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Note from Editorial Board

Bangladesh agriculture has achieved remarkable progress during the last decade towards self-sufficiency in food grain production. About 50 percent of Bangladesh's population is primarily employed in agriculture, with more than 70 percent of its land dedicated to growing crops. Despite agriculture contributing to such a large percentage of Bangladesh's overall economy, it has remained largely subsistence based, with uncertain crop yields and inefficient infrastructure limiting the ability of farmers to fully commercialize their production.

Bangladesh is one of the promising countries towards attaining SDGs on action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. As part of the UN Development System, United