the most significant contributing factor and negative influence on farmers' practice of boro rice yield gap minimizing strategies. In the present study it seemed that the low yield gap inspired farmers to follow more advanced strategies to obtain higher yields.

d) Training received on rice cultivation significantly contributed to farmers' practice of boro rice yield gap minimizing strategies. It can be concluded that participation in different rice cultivation training increased the knowledge and skill of the farmers which aware them to adopt different boro rice yield gap minimizing strategies to get higher yield.

e) Agricultural extension media contact had a significant contributing factor to farmers' practice of minimizing the boro rice yield gap. It can be concluded that agricultural extension media contact provided up-to-date information to the farmers which assisted them in minimizing the rice yield gap.

f) The problem faced in practicing boro rice yield gap minimizing strategies had a negative influence and was a significant contributing factor to farmers' practice of boro rice yield gap minimizing strategies. It can be concluded that farmers facing fewer problems in rice production got higher yields than the farmers facing more problems in rice production.

Recommendations

i. Farmers practiced strategies which were very popular. So, MoA, DAE, BRRI, BADC and other agricultural organizations should come forward to make available the expensive inputs to farmers *i.e.*, seeds, fertilizers, pesticides, seed treatment fungicides, herbicides, tractor, power tiller, rice weeder, winnower, dryer etc.

ii. Most of the farmers had a low and medium level of knowledge on rice yield gap minimizing strategies and practiced minimum and medium level strategies. Adequate technical support, training and other instructional activities should be undertaken and continued in order to make them capable of practicing the maximum level of strategies.

iii. Education is important for practicing strategies to minimize the rice yield gap. It is therefore recommended that proper steps should be taken to increase the level of education of the old and middle aged farmers to have adequate knowledge on agriculture and proper strategies practiced to minimize the yield gap.

iv. Farmers mostly want to get proper suggestions about rice yield gap minimizing strategies and early forecasting about pests and diseases. It is therefore recommended that DAE and other concerned organizations should take special programs to get farmers acquainted with modern practices of rice yield gap minimizing strategies and advanced communication channels.

v. Agricultural extension media contact increases farmers' diversified knowledge and enables them to cope with adverse situations. So, policies should be taken to engage farmers with diversified extension media to broaden their outlook and develop a positive attitude toward adopting yield gap minimizing strategies. GOs and NGOs can also play a vital role in this regard.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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