BORO RICE YIELD GAP MINIMIZING STRATEGIES PRACTICED BY THE FARMERS OF DHAMRAI UPAZILA UNDER DHAKA DISTRICT

BY

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CERTIFICATE

This is to certify that the thesis entitled **"Boro Rice Yield Gap Minimizing Strategies Practiced by the Farmers of Dhamrai Upazilla Under Dhaka District"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science in Agricultural Extension**, embodies the result of a piece of authentic research work carried out by **Md. Omar Faruq**, Registration No. **15-07007** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated:
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DEDICATED TO

MY

BELOVED PARENTS

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The Author

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ACRONYMS AND ABBREVIATIONS

AIS Agriculture Information Service

BADC Bangladesh Agricultural Development Corporation

BARI Bangladesh Agriculture Research Institute

BBS Bangladesh Bureau of Statistics

BINA Bangladesh Institute of Nuclear Agriculture

BRRI Bangladesh Rice Research Institute

DAE Department of Agricultural Extension

FAO Food and Agriculture Organization

HYV High Yielding Variety

IPM Integrated Pest Management

IRRI International Rice Research Institute

KRKB Kenyan Rice Knowledge Bank

MT Million Ton

OFRD On Farm Research Division

ABSTRACT

Rice yield gap minimizing strategies can boost up rice production, ensure our food security and growth in 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. 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, percentage distribution. Multiple Linier Regression was used for testing 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, educational qualification, yield gap of boro rice, training received on rice production, agricultural extension media contact and problem faced in practicing rice yield gap minimizing strategies had significant contribution on 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, knowledge on rice yield gap minimizing strategies had no contribution on boro rice yield gap minimizing strategies practiced by the them. It is concluded that farmers can minimize rice yield gap by increasing their knowledge of rice production technology through increasing their participation on pedagogic program, training on rice cultivation, agricultural extension media, adoption of advance technologies like crop calendar, quality seed, seed treatment, recommended use of fertilizer and pesticide, following recommended post-harvest operation.

CHAPTER I
INTRODUCTION

1.1 Background of the Study

The difference between the potential farm yield and the actual average farm yield is termed as yield gap (Uddin, 2009). In Bangladesh, yield gaps exist in different crops ranging up to 60% (Mondal, 2011). According to the recent study conducted by BRRI, yield gap in rice was estimated 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 (Mondal, 2011). Because of the continuous population growth, rice demand in 2050 is projected to be 56% higher than in 2001 (Mukherjee et al., 2011).

Bangladesh agriculture involves food production for 163.65 million people from merely 8.75 million hectares of agricultural land (Salam et al., 2014). Since independence, there has been a 3-fold increase in rice production in Bangladesh, which jumped from nearly 11 MT (million ton) in 1971-72 to about 34.86 MT in 2014-15 (AIS, 2016). In the last few years (2009-2014), rice production has increased by 0.34 MT per year (BBS, 2014). Stagnant national rice yield (tn/ha) is also a constant and the value 3.17 tn/ha was derived from weighted average of national yield of Aus, T. Aman and Boro during 2009-2013 (BBS, 2015). 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 (FAOSTAT, 2012). Moreover, around 25% of the production is required for non-consumption uses like seed, feed, wastage, and processing (FAO, 2011). 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 (BRRI, 2010). So that, as a small and densely populated environmentally vulnerable country, minimizing rice yield gap is an urgent necessity in context of Bangladesh.

1.2 Statement of the Problem

In Bangladesh, yield gaps in rice and other agricultural crops exists because the best available production technologies are not adopted in farmers' fields. This could be due to farmers' characteristics (e.g., age, education, lack of knowledge and skills), farm characteristics (e.g., poor soil, difficult terrain, and inaccessibility), and inappropriateness of the technology to farmers' circumstances (e.g., labor intensive, high investment costs, and poor access to inputs). However, a large portion of this yield

gap remains unexplained (Quais, 2015). Small farmers often practice traditional methods of cultivation with their limited knowledge and resources, which does not minimize yield gap. Researchers in various study mentioned the scientific causes of yield gap and its mitigating strategies. However, how many strategies are being practiced by the farmers have rarely been investigated. Under this circumstances stated above, it is important to determine the extent of use of rice yield gap minimizing strategies by the farmers. Moreover, among the three rice season aus, aman and boro, boro season covers the highest rice production area (Economic Review, 2016). Therefore, the researcher has undertaken the study titled "Boro Rice Yield Gap Minimizing Strategies Practiced by the Farmers of Dhamrai Upazila under Dhaka District".

In order to make the study manageable the following research questions were taken into consideration:

i. What are the selected characteristics of the farmers that influence their practice of boro rice yield gap minimizing strategies?
ii. What are the boro rice yield gap minimizing strategies practiced by the farmers?
iii. What is the extent of practice of boro rice yield gap minimizing strategies by the farmers?
iv. What is the contributing relationship between the selected characteristic of the farmers with their practice of boro rice yield gap minimizing strategies?

1.3 Objectives of the Study

Considering the importance of boro rice yield gap minimizing strategies, the following objectives were formulated in order to give proper direction in the study:

i. To describe the selected characteristics of the boro rice farmers,
ii. To identify the boro rice yield gap minimizing strategies practiced by the farmers,
iii. To determine the extent of practice of boro rice yield gap minimizing strategies by the farmers; and
iv. To explore the contributing relationship between the selected characteristics of the farmers with their practice of boro rice yield gap minimizing strategies.

1.4 Justification and Scope of the Study

The estimated yield gap of Aus, Aman and Boro rice were 44.44%, 60.00% and 23.42% respectively (Alam, 20006; Roy, 1997). 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 of food production in the background of increasing population (Brolley, 2015). In every steps of rice production system there is huge difference between the research station and the farmers field which is the main reason behind yield gap. To ensure sufficient level of food production for ample population it is important to minimize yield gap of rice and all other agronomic and horticultural crops.

In this fact stated above, the researcher felt a necessity to identify the extent of rice yield gap minimizing strategies practiced by the farmers in every steps of rice production system. The researcher seems that the findings of the study would be helpful to undertake appropriate policies to mitigate rice yield gap by the policy makers, researchers and extension providers which will enhance rice production of the country.

1.5 Assumptions of the Study

An assumption is the supposition that an apparent fact or principle is true in the light of the available evidence (Goode and Hatt, 1952). An assumption is taken as a fact or belief to be true without proof. The research was carried out keeping the following assumptions in mind:

i. The respondent had the capacity to answer the questions furnished in the interview schedule.
ii. The sample size was representative to the whole population of the study area.
iii. The items, questions and scale of measurement of the variables were reasonably authentic to represent the actual condition of the respondents.
iv. The data collected by the researcher were free from bias.
v. The findings of the study would give a clear concept on boro rice yield gap minimizing strategies practiced by the farmers.
vi. The researcher was capable to adjust with the social and cultural environment of the study area.

1.6 Limitations of the Study

Considering the time, money and other resources available to the researcher and to make the study meaningful, it became necessary to impose certain limitations as noted below:

i. The research was conducted to a confined area of Dhamrai Upazila under Dhaka District.
ii. Data were collected from the selected farmers furnished by them from their memory during interview.
iii. Boro rice yield gap minimizing strategies practiced by the farmers were measured by asking questions to them.
iv. The characteristics of the farmers of the study area were many and varied but only eleven of them were selected for this study.

1.7 Definition of the Related Terms

Age: Age of a farmer referred to the period of time in years from his birth to the time of interview.

Agricultural extension media contact: Agricultural extension media contact referred to an individual exposure to different information sources and personalities relate to agriculture for dissemination of new technologies.

Annual family income: The term annual family income referred to the total amount of money earned by the respondent himself and his family members from agriculture, livestock, fisheries and other accessible sources (business, service, daily labour etc.) during the previous year.

Education: Education referred to the ability of the respondents to read and write or having formal education received up to a certain level from educational institute at the time of interview.

Farm size: Farm size referred to the total area of land on which a farmers' family carried on farming operations and the area being estimated in terms of full benefit to the farmers' family.

Knowledge: Knowledge referred to the extent of facts or information about an idea, object or persons knows. Regarding knowledge aspects knowledge occurs when an individual is exposed to technologies existence and gain some understanding of how it functions (Rogers, 1995).

Problem faced: Problem faced in practicing *boro* rice yield gap minimizing strategies meant any difficult situation which requires some actions to minimize rice yield gap between "what ought to be" and "what exist". The term problem faced referred to different problem faced by the farmers during practicing *boro* rice yield gap minimizing strategies.

Profit: Profit referred to the monetary surplus left to a producer or employer after deducting wages, rent, cost of raw materials, etc.

Strategy: According to Oxford Dictionary, "Strategy is a plan of action designed to achieve a long-term or overall aim." According to Business Dictionary, "Strategy is a method or plan of action to bring about a desired future, such as achievement of a goal or solution to a problem."

Training received: It referred to the total number of days attended by the farmers in his life in institutional training to the various rice production related subject matter.

Yield Gap: The difference between the potential farm yield and the actual average farm yield is termed as yield gap (Uddin, 2009).

CHAPTER 2

REVIEW OF LITERATURE

The study was mainly concerned with rice yield gap minimizing strategies practiced by the farmers. Thus, an attempt was made in this chapter to review the interlinked literatures in this aspect. The researcher, therefore, made an effort to review research directly and indirectly related to the present study. The researcher, collected necessary information through seeking relevant studies, thesis, journals, articles, websites etc. The reviews are conveniently presented in eight sub-sections based on the objectives of the study. The available literatures relevant to this study are discussed below.

2.1 Concept of Crop Yield Gap

The concept of yield gap originated from the studies conducted by IRRI in 1970's. The difference between the potential farm yield and the actual average farm yield is termed as yield gap. Yield gap has at least two components. (i) Gap I- Environmental difference and non-transferable factors. This is mainly due to the factors those are generally not transferable, such as environmental conditions and some built-in component technologies available at research stations. Therefore, it cannot be narrowed or is not exploitable. (ii) Gap II- Difference in crop management. This is mainly due to differences in management practices. This gap exists as farmers use sub-optimal doses of inputs and cultural practices. Gap II is manageable and can be narrowed by deploying more efforts in research and extension services as well as Governments' appropriate intervention particularly on the institutional issues (De Datta, 1981). Gap II was considered in this study.

2.2 Factors Responsible to Yield Gaps in Crop

Yield gaps is actually present, due to the following factors: (i) Physical factors: problem soils, poor water management, drought, flash floods and temperature stresses; (ii) Biophysical factors: varieties, seeds, weeds, insect, diseases and pests, inadequate crop management; (iii) Post-harvest losses, which vary from 10-30% yield gap; (iv) Socio-economic factors: labour shortage, cost-benefit, farmers' knowledge, skills and welfare conditions; (iv) Institutional factors: government policies, rice price, agricultural credit and input supply, land tenure, agricultural research and extension (Ramasamy, 1996).

2.3 Estimation of Crop Yield Gap

To evaluate the yield gap in boro rice, a study was conducted by BRRI in Rajapur village of Bhanga upazila of Faridpur and Meghdubi village of Gazipur district. Under farmers' practice, the yield of boro rice were 4.47 tn/ha and 3.67 tn/ha, while the potential yields with better management were 5.90 tn/ha and 4.73 tn/ha at Rajapur and Meghdubi villages, respectively. The yield gaps were thus 1.43 tn/ha and 1.06 tn/ha which were 24.24% and 22.41% of the potential yield at Rajapur and Meghdubi, respectively (Alam, 2006).

Roy (1997) reported that yield gaps were found to 44.44% and 60.00% in aus and aman, respectively. The average productivity (7 $Mg \cdot ha^{-1}$) of this system is far below attainable yields (14 $Mg \cdot ha^{-1}$) in farmers' fields, resulting in a large yield gap mainly due to farmers' traditional management practices. Yield gap in rice was about 1.74 tn/ha and at least Tk. 1260 billion could be earned from the additional production annually by narrowing the yield gap (BRRI, 2010).

A yield gap study was carried out by OFRD on wheat (var. Kanchan) at the MLT site Palashbari, Rangpur (OFRD, 2003- 2004). It was observed that the better managed plot gave higher yield of 2.56 tn/ha whereas the average managed farmers' plot yield was 1.87 tn/ha indicating a yield gap of 27%. A similar study was undertaken at the MLT site, Atgharia upazila of Pabna district to evaluate the yield gap in mustard using the variety BARI Sharisha-13 (OFRD, 2008-2009). Better managed plots gave higher yield (1366 kg/ha) than farmers' practice (894 kg/ha) with a yield gap of 35.03%.

Yield gaps of groundnut and sesame were found to be 26.66% and 33.33%, respectively (ORC, BARI, 2002). In Potato and sweet potato, yield gaps were 44.72 and 64.01%, respectively, between demonstration and farmers' average. (OFRD 2003-2004). Yield gap study was also conducted by OFRD with chickpea (var. BARI Chola-5). The study revealed yield gap of 31.43% in chickpea (OFRD 2003-2004).

A study was also undertaken to assess yield gap in tomato (var. Ratan) and radish (var. Tasaki sun). The yield gaps were found to be 36.68% and 40.28%, respectively (Matin et al., 1996; Roy, 1997). It is thus evident that yield gaps in different crops varied from 19% to 64% (Mondal, 2011).

2.4 Constrains to Minimize Rice Yield Gap in Bangladesh

The productivity and sustainability of rice-based cropping systems are threatened because of the following factors: (i) inefficient use of fertilizer, water, and labor; (ii) increasing scarcity of water and labor; (iii) climate change; (iv) emerging energy crisis and rising fuel prices; (v) emerging socio-economic changes such as urbanization, migration of labor, and preference for nonagricultural work (Ladha, et al., 2009). Major challenges to implement the interventions include shrinking net cropped area, scarcity of water for irrigation and increasing pressure on soil fertility. In addition, recent increases in the prices of farm inputs in relation to outputs, fewer off-farm work opportunities for supplementing farm income, reduced remittances from relatives working outside villages, and declining income and purchasing power of poor consumers have threatened the existence of rice producers and consumers (Ladha et al., 2009). Moreover, imbalanced fertilization and increased cropping intensity is hampering soil health. Due to deterioration of soil and use of excessive agrochemicals soil organic matter content become decreasing day by day. Declining ground water table is a common scenario across Bangladesh which greatly affect Boro rice (Kabir, et al., 2105).

2.5 Strategies Provided to Minimize Rice Yield Gap

The yield gaps are mainly caused by biological, socio-economic, climatic, institutional and policy related factors. Different strategies, such as integrated crop management (ICM) practices, timely supply of inputs including credit to farmers, research and extension collaboration to transfer the new technologies can minimize crop yield gap (Mondal, 2011).

Three major interventions i.e (i) accelerating genetic gain; (ii) minimizing yield gap and (iii) curtailing adoption lag are proposed to break the barriers to achieve the target. Smart technology such as, location specific variety, profitable cropping sequences, innovative cultural management, and mechanization coupled with smart dissemination using multiple means, would ease production barriers (Kabir et al., 2015).

IRRI (2015) provided 13 steps to successful rice production. These are: (i) use of crop calendar; (ii) choose the best variety; (iii) use high quality seed; (iv) prepare and level the fields well; (v) plant on time; (vi) weed early; (vii) fertilize to maximize returns;

(viii) use water efficiently; (ix) control pests and diseases effectively; (x) harvest on time; (xi) store safely; (xii) mill efficiently; (xiii) understand the market.

BRRI (2016), provided 20 steps to obtain desire rice yield. These are: (i)selection of right variety, (ii) use of quality seed, (iii) seed selection, (iv) seed purification, (v) seed soaking, (vi) making of seedbed, (vii) seed rate, (viii) rearing of seedbed, (ix) age of seedling, (x) picking up of seedlings, (xi) carrying of seedlings, (xii) land preparation, (xiii) sowing of seedlings, (xiv) time of sowing seedlings, (xv) fertilizer management, (xvi) removal of weeds, (xvii) irrigation management, (xviii) pests management, (xix) disease management, (xx) harvesting, threshing and storing.

To summarize boro rice yield gap minimizing strategies, the researcher had considered following two techniques; (i) It has developed based on reference booklet of BR 29 Production Manual (BRRI, 2016); (ii) By taking expert opinion from subject matter specialists; validity test of the above mentioned recommended steps in the sturdy area according to persuasion, knowledge and capacity of the farmers. The strategies are discussed below.

2.5.1 Use of crop calendar

A crop calendar is a picture of rice growing season which includes: crop production from the fallow; land preparation; crop establishment and maintenance through harvest and storage. By using a crop calendar, farm activities are better planned, and performed at the right time. It is easier to organize labor and obtain inputs such as seed and fertilizer. Better planning will decrease input costs and increase yields. A crop calendar can be created by determining the best date to plant and determining the time the variety takes from planting to harvest (short duration, 100–120 days; medium duration, 120–140 days; long duration, 160 days or more). The date of planting and when each other operation needs to be done (plowing, weeding, fertilizing, and harvesting) should be marked on the calendar (IRRI, 2015).

However, extent of practice of crop calendar by the farmers as a strategy to minimize rice yield gap in Bangladesh has not been measured so far, which requires further research.

2.5.2 Choose the best variety

Varieties should be selected based on good yield potential, resistance to disease, good eating qualities, high milling yield, and are suitable for the market. During selecting variety characteristics like crop duration, crop hight, grain quality etc. should be checked (IRRI, 2015).

Since 2017, BRRI has developed 86 rice varieties, and BINA has developed 16 rice varieties for different environment and seasons. In Boro season, BR 58 is 7-10 days earlier than widely adopted BR 29 with similar yield potential and grain quality. Whereas BR 60 has ~1.0 t ha^{-1} yield advantage with extra-long slender grain and 3-4 days longer growth duration than another mega-variety BR 28. BR 50 and BR 63 are the export potential premium quality high yielding (6.0-7.0 t ha^{-1}). BR 74 is a zinc enriched (24.2 ppm) variety, yielding ability of 7.1–8.3 t ha^{-1}, 147 days duration, 28% amylose content, moderately tolerant to blast disease. BR 67 has slender grains is better tolerant to salinity compared to BR 47 (Kabir et al. 2015). The average yield of BR 29 was 6.1 t/h. It is highest among the inbred improved varieties. BR 28 however produced almost 1.0 t/ ha lower yield than BR 29. It is also lower yielding compared to some earlier popular varieties such as IR8 (5.99 tn/ha), BR3 (5.62 tn/ha), BR8 (5.71 tn/ha) and BINA 6 (5.38 tn/ha). The popularity of BR 28 is due to its shorter life cycle. It matures 2-3 weeks earlier than BR 29 if planted on the same date with seedlings of same age. BR 29 is grown in low-lying land. BR 28 is grown in medium and higher lands. (Hossain et al., 2006).

The average yield of BR 29 is 6.13 tn/ha and 5.11 tn/ha for BR 28, compared to 3.92 tn/ha for BR11 and 3.79 for Swarna. The hybrid rice varieties that have 20% yield advantage than the inbred high yielding varieties are also grown during the boro season (Hossain et al 2002). The popular Indian varieties found in Boro season are Ratna, Bhajan, Minikit, Parijat, Nayanmoni and Jaya. These varieties had appeal to the farmers because of their shorter maturity (Parijat), drought tolerance (Nayon Moni), superior grain quality (Minikit). The highest yielding among these varieties was Bhajan with a yield of 5.99 tn/ha, almost similar to BR 29 (Hossain et al., 2006).

However, farmers' choice of best varieties and practice of using best varieties as a strategy to minimize rice yield gap has not measured yet, which requires further research.

2.5.3 Use of best quality seeds

Ensuring quality seed supply has considerable effect in rice yield gap minimization. BRRI annually produces around 100 tons “Breeder Seed”, from which 6.5 lakh ton “Certified Seed” can be produced. However, 35% of the quality seed is now being supplied by the government. The rest of the seed sources are the farmers’ saved rice seed produced for their own food, NGO’s seed, private traders or local market. Those are not good quality seeds as a whole (Kabir et al., 2015). More than 50% of the farmers in Bangladesh use seeds from their own harvest. BADC is the main government organization in charge of producing and marketing quality seeds, contributes about 25% of the seeds planted (Hossain et al., 2012).

Demonstration plot (DP) gave 25.15% higher yield than non-demonstration plot (NDP) due to use of best quality seed, appropriate age of seedlings (30 days), closer spacing, optimum number of seedlings per hill, use of balanced fertilizer and pest control in proper time. Although cultivation cost of DP was higher (Tk.2218 ha^{-1}) than that of NDP (Razzaque et. al 2007).

Plot planted with IRRl supplied seeds had 7% higher yield than the plot planted with farmers-kept seeds in the site where the yield level is already high (Diaz et, al 1998). The deterioration of the seed vigor in rice crop accounted for 20% of the yield losses (Shenoy et al, 1988). Most of the traditional varieties have been degenerated with mixture of other varieties and weeds, which is another reason for low yield besides genetic traits (Hossain et al., 2006).

Healthy seeds should be selected by grading. Seeds should be dipped in water solution (40 litre + 2kg Urea). Seed should be treated with Agrosan GN 1.5 g/kg seed or Granosan M 1g/kg seed (Islam et., al 2007, BRRI, 2016). Sprouted seeds are sown in the nursery bed for rising seedling.

When the age of seedlings become 40-45 days (boro rice), 20-35 days (aman rice) and 20-30 days (aus rice) then they are transplanted in the main field. (Islam et. al., 2007. BRRI, 2016).

However, extent of practice of using quality seed (truthfully leveled seed, registered seed, certified seed, foundation seed) and seed treatment as strategy to minimize rice yield gap by the farmers has not been measured so far, which requires further research.

2.5.4 Land preparation for rice production

Land preparation in irrigated paddy fields is normally carried out after bunding and flooding. This ensures that the fields are wet enough to allow ploughing and strong enough to give reasonable levels of traction or grip to the tractor. Manual land preparation is predominately practiced among small holder farmers. The second operation is carried out in the irrigated paddies to reduce clog sizes, weed control, and incorporate fertilizers in the soil and puddling. Land preparation ends up with final operation that adequately levels the field. Levelling is done to ensure fair distribution of water across the field. Land Preparation and leveling improves and restore soil fertility, ensures proper aeration and good root penetration, proper land levelling, improves soil workability, improves nutrient uptake by crops (KRKB, 2017).

Proper levelling in the field solves more than 50% of the problems in rice production. To ensure a well-leveled land, it is recommended to have 3-5 cm water in the field using a metal or wooden plank (Bautista, 2016).

However, farmers' knowledge on land preparation and practice of land preparation as a strategy to minimize rice yield gap have not been measured so far, which requires further research.

2.5.5 Use of recommended doses of fertilizer

Use of balanced fertilizers is a necessary mean to explore yield potential of rice varieties. Farmers apply fertilizers, pesticide, herbicide and weedicide according to their own experience (Sayed et al. 2015).

Fertilizer dose recommended for BR 29: Urea 30-40 kg/bigha, TSP 7-14 kg/bigha, MoP 8-16 kg/bigha, Gypsum 4-8 kg/bigha and $ZnSO_4$ 0.7-1.4 kg/bigha. Fertilizer dose recommended for BR 28: Urea 30-40 kg/bigha, TSP 7-10 kg/bigha, MoP 8-16 kg/bigha, Gypsum 4-11 kg/bigha and $ZnSO_4$ 0.7-1.0 kg/bigha (BR 29 production manual). Application of fertilizer should be done according to soil type and expected yield. Organic fertilizer (manure, compost, straw, husk, plant leaves) should be used whenever possible, especially in nurseries. TSP, MoP, Gypsum and $ZnSO_4$ all these fertilizers should be applied during final land preparation. Urea should be applied in 3 equal splits. The first $1/3^{rd}$ should be applied at 20 DAT as top dressing, the 2^{nd} $1/3^{rd}$ should be applied during early tillering stage (30-35 DAT) and last $1/3^{rd}$ at panicle

initiation stage (50-55) DAT as top dressing (BRRI, 2016). Instead of the using normal urea, the urea super granule is an effective to reduce fertilizer use for optimum yield (Paul et al., 2013; Qurashi et al., 2013).

Fertilizer used per hectare was found to vary according to rice variety. Compared to high yielding or hybrid varieties, use of all types of fertilizers was considerably low for traditional varieties. Per hectare use of Urea, TSP and MoP for traditional varieties of rice were found to be 96.4 kg, 34.4 kg and 16.4 Kg. while for the most popular HYV Boro rice, BR 29, these were 204.2 kg, 95.7 kg and 56.0 kg respectively. Again, uses of fertilizers for Hybrid rice like Jagoran, Hira, etc. were found to be a bit higher than HYVs. Use of fertilizers was also found to vary considerably in different districts. For example, in the case of Urea, high dose is used in the districts of Chuadanga (260 kg/ha), Munshigan (236 kg / ha), Sirajganj (213 kg / ha), etc. compared to the districts of Patuakhali (73 kg/ha), Maulvibazar (86 kg/ha), Pirojpur (95 kg/ha), etc. (Hossain et al., 2006).

However, extent of practice of recommended doses of fertilizers in boro rice by the farmers as a strategy to minimize rice yield gap has not been measured so far, which requires further research.

2.5.6 Timely transplanting of seedlings and spacing

Effect of planting date on plant height, total sterile spikelet per panicle, 1000 grains weight, total tiller number, panicle number per m^2, grain yield and harvest index was significant at 0.01 probability level. Also planting date had a significant effect on fertile tiller number at 0.05 probability levels. Seedling had a significant effect on fertile tiller at 0.05 probability level. When date of planting is delayed grain yield decreases because the 1000 grains weight decreases and total strile spikelet per panicle increases (Faghani, et. al., 2011).

Delayed transplanting of aman decreases spikelet fertility and reduces yield due to cold stress at the flowering stage (Nahar et al., 2009b). In the case of boro, optimum sowing time for Boro rice is mid-December to mid-January, early-planted crops face low-temperature stress at vegetative as well as reproductive stages and late-planted ones face high-temperature stress at the reproductive stage (Haque, 2006).

The age of seedling varies from variety to variety. For short duration varieties 3-4 week and for long duration varieties 5-6 weeks old seedlings are the optimum age for planting. In boro season, 35-45 days old seedlings should be transplanted. In saline soil of southern region, nursery seed bed should be made before optimum time of seed sowing to avoid damage due to salinity in panicle initiation stage during (March-April). Spacing should be made line to line 25-20 cm, plant to plant 15-20 cm and 2-3 seedlings per hill (Boro Dhaner Chash, BRRI, 2016).

However, farmers' knowledge on timely transplanting of seedlings as a strategy to minimize rice yield gap has not been measured so far, which requires further research.

2.5.7 Weed management

About 72.5% and 15% farmers controlled their weed by hand weeding method and weedicide application respectively (Sayed et al. 2015). Knowing the critical period for weed control (CPWC) is useful in making decisions on the need for and timing of weed control and in achieving efficient herbicide use from both biological and economic perspectives (Knezevic et al. 2002).

Weed problems are the result of permanent monocropping in rice. Rainfed rice is normally affected by species such as *Rottboellia cochinchinensis*, *Cynodon dactylon* and *Cyperus rotundus*, while other species prevail in flooding conditions. *Echinochloa, E. colona, Cynodon dactylon, Cyperus rotundus* are major weeds in Bangladesh (Labrada, 1996). Alchlor, Butachlor, Nutrofen and Oxidiazon are the most commonly used pre-emergence herbicide in Bangladesh. 2,4-Disopropyl Ester is the most commonly used post-emergence (30-40 DAT) herbicide in Bangladesh. Mulching reduce weed growth although substantially greater soil cover is required to suppress weeds (Naudin et al., 2011).

For Boro rice, land should be kept free from weeds up to 40-50 days after transplanting. Generally, 2 times weeding is done. 1st weeding is done 15 DAT and 2nd weeding is done 30-35 DAT. In case of dense weed population, 3rd weeding should be done 45-50 DAT. It is important to use Japanies Rice Weeder in 1st weeding when stagnant water is available and during 2nd weed operation manual weeding is effective (Uddin, et. al., 2009).

However, farmers' knowledge and extent of practice of recommended weeding as a strategy to minimize rice yield gap has not been measured so far, which requires further research.

2.5.8 Irrigation management

In an efficient system, each 1 kg of grain production requires a minimum of 2,000 liters of water (IRRI, 2015). Farmer's paid on an average 4800 Tk. per hectare for irrigation purpose (Sayed et al. 2015). A large gap exists between actual water needed for growing rice and that used by farmers (Bhuiyan et al. 1999). In 2008, the national irrigation coverage was 5.05 million ha, about 60% of total cultivable land, with groundwater covering 79% and surface water 21% (FAO, 2010). The precondition for growing high yielding varieties in boro season is proper water management. In favorable ecological areas, about 92% of the farmers use irrigation; of these, only 28% have own irrigation equipment, while 62% buy irrigation water (Hossain et al., 2013).

Instead of flood irrigation, alternate wet and dry (AWD) methods of irrigation can be used (Biswas, 2014). Intermittent irrigation of 3 day and 7 day intervals produced water savings of 55% and 74% compared to continuous flooding. Plant height and leaf area were greater in plants exposed to intermittent irrigation of 3 days intervals (Pascula et al. 2016).

However, extent of practice of recommended irrigation by the farmers as a strategy to minimize rice yield gap by the farmers has not been measured so far, which requires further research.

2.5.9 Disease management

Rice diseases always have a significant impact on rice productivity. In Bangladesh, a total of 32 rice diseases have been identified. Bacterial leaf blight, sheath blight, leaf blast, sheath blast, tungro, stem rot, brown spot, bakani are the major rice diseases in Bangladesh (Shelly, et al., 2016). Bacterial leaf blight and neck blast are chronic diseases both in T. Aman and Boro season in Bangladesh while severity of sheath blight has been higher in T. Aman season. Bacterial leaf streak has become an emerging disease in both T. Aman and Boro season. Tungro and Root knot diseases are serious threat to Aus rice cultivation in Bangladesh. BR 28 is being affected seriously with leaf or neck blast although it had been considered as moderately resistant to blast since

its release (BRRI 2015a). In case of fungal diseases i.e Brown spot, Blast, Stem root, Seed rot and Bakani seed treatment with Bevistin or Vitavax @ 0.4% of seed weight is recommended. In case of Bacterial disease i.e Bacterial leaf blight and Bacterial leaf streak seed treatment with Tilth 250 EC @ 1g/L of water or Homai @ 2.5-3g/kg is recommended. In case of viral disease i.e Tungro, Mosaic, Dwarf Diazinon @ 15 ml/10 L of water spray is recommended (BRRI 2015b). Late planting is also vulnerable to production of sclerotia (the resting stage of the pathogen), the inoculum source for next year's disease infection (Kabir et al., 2015).

However, extent of practice of recommended seed treatment and use of recommended fungicides by the farmers to avoid seed born diseases of rice has not measured yet, which requires further research.

2.5.10 Integrated pest management

Brown plant hopper, rice stem borer, green leaf hopper, white-backed plant hopper, rice gall midge, rice hispa and rice leaf folder are common insect pests of rice in Bangladesh (Alam, 2013, Nasiruddin and Roy, 2012, Fatema et al., 1999, Kamal et al., 1993, Alam, 1981, BRRI 1997, 2000, 2001, 2007, 2009). Weeds and pests are important biotic constraints reducing rice yield nearly 25% (C. Diaz et al. 1998). Crop rotations sometimes allow the inclusion of nitrogen fixing legumes and break pest and disease cycles of crops that are too frequently planted in the same field (Chikowo et al. 2004). The overuse of fertilizers led to high pest and disease infestations and resulted in even higher usage of pesticides (Hossain et al. 2006). A strong understanding of the population ecology of insect, rodent, and weed pests, and the behavior of rodents and insects is important to effectively manage them (Azucena et al. 2015). The traditional method leads to harvesting a little earlier makes the fields latter vulnerable to pests (Rahman, 2016). Dikes must be cleaned to remove grasses or weeds that harbor pests. Too much vegetative growth makes the crop more susceptible to late-season diseases and instability, which causes the plants to fall over called lodging (Chauhan et al. 2006).

Integrated pest management (IPM) plays significant role in reducing pest infestation in Bangladesh. Crop based pest model is invented. Invading new pests like Rice black beetle could evolve causing threat. Furthermore, some insects might change their biotype (e.g., BPH). Therefore, preventive measures by strengthening surveillance and

field monitoring system for pests (such as, using Light Trap and Yellow Sticky Trap) and environment friendly pest management options like perching, eco-engineering with pest and natural enemies, and establishment of Owl watching tower for rat control should be taken into account (Kabir et al., 2015).

Ghimire and Kafle (2014) conducted a study on IPM and its Adoption by the farmers in Nepal. The study revealed that about 53 percent of farmers were satisfied with the practice.

However, extent of practice of IPM as a strategy to minimize rice yield gap has not measured yet, which requires further research.

2.5.11 Harvesting threshing and storing

Early harvesting leads to many unfilled and immature grains. Late harvesting leads to heavy losses through shattering and bird attacks. Quality will also decrease due to grain weathering, resulting in breakage and downgrading due to undesirable grain color. Crop should be harvested when (i) 80-85% ripe grains grain are straw color; (ii) Grain moisture content ideally is between 20- 25% wet basis. A rule of thumb for seed is that the life of the seed will be halved for every 1% increase in moisture content or a 5°C increase in storage temperature above recommended levels (IRRI, 2015).

Traditionally people of Bangladesh use different types of local made tools for harvesting among them sickles are widely used for manual cutting. Maximun threshing are done by mechanically like paddle thresher, open drum thresher, close drum thresher as well as striking on hard surface. Paddy cleaning also done traditionally at grower's level but now a day's it is done by using power operated cleaner. There is huge scope to minimize postharvest losses by using modern technologies and mechanization. People's awareness on step wise post-harvest losses are increasing, various development activities are going on in this regard. Farmers are now adopting different techniques (Bari, 2015).

It has been reported that about 9% of paddy is lost due to use of old and outdated methods of drying and milling, improper and non-scientific methods of storage, transport and handling. It has been estimated that total post-harvest losses of paddy at producers' level was about 2.71% of total production. Losses in threshing and winnowing can be avoided by using better mechanical methods. Proper sanitation during drying, milling and after milling is required to avoid contamination of grains

and protect from insects, rodents and birds. To avoid storage losses maintaining optimum moisture content i.e. 12% for longer period and 14% for shorter storage period is essential (Patil, 2016). Rice can be stored in 3 ways i.e (i) bag storage; (ii) bulk storage and (iii) hermetic or sealed storage (IRRI, 2015).

However, extent of persuasion of post-harvest operations by the farmers as strategy to minimize rice yield gap has not been measured so far, which requires further research.

2.6 Review of Concerning Relationships of the Selected Characteristics of the Farmers with their Rice Yield Gap Minimizing Strategies Practiced

Rice yield gap minimizing strategy is a relatively new research concept. Therefore, no direct study regarding relationship between the selected characteristics of the farmers and their practice of rice yield gap minimizing strategies were found.

Hasan (2015) found that farmers age had significant and positive contribution to adoption of modern practices in rice cultivation. Talukder (2006) found that farmers age had significant and positive relationship with their adoption to selected rice production practices. Ahmed (2006) found that age had non-significant relationship with adoption to selected rice production technologies by the farmers.

Taluker (2006) found non-significant relationship between education and adoption of rice production practices of the farmers. Hasan (2015) found significant contribution of farmers education to adoption of modern practices in rice cultivation. Ahmed (2006) found positive significant relationship between farmers' education and adoption of selected rice production technologies.

Talukder (2006) found positive significant relationship between farm size and adoption of selected rice production practices. On the other hand, Hasan (2015) found non-significant contribution of farm size to adoption of modern practices in rice cultivation. Ahmed (2006) also found non-significant relationship between farm size and adoption of selected rice production technologies

Talukder (2006) and Ahmed (2006) found positive significant relationship between annual family income and farmers adoption of selected rice production practices and technologies. On the other hand, Hasan (2015) found no significant contribution of annual family income to adoption of modern practices in rice cultivation by the farmers.

Ahmed et al., (2009), found that cultivation of potato was more profitable than boro rice in view point of farmers. Haque et al., (2014), found rice seed production was not so profitable as investment in rice seed cultivation.

The yield gap of boro rice were 1.43 tn/ha and 1.06 tn/ha which were 24.24% and 22.41% of the potential yield at Rajapur and Meghdubi of Rangpur District respectively (Alam, 2006). Roy (1997) reported that yield gaps were found to 44.44% and 60.00% in aus and aman, respectively.

Ahmed (2006) found no significant relationship between training exposure and adoption of selected rice production technologies by the garo farmers. Hasan (2015) also found no significant contribution of training exposure to adoption of modern practices in rice cultivation by the farmers.

Talukder (2006) and Ahmed (2006) found significant positive relationship between extension contact and adoption of selected rice production practices and technologies by the farmers. Hasan (2015) also found significant contribution of extension contact to adoption of modern practices in rice cultivation by the farmers.

Hasan (2015) found no significant contribution of rice production knowledge to adoption of modern practices in rice cultivation by the farmers. On the other hand, Talukder (2006) and Ahmed (2006) found significant positive relationship between knowledge and adoption of selected rice production practices and technologies.

Talukder (2006) found significant positive relationship between problems and adoption of selected rice production practices by the farmers.

2.7 Research Gap

According to the review of literature of the present study the researcher has found the following research gaps:

i. Very few research on adaption of rice production practices by the farmers has so far been conducted and no research has so far been conducted to measure the rice yield gap minimizing strategies practiced by the farmers. Hence the researcher carried out the present study to determine the boro rice yield gap minimizing strategies practiced by the farmers.
ii. No research work has so far been conducted to measure farmers level of problem faced in practicing boro rice yield gap minimizing strategies and

extent of practices of selected strategies i.e. use of crop calendar, quality seed, seed treatment with recommended doses of fungicides, sowing seedling in optimum time, transplanting of seedling, maintain sowing distance, use of recommended weeding, recommended irrigation, recommended doses of fertilizer, use of IPM, harvesting during maturity index and following recommended steps of post-harvest operation by the farmers to minimize rice yield gap. The researcher carried out the study to explore the extent of practices of those strategies and level of problem faced by the famers in practicing those strategies to minimize rice yield gap.

iii. No research work has so far been carried out to explore the contributing relationship between each of the selected characteristics of the farmers with their practice of rice yield gap minimizing strategies. The researcher carried out the study to explore the contributing relationship between each of the selected characteristics of the farmers with their practice of boro rice yield gap minimizing strategies.

2.8 Conceptual Framework of the Study

Conceptual framework is the representation of the study variables. Properly constructed hypothesis of any research contains “dependent variable” and “independent variable”. In view of the theme of the study, the researcher constructed a conceptual framework which is self-explanatory and is presented in Figure 2.1.

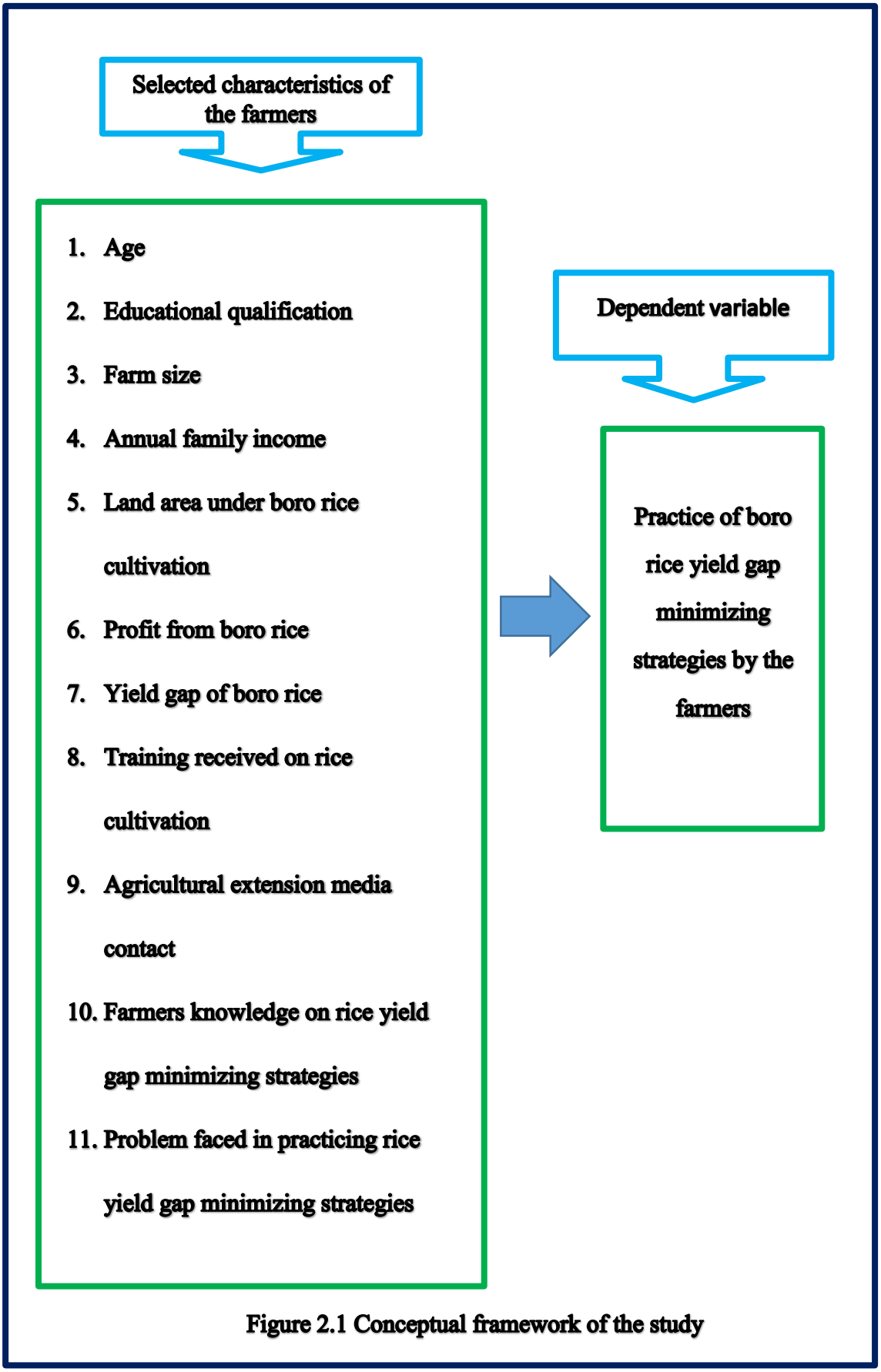

Figure 2.1 Conceptual framework of the study

CHAPTER 3

METHODOLOGY

Methods and procedures will be used for collection and analysis of data are very important in any scientific research. It requires a careful consideration before conducting a study. The researcher has great responsibilities to clearly describe as to what sorts of research design, methods and procedures he would follow in collecting valid and reliable data and to analyze and interpret those to arrive at correct conclusions. The methods and procedures will be followed in conducting this study have been discussed in this Chapter. Further, this Chapter includes the operational format and comparative reflection of some variables used in study. Statistical methods and their use have been mentioned in the later section of this Chapter.

3.1 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 village. A map of Dhamrai Upazila showing the study area presented below in figure 3.1.

Figure 3.1 A map of Dhamrai Upazila showing the study area

3.2 Population and Sampling

BR-29 rice variety cultivated by all farmers under study area were the population of the study. According to Yamane's (1967) formula, sample size was determined as 102. A reserve list of 10 farmers were prepared in case of their absence for 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

Z= the value of the standard normal variable at the chosen confidence level

P= the proportion or degree of variability

Proportionate random sampling technique were used to select sample from three villages of 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) were kept purposively if any respondents will be unavailable at the time of data collection. The distribution of population and sample will be shown in Table 3.1

Table 3.1 Distribution of the population and sample including reserve list

Study area (Villages)	Population size	Sample size	Reserve sample size
Bhararia	107	45	4
Chandra Para	41	18	2
Asulia	92	39	4
Total	240	102	10

3.3 Development of Data Collecting Instrument

In order to collect valid and reliable information an interview schedule was prepared. It was carefully designed keeping the objectives of the study in mind. Both open and closed form of question were used to collect information. Simple, direct question 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 using it for final data collection among 15 respondents of the study area. Reliability test was done. Necessary corrections, modifications and additions were made in the interview schedule on the basis of results of pre-test. The interview schedule was then printed in its final forms. Necessary photocopies were then made. A copy of the interview schedule in English version is furnished in Appendix-A.

3.4 Collection of Data

Before data collection, the researcher met with the Upazila Agriculture Officer (UEO), Agriculture Extension Officer (AEO) and Sub-Assistant Agriculture Officer (SAAO) of that blocks for necessary help and cooperation. Data was collected in-person by the researcher himself through face to face interview. Interview was conducted in respondent's farm and home during their leisure period. Before starting 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 felt difficulty in understanding any questions, the researcher took utmost care to explain and clarify the question.

3.5 Variables of the Study

In a 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 about the nature and scope of the variables involved in research studies. Ezekiel and Fox (1959) 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 that factor which is manipulated by the researcher in his attempt to ascertain its relationship to an observed phenomenon (Townsend, 1959). A

dependent variable is that factor which appears, disappears or varies as the experimenter introduces, removes or varies in the independent variables. The dependent variables are often called the criterion or predicted variable, whereas the independent variable is called the treatment, experimental and antecedent variables (Dalen, 1977). Variables are very important for social research on which the statistical analysis will be done by obtained score on these variables. These following eleven characteristics of the farmers were considered as independent variables of this study.

1. Age

2. Educational qualification

3. Farm size

4. Annual family income

5. Land area under boro rice cultivation

6. Profit from boro rice

7. Yield gap of boro rice

8. Training received on rice cultivation

9. Agricultural extension media contact

10. Farmers knowledge on rice yield gap minimizing strategies

11. Problem faced in practicing rice yield gap minimizing strategies

In this study, the dependent variable was “Practice of boro rice yield gap minimizing strategies by the farmers”.

3.6 Measurement of Independent Variables

Measurement of the selected characteristics of the farmers are discussed in the following subsection:

3.6.1 Age

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

3.6.2 Educational qualification

Level of education of a respondent was measured on the basis of classes passed in formal educational institution. For example, if a respondent passed upto 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.

3.6.3 Farm size

Farm size of a respondent was determined as the total area of his farm. It included as area of farm owned by him as well as those obtained from other by rented in, lease or other means. Farm size of the respondent was measured in hectors by using the following formula:

FS= A+B+1/2(C+D) +E

Where,

FS= Farm size

A= Homestead area including pond

B= Own land under own cultivation

C= Land given to others as borga

D= Land taken from others as borga

E= Land taken from others as lease

3.6.4 Annual family income

Annual family income referred as 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).

3.6.5 Land area under boro rice cultivation

Land area under boro rice cultivation of a respondent was measured by total land area of his farm under boro cultivation last year. Land area under boro rice cultivation of a respondent was measured in hectors.

3.6.6 Profit from boro rice

Profit from boro rice cultivation referred as 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 subtraction of annual expenditure of boro rice cultivation from income from boro rice cultivation.

3.6.7 Yield gap of boro rice

Yield gap of boro rice of a respondent was referred as the difference between the potential farm yield and the actual average farm yield (Uddin, 2009). It was measured in ton/hector.

3.6.8 Training received on rice cultivation

Training received by the respondent on rice cultivation was determined by total number of days of training received by the respondent from any organization on rice cultivation. If a respondent took 2 days training on any aspect of rice cultivation from any GOs, NGOs then his training received score would be 2.

3.6.9 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.

3.6.10 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.

3.6.11 Problem faced in practicing rice yield gap minimizing strategies

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.

3.7 Measurement of Dependent Variable

Measurement of the dependent variable is discussed in the following subsection.

3.7.1 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 were done on the basis of mean value of practicing of each of the 12 strategies by the respondents.

3.7.2 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.

3.8 Statement of the Hypothesis

According to Kerlinger (1973), a hypothesis is a conjectural statement of the relation between 2 or more variables. Hypothesis is always declarative sentence form and relate either generally of specifically variables to sentences form and relate either generally or specifically variables to variables. Hypothesis may be broadly divided into two categories, namely research hypothesis and null hypothesis.

3.8.1 Research hypothesis

To find out the relationship between the independent and dependent variables the researcher first formulated research hypothesis. The following research hypothesis were formulated to explore the relationship.

- 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 rice yield gap minimizing strategies and problems faced in practicing rice yield gap minimizing strategies) of the farmers has significant contributing factor with their practice of boro rice yield gap minimizing strategies.

3.8.2 Null hypothesis

A null hypothesis states that there is no relationship between the concerned variables. The following null hypotheses were formulated to explore the relationship.

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

3.9 Data Processing

3.9.1 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.

3.9.2 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 were transferred into a master sheet to facilitate tabulation and categorization.

3.9.3 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 have been discussed while describing the variables under consideration in Chapter 4.

3.9.4 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.

CHAPTER 4
RESULTS AND DISCUSSION

The findings of the study and interpretations of the results have been presented in this chapter. These are presented in four sub-sections according to the objectives of the study. The first sub-section deals with the selected characteristics of the farmers, while the second sub-section deals with the boro rice yield gap minimizing strategies practiced by the farmers, the third sub-section deals with the level of practice of the boro rice yield gap minimizing strategies and the fourth sub section deals with exploring the contributing relationship between the selected characteristics of the farmers and boro rice yield gap minimizing strategies practiced by them.

4.1 Selected Characteristics of the Farmers

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.

The salient features of the selected characteristics of the farmers are shown in the following table.

Table 4.1 Salient features of the selected characteristics of the farmers

Sl. No.	Characteristics	Unit of measurement	Possible range	Observed range	Mean	S. D.
1	Age	Year	Unknown	30-68	50.69	8.965
2	Educational qualification	Year of schooling	Unknown	0-14	4.539	2.944
3	Farm size	Hectare	Unknown	0.13-4.10	0.863	0.795
4	Annual family income	'000' Tk	Unknown	40-520	134.85	95.707
5	Land area under boro rice cultivation	Hectare	Unknown	0.12-3.6	0.733	0.646
6	Profit from boro rice	'000' Tk	Unknown	12-300	61.64	55.83
7	Yield gap of boro rice	Ton/ha	Unknown	2.46-3.72	3.364	0.308
8	Training received on rice cultivation	Number of days	Unknown	2-4	2.63	0.596
9	Agricultural extension media contact	Score	0-30	14-24	18.94	2.677
10	Knowledge on rice yield gap minimizing strategies	Score	0-24	14-22	17.15	2.279
11	Problem faced in practicing rice yield gap minimizing strategies	Score	0-40	14-21	17.85	1.643

4.1.1 Age

Age of the respondents were varied from 30 to 68 years with mean of 50.69 years and standard deviation of 8.965. Based on age, the farmers were classified into three categories namely “young aged”, “middle aged” and “old aged”. This distribution was supported by Hoque (2016) and Masud (2007) and shown in the Table 4.2.

Table 4.2 Distribution of the farmers according to their age

Categories	Farmers		Mean	SD
	Number	Percent		
Young aged (up to 35 year)	5	4.9	50.69	8.965
Middle aged (36 to 50 year)	44	43.14		
Old aged (> 50 year)	53	51.96		
Total	102	100		

Data contained in Table 4.2 indicate that an overwhelming majority (95.10%) of the farmers in the study area were middle to old aged. Ahmed (2006) found almost similar findings. It may due to middle to old aged people have more land ownership than young aged people.

4.1.2 Educational qualification

The educational qualification of the respondents varied from 0 to 14 with the mean of 4.54 and standard deviation of 2.94. Based on the level of education, farmers were classified into four categories namely “illiterate”, “primary”, “secondary” and “above secondary”. This distribution was supported by Hoque (2016) and Masud, (2007) and shown in the Table 4.3.

Table 4.3 Distribution of the farmers according to their educational qualification

Categories	Farmers		Mean	SD
	Number	Percent		
Illiterate (0)	22	21.6	4.54	2.94
Primary (1-5)	45	44.1		
Secondary (6-10)	31	30.4		
Higher secondary and above (>10)	4	3.9		
Total	102	100		

Data presented in the table 4.3 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. Ahmed (2006), Hasan (2015) 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.

4.1.3 Farm size

The farm size of the respondents in the study area varied from 0.13- 4.1 hectares with the mean of 0.862 ha and standard deviation of 0.795. Based on the farm size, the farmers were classified into three categories (according to DAE, 1999) namely "small farm size", "medium farm size" and "high farm size" as shown in Table 4.4.

Table 4.4 Distribution of the farmers according to their farm size

Categories	Farmers		Mean	SD
	Number	Percent		
Small farm (<1.0 ha)	72	70.59	0.8625	0.795
Medium farm (1- 3 ha)	22	21.26		
Large farm (> 3.0 ha)	8	7.84		
Total	102	100		

Data contained in Table 4.4 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 (.862 hectares) was higher than that of national average (0.60 hectare) of Bangladesh (BBS, 2014).

4.1.4 Annual family income

Annual family income of the respondents ranged from Tk. 40 to Tk. 520 thousand with the mean of Tk. 134.850 thousand and the standard deviation of 95.707. On the basis of the observed range of annual family income, the farmers were classified into three categories namely "low income", "medium income", and "high income" as shown in Table 4.5.

Table 4.5 Distribution of the farmers according to their annual family income

Categories	Farmers		Mean	SD
	Number	Percent		
Low income (up to 173)	76	74.5	134.850	95.707
Medium income (174-346)	20	19.6		
High income (>346)	6	5.88		
Total	102	100		

Data presented in Table 4.5 indicate that 74.5% 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.

4.1.5 Land area under boro rice cultivation

The land area under boro rice cultivation of the respondents varied from 0.12 to 3.60 hectares with the mean of 0.733 ha and the standard deviation of 0.646. Based on the land area under boro rice cultivation, the farmers were classified into three categories (Mean ± 0.5 SD) namely “small farmer”, “medium farmer” and “big farmer” as shown in Table 4.6.

Table 4.6 Distribution of the farmers according to their land area under boro rice cultivation

Categories	Farmers		Mean	SD
	Number	Percent		
Small boro farmer (up to 0.41ha)	42	41.17	0.733	0.646
Medium boro farmer (0.42-1.06 ha)	43	42.16		
Large boro farmer (>1.11 ha)	15	14.70		
Total	102	100		

Data presented in Table 4.6 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, winter vegetables cultivation.

4.1.6 Profit form boro rice

Profit from boro rice of the respondents varied from Tk. 12 to Tk. 300 thousand with the mean of Tk. 61.64 thousand and the standard deviation of 55.828. On the basis of observed range of profit, the farmers were classified into three categories (Mean ± 0.5 SD) namely "low profit", "medium profit", and "high profit" as shown on Table 4.7.

Table 4.7 Distribution of the farmers according to their profit from boro rice

Categories	Farmers		Mean	SD
	Number	Percent		
Low profit (upto 33)	36	35.29	61.64	55.828
Medium profit (34-95)	47	46.07		
High profit (>95)	19	18.62		
Total	102	100		

Data contained in table 4.7 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 due to high price of boro rice, availability of rice mills in the locale and good transport facilities with the capital.

4.1.7 Yield gap of boro rice

Yield gap of boro rice varied from 3.72 to 2.46 tn/ha with the mean of 3.364 tn/ha and standard deviation of 0.303. Based on yield gap farmers are classified into two categories (Mean ± SD) namely, "medium yield gap", "high yield gap", "very high yield gap" as shown in Table 4.8.

Table 4.8 Distribution of the farmers according to their yield gap of boro rice

Categories	Farmers		Mean	SD
	Number	Percent		
Medium yield gap (upto 3.05 tn/ha)	19	18.62	3.364	0.308
High yield gap (3.06-3.67 tn/ha)	77	75.49		
Very high yield gap (>3.67 tn/ha)	6	5.88		
Total	102	100		

Data presented in the table 4.8 revealed that an overwhelming majority (75.49%) of the farmers had high yield gap and 18.62 % of the farmers had medium yield gap and 5.88% of the farm. High yield gap exists in the locale, which may due to famers lack of knowledge, education, and low practices of rice yield gap minimizing strategies.

4.1.8 Training received on rice cultivation

Training received by the respondents on rice cultivation varied from 1 to 4 with an average of 2.63 and standard deviation of 0.596. Based on training received the farmers are classified into three categories (Mean ± SD) namely “low training received”, “medium training received”, high training received” as shown in Table 4.9.

Table 4.9 Distribution of the farmers according to training received on rice cultivation

Categories	Farmers		Mean	SD
	Number	Percent		
Low training received (up to 2 days)	44	43.1	2.63	0.596
Medium training received (3days)	52	51.0		
High training received (4 days)	6	5.9		
Total	102	100		

Data contained in the table 4.9 indicate that 43.1% of the farmers had low training exposure, 51.0% had medium training exposure and 5.9% had high training exposure on rice cultivation. Hasan (2015) found the similar findings. 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.

4.1.9 Agricultural extension media contact

The extension media contact of the respondents varied from 14 to 24 against the possible range of 0 to 30 with the mean of 18.94 and standard deviation of 2.677. Based on extension media contact the farmers were classified into three categories (Mean ± SD) namely "low contact", "medium contact", "high contact" as shown in Table 4.10.

Table 4.10 Distribution of farmers according to their agricultural extension media contact

Categories	Farmers		Mean	SD
	Number	Percent		
Low contact (up to 16)	24	23.53	18.94	2.677
Medium contact (17-22)	70	68.63		
High contact (23-30)	8	7.84		
Total	102	100		

Data presented in the table 4.10 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. Hasan (2015) found almost similar findings. Extension contact of the respondents varied, which may 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.

4.1.10 Knowledge on rice yield gap minimizing strategies

The observed knowledge of the respondents varied from 12 to 22 against the possible range of 0 to 24 with the mean of 17.15 and standard deviation of 2.279. Based on knowledge farmers are classified into 3 categories (Mean ± SD) namely "poor knowledge", "moderate knowledge", "good knowledge" as shown in the table 4.10.

Table 4.11 Distribution of the farmers according to their knowledge on rice yield gap minimizing strategies

Categories	Farmers		Mean	SD
	Number	Percent		
Poor knowledge (up to15)	31	30.4	17.15	2.279
Moderate knowledge (16-19)	50	49		
Good knowledge (20-24)	21	20.6		
Total	102	100		

Data contained in Table 4.11 reveal that 30.4% of the farmers had poor knowledge, 49% had moderate knowledge and 20.6% had good knowledge on rice yield gap minimizing strategies. Talukder (2006), Hasan (2015) found almost similar findings. Lack of education, agricultural extension media contact and training exposure to rice cultivation may the reason behind this.

4.1.11 Problem faced in practicing rice yield gap minimizing strategies

Problem faced by the respondents varied from 12 to 21 against the possible range of 40 with the mean of 17.85 and standard deviation of 1.643. Based on the problem faced farmers are classified into three categories (Mean ± SD) namely, “low problem”, medium problem” and high problem” as shown in the table 4.12

Table 4.12 Distribution of the farmers according to their problem faced in practicing rice yield gap minimizing strategies

Categories	Farmers		Mean	SD
	Number	Percent		
Low problem (up to16)	21	20.6	17.85	1.643
Medium problem (17-19)	56	54.9		
High problem (20-21)	25	24.5		
Total	102	100		

Data presented in the table 4.12 reveal that an overwhelming majority (79.4%) of the farmers faced medium to high problem and 20.6% of the farmers faced low problem in practicing rice yield gap minimizing strategies. Talukdar (2006) found almost similar findings. 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 the them.

4.2 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 the Table 4.13.

Data presented in the Table 4.14 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 happen 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 occur 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 the 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.

Table 4.13 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	.254	2
Use of IPM	3.89	.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	.541	4
Use of recommended irrigation (AWD, 7-10cm transplanting to maximum tillering stage, from 40 DAT 12-15 cm up to late tiller production)	3.49	.502	5
Use of recommended weeding (15 DAT, 30/35 DAT and 45/50 DAT)	3.2	.423	6
Use of recommended doses of fertilizer (Urea-40kg, TSP-13kg, MoP-22kg, Zipsum-15kg, $ZnSO_4$-1.5kg/ Bigha in 3 installment)	1.36	.842	7
Seed treatment with recommended fungicides (For funagal disease Agrosan, Bavistin, Vitavax 200, Homai 0.4% seed weight; Hot water treatment 54^{o}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	.978	9
Use of crop calendar	0	0	10

Use of recommended irrigation (AWD, 7-10cm 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-40kg, TSP-13kg, MoP-22kg, Zipsum-15kg, $ZnSO_4$-1.5kg/ 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^{o}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.

4.3 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 the figure 4.14.

Table 4.14 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 the table 4.13 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.

4.4 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 the Table 4.15.

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 4.15 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	F	p
Boro rice yield gap minimizing strategies practiced by the farmers	Age	.086	.031*	.838	.825	68.861	.000**
	Educational qualification	.217	.001**				
	Farm size	-.320	.133				
	Annual family income	.118	.341				
	Land area under boro rice cultivation	.357	.190				
	Profit from boro rice cultivation	-.082	.592				
	Yield gap of boro rice	-.588	.000**				
	Training received on rice cultivation	.104	.017*				
	Agricultural extension media contact	.121	.048*				
	Knowledge on rice yield gap minimizing strategies	-.096	.191				
	Problem faced in practicing rice yield gap minimizing strategies	-.120	.044*				

** Significant at $p < 0.01$

* Significant at $p < 0.00$

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 =.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 .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 4.15 it was observed that farmers age, educational qualification, yield gap of boro rice, training received on rice production, agricultural extension media 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 problem faced in practicing rice yield gap minimizing strategies had also significant contributing factor at (p<0.05) 5% level of significance on boro rice yield gap minimizing strategies practiced by the farmers.

In summary, the model suggest 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 problem 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 4.15 revealed that, farmers age had positive influence on their practice of boro rice yield gap minimizing strategies. Data also showed that farmers age had 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 4.15 showed that, farmers educational qualification had positive influence on their practice of boro rice yield gap minimizing strategies. Farmers educational qualification had 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 advance strategies to minimize rice yield gap.

Data revealed from Table 4.15 showed that, yield gap of boro rice had negative influence on farmers practice of boro rice yield gap minimizing strategies. Data also showed that yield gap of boro rice had 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 4.15 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 4.15 showed that, agricultural extension media contact had positive influence on farmers practice of boro rice yield gap minimizing strategies. Agricultural extension media contact had 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 4.15 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.

CHAPTER 5

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

Findings of different aspects of the study are summarized below:

5.1.1 Selected characteristics of the farmers

5.1.1.1 Age

Age of the farmers varied from 30 to 68 years. The mean was 50.69 years and standard deviation was 8.965. Highest proposition 51.7% of the farmers in the study area were in old age, 43.13% of the farmers were middle aged and 4.9% of the farmers were young aged category.

5.1.1.2 Educational qualification

The educational qualification of the respondents varied from 0 to 14. The mean was 4.54 and the standard deviation was 2.94. Highest proportion 44.1% of the farmers had primary level education, 30.4% of the farmers had secondary level of education, 21.6% of the farmers were illiterate and 3.9% of the farmers had higher secondary and above level of education.

5.1.1.3 Farm size

The farm size of the respondents varied from 0.13- 4.1 hectares. The mean was 0.8625 ha and the standard deviation was 0.795. Highest proportion 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.

5.1.1.4 Annual family income

Annual family income of the respondents ranged from Tk. 40 thousand to Tk. 520 thousand. The mean was Tk. 134.850 thousand and the standard deviation was 95.707. Highest proportion 74.5% of the farmers had low annual family income, 19.69% of the farmers had medium annual family income and 5.88% of the farmers had high annual family income.

5.1.1.5 Land area under boro rice cultivation

The land area under boro rice cultivation of the respondents varied from 0.12 to 3.60 hectares. The mean was 0.7013 ha and the standard deviation was 0.5857. Highest proportion 42.16 % of the farmers in the study area were medium boro farmer, 41.17 % were small boro farmer and 14.70 % were big boro farmer.

5.1.1.6 Profit from boro rice

Profit from boro rice of the respondents varied from Tk. 12 to Tk. 350 thousand. The mean was Tk. 61.64 thousand and the standard deviation of 55.828. Highest proportion 46.07% of the farmers had medium profit, 35.29% of the farmers had low profit, and 18.62% of the farmers had high profit.

5.1.1.7 Yield gap of boro rice

Yield gap of boro rice of the respondents varied from 3.72 to 2.46 tn/ha. The mean was 3.364 tn/ha and standard deviation was 0.308. Highest proportion 75.49% of the farmers had high yield gap, 18.62% of the farmers had medium yield gap and 5.88% had very high yield gap.

5.1.1.8 Training received on rice cultivation

Training received by the respondents on rice cultivation varied from 1 to 4. The mean was 2.63 and standard deviation was 0.596. Highest proportion 51.0% of the farmers had medium training exposure, 43.1% had low training exposure and 5.9% had high training exposure.

5.1.1.9 Agricultural extension media contact

Agricultural extension media contact of the respondents varied from 14 to 24 against the possible range of 0 to 30. The mean was 18.94 and standard deviation was 2.677. Highest proportion 68.63% of the farmers had medium extension media contact, 23.53% had low extension media contact and 7.84% had high extension media contact.

5.1.1.10 Knowledge on rice yield gap minimizing strategies

The observed knowledge of the respondents varied from 14 to 22 against the possible range of 0 to 24. The mean was 17.15 and standard deviation was 2.279. Highest

proportion 49% of the farmers had medium knowledge 30.4% had poor knowledge and 20.6% had high knowledge on rice yield gap minimization.

5.1.1.11 Problem faced in practicing rice yield gap minimizing strategies

Problem faced by the respondents varied from 14 to 21 against the possible range of 40. The mean was 17.85 and standard deviation was 1.643. Highest proportion 54.9% of the farmers faced medium problem, 20.6% faced low problem and 24.5% faced high problem in rice production.

5.1.2. Boro rice yield gap minimizing strategies practiced by the farmers

Farmers score on sowing seedling within mid-December to mid-January, transplanting 35-45 days old seedling, maintaining sowing distance (20-25×15-20 cm) was 4 and ranked 1st with mean 4.0 and no deviation was found there.

Farmers score on harvesting during maturity index (80% panicles have about 80% ripened spikelets) varied from 3-4 and ranked 2nd with the mean of 3.93 and SD of 0.254.

Farmers score on use of IPM varied from 3-4 and ranked 3rd with the mean of 3.89 and SD of 0.312.

Farmers score on 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) varied from 2-4 and ranked 4th with the mean of 3.64 and SD of 0.541.

Farmers score on use of recommended irrigation (AWD, 7-10cm transplanting to maximum tillering stage, from 40 DAT 12-15 cm up to late tiller production) varied from 3-4 and ranked 5th with the mean of 3.49 and SD of 0.502.

Farmers score on use of recommended weeding (15 DAT, 30/35 DAT and 45/50 DAT) varied from 2-4 and ranked 6th with the mean of 3.2 and SD of 0.423.

Farmers score on use of recommended doses of fertilizer (Urea-40kg, TSP-13kg, MoP-22kg, Zipsum-15kg, $ZnSO_4$-1.5kg/ Bigha in 3 installment) varied from 0-4 and ranked 7th with the mean of 1.36 and SD of 0.842.

Farmers score on seed treatment with recommended fungicides (For funagal disease Agrosan, Bavistin, Vitavax 200, Homai 0.4% seed weight; Hot water treatment 54^{o}c for 15 min, Agrimycin 0.025% 12 hour before sowing for bacterial disease) varied from 0-4 and ranked 8th with mean 1.13 and SD 1.04.

Farmers score on use of quality seed (TLS/ registered/ certified/ foundation seed) varied from 0-3 and ranked 9th with the mean of 1.12 and SD of 0.978.

Farmers score on use of crop calendar ranked 10th with mean 0 and SD 0.

5.1.3 Extent of practice of boro rice yield gap minimizing strategies

Score on rice yield gap minimizing strategies practiced by the farmers varied from 28 to 42 against the possible range of 0 - 48. The mean was 33.85 and the standard deviation was 3.253. Highest proportion 60.78% of the farmers practiced medium strategies, 29.41% of the farmers practiced minimum strategies and 9.8% of the farmers practiced maximum strategies.

5.1.4 Significant factors on practice of boro rice yield gap minimizing strategies

Farmers age had positive influence on their practice of boro rice yield gap minimizing strategies. It had significant contributing factor ($p<0.05$) on farmers practice of boro rice yield gap minimizing strategies.

Educational qualification of the farmers had positive influence on their practice of boro rice yield gap minimizing strategies. It had most significant ($p<0.01$) contributing factor on farmers practice of boro rice yield gap minimizing strategies.

Yield gap of boro rice had negative influence on farmers practice of boro rice yield gap minimizing strategies. It had most significant ($p<0.01$) contributing factor on farmers practice of boro rice yield gap minimizing strategies.

Training received on rice cultivation had positive influence on farmers practice of boro rice yield gap minimizing strategies. It had significant ($p<0.05$) contributing factor on farmers practice of boro rice yield gap minimizing strategies.

Agricultural extension media contact had positive influence on farmers practice of boro rice yield gap minimizing strategies. Agricultural extension media contact had significant ($p<0.05$) contributing factor on farmers practice of boro rice yield gap minimizing strategies.

Problem faced by the farmers in practicing rice yield gap minimizing strategies had negative influence on farmers practice of boro 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.

5.2 Conclusions

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

i. Age of the farmers had significant contributing factor on boro rice yield gap minimizing strategies practiced by them. So it could be concluded that farmers age played important role on their practice of boro rice yield gap minimizing strategies.

ii. Educational qualification of the farmers had most significant contributing factor on their practice of boro rice yield gap minimizing strategies. So it could be concluded that education increased knowledge and ability of farmers to understand and response to advance agricultural practices which drove them to adopt advance strategies to minimize rice yield gap.

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

iv. Training received on rice cultivation had significant contributing factor on farmers practice of boro rice yield gap minimizing strategies. It can be concluded that participation in different rice cultivation training increased knowledge and skill of the farmers which aware them to adopt different boro rice yield gap minimizing strategies to get higher yield.

v. Agricultural extension media contact had significant contributing factor on farmers practice of boro rice yield gap minimizing strategies. It can be concluded that agricultural extension media contact provided up to date information to the farmers which assisted them to minimize rice yield gap.

vi. Problem faced in practicing boro rice yield gap minimizing strategies had negative influence and significant contributing factor on farmers practice of boro rice yield gap minimizing strategies. It can be concluded that farmers facing less problem in rice production got higher yield than the farmers facing more problem in rice production.

5.3 Recommendations

On the basis of the findings of the study some recommendations are presented below. Recommendations are divided into two groups- (a) recommendations for policy implications and (b) recommendations for further research.

5.3.1 Recommendations for policy implications

i. Farmers practiced strategies which were very common and cheap. 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 low and medium level of knowledge on rice yield gap minimizing strategies and practiced minimum and medium level of strategies. Adequate technical support, training and other instructional activities should be undertaken and continued in order to make them capable of practicing maximum level of strategies.

iii. Education is important for practicing rice yield gap minimizing strategies. 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 yield gap.

iv. Farmers mostly want to get proper suggestions about rice yield gap minimizing strategies and early forecasting about pests and disease. 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 advance communication channels.

v. Agricultural extension media contact increases farmers diversified knowledge and make them able to cope with adverse situations. So, policies should be taken

to engage farmers with diversified extension media to broaden their outlook and to develop positive attitude on adopting yield gap minimizing strategies. GOs and NGOs can also play a vital role in this regard.

5.3.2 Recommendations for further research

i. This study investigated the contribution of eleven selected characteristics of the farmers with their practice of boro rice yield gap minimizing strategies. It is recommended that further study should be conducted with other characteristics of the farmers and other dependent variables.

ii. Researcher did not find significant contributing factor of farm size, annual family income, land area under boro rice cultivation, profit from boro rice and knowledge on rice yield gap minimizing strategies with the dependent variable. In this regard further study may be conducted to justify the contribution of the variables in practicing rice yield gap minimizing strategies.

iii. Similar studies can be conducted in other high yield gap areas of the country which will be helpful for effective policy implementation.

iv. In this study, only boro rice yield gap minimizing strategies aspects were considered. Other major rice, crops like wheat, maize, sugarcane, potato, jute etc. can be considered and research can be conducted.

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APPENDIX-A

(English version of the interview schedule)

Department of Agricultural Extension and Information System

Sher-E-Bangla Agricultural University

Dhaka-1207

An interview schedule for a research study entitled

Rice Yield Gap Minimizing Strategies Practiced by the BR 29 Rice Farmers of Dhamrai Upazila Under Dhaka District

Sl. No. …….

Name of the respondent:

Village: Union:

Upazila: District:

Mobile number:

(Please answer the following questions)

1. Age

How old are you? ……Years

2. Educational qualification

a) Illiterate (……)

b) I read up to class……

c) I took non-formal education and it is equivalent to…….

3. Farm size

Please furnish information about your firm size:

Sl. No.	Land type	Area	
		Local unit(Decimal)	Hectare
1.	Homestead area including pond (A)		
2.	Own land under own cultivation (B)		
3.	Land given to others as borga (C)		
4.	Land taken from others as borga (D)		
5.	Land taken from others as lease (E)		
Total= A+B+1/2(C+D)+E			

4. Annual family income

Please state the income from different sources during the last year:

Sl. No.	Sources of income	Total price (Tk)
A. On farm income		
1	Agriculture	
2	Fisheries	
3	Livestock	
B. Off farm income		
1	Business	
2	Services	
3	Daily labour	
4	Remittance	
5	Others (if any)	
Total= (A+B)		

Total annual income = A+B =……Tk

5. Land area under boro rice cultivation

Please indicate your land area under boro rice cultivation……bigha i.e…….....hectare.

6. Profit from boro rice

a) Yearly expenditure for boro rice cultivation …… tk.

b) Yearly income from boro rice cultivation …… tk.

c) Yearly net profit/loss from rice cultivation (a ± b)…… tk

7. Yield gap of boro rice (BR 29)

Potential yield - Obtained yield= …….. tn/ha.

(Potential yield= 7.5 tn/ha. Obtained yield=……. maund/bigha i.e ……. tn/ha)

8. Training received on rice production

Have you received any training on rice production? Yes (……) No (……)

If yes, please give the following information:

Sl. No.	Name of training course	Duration of training (Days)	Training provider
1			
2			
3			
4			
5			
Total			

9. Agricultural extension media contact

Please indicate the nature of your contact to the following media:

Sl. No.	Communication media	Extent of Communication			
		Regularly (3)	**Occasionally (2)**	**Rarely (1)**	**Not at all (0)**
Personal Contact					
1	Meet with SAAOs (per 3 months)	≥6 ( )	3-5 ( )	1-2 ( )	0 ( )
2.	Meet with Agriculture Extension Officer (per year)	≥6 ( )	3-5 ( )	1-2 ( )	0 ( )
3.	Meet with contact growers (per 3 months)	≥6 ( )	3-5 ( )	1-2 ( )	0 ( )
4.	Meet with ideal farmers (per 3 months)	≥6 ( )	3-5 ( )	1-2 ( )	0 ( )
Group Contact					
1	Participation in focused group discussion (FGD) program (per year)	3 ( )	2 ( )	1 ( )	0 ( )
2.	Participation in agricultural result demonstration program (per year)	3 ( )	2 ( )	1 ( )	0 ( )
3.	Participation in farmers field day (per year)	3 ( )	2 ( )	1 ( )	0 ( )
Mass Media Contact					
1.	Listening agricultural program on Radio (per month)	≥4 ( )	2-3 ( )	1 ( )	0 ( )
2.	Watching agricultural program on Television (per month)	≥4 ( )	2-3 ( )	1 ( )	0 ( )
3.	Reading agricultural features from printed media (daily newspaper, leaflet, booklet, magazine etc.)	( )	( )	( )	( )
Total=(A+B+C)					

10. Farmers knowledge on rice yield gap minimizing strategies

Please answer the following questions:

Sl. No.	Questions	Assigned Score	Obtained Score
1.	What is rice crop calendar?	2	
2.	Name 4 HYVs of boro rice.	2	
3.	Mention 2 major seed treating techniques.	2	
4.	Mention 2 special land preparation techniques that helps to minimize rice yield gap?	2	
5.	What are the impact of early and delay sowing?	2	
6.	Mention 2 optimum period of weeding operation to minimize rice yield gap (15 DAT, 30/35 DAT and 45/50 DAT).	2	
7.	Mention fertilizer doses of boro rice (Urea 35-40kg, TSP 12kg, MoP 20kg, Gypsum 15kg, Zink 1.5kg/ Bigha)	2	
8.	What do you know about AWD and flood irrigation method?	2	
9.	Mention 2 major pests of rice and their control measures.	2	
10.	Mention 2 major diseases of rice and their control measures.	2	
11.	Mention maturity index for harvesting rice.	2	
12.	Mention 4 major post-harvest activities to store rice grain properly.	2	
Total		24	

11. Problems faced in practicing rice yield gap minimizing strategies

Please mention the extent of problems related to rice yield gap minimization:

Sl. No.	Problems	Extent of problem				
		Very High (4)	High (3)	Medium (2)	Low (1)	Not at all (0)
1	Lack of quality seed	( )	( )	( )	( )	( )
2	Lack of tillage implements (tractor/ power tiller)	( )	( )	( )	( )	( )
3	Delay planting due to adverse climate	( )	( )	( )	( )	( )
4	High cost of inputs (seed, fertilizer and pesticides)	( )	( )	( )	( )	( )
5	Labor shortage (during land preparation, weeding, and harvesting)	( )	( )	( )	( )	( )
6	Scarcity of irrigation (during critical stages of crop growth)	( )	( )	( )	( )	( )
7	Severe pests outbreak	( )	( )	( )	( )	( )
8	Severe disease infestation	( )	( )	( )	( )	( )
9	Crop damage due to adverse climate	( )	( )	( )	( )	( )
10	Lack of equipment for harvesting, drying, threshing and storing	( )	( )	( )	( )	( )
Total						

12. Boro rice yield gap minimizing strategies practiced by the farmers

Please response to the following rice yield gap minimizing strategies:

Sl. No.	Yield gap minimizing strategies	Extent of response				
		Regularly (4)	Often (3)	Occasionally (2)	Rarely (1)	Not at all (0)
1	Use of crop calendar	( )	( )	( )	( )	( )
2	Use of quality seed (TLS/registered/certified/ foundation seed)	( )	( )	( )	( )	( )

3	Seed treatment and use of recommended fungicides (Funagal disease- Agrosan, Bavistin, Vitavax 200, Homai 0.4% seed weight; Hot water treatment 54^{o}c for 15 min, Agrimycin 0.025% 12 hour before sowing for bacterial disease)	( )	( )	( )	( )	( )
4	Sowing seedling within mid-December to mid-January	( )	( )	( )	( )	( )
5	Transplanting 35-45 days old seedling	( )	( )	( )	( )	( )
6	Maintaining sowing distance (20-25×15-20 cm)	( )	( )	( )	( )	( )
7	Use of recommended weeding (15 DAT, 30/35 DAT and 45/50 DAT)	( )	( )	( )	( )	( )
8	Use of recommended irrigation (AWD/ 7-10cm transplanting to maximum tillering stage, from 40 DAT 12-15 cm up to late tiller production)	( )	( )	( )	( )	( )
9	Use of recommended doses of fertilizer (Urea-40kg, TSP-13kg, MoP-22kg, Zipsum-15kg, $ZnSO_4$-1.5kg/ Bigha in 3 installment)	( )	( )	( )	( )	( )
10	Use of IPM	( )	( )	( )	( )	( )
11	Harvesting during maturity index (80% panicles have about 80% ripened spikelets)	( )	( )	( )	( )	( )
12	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)	( )	( )	( )	( )	( )
Total						

Thank you for your nice cooperation.

…….

Date and Signature

of the interviewer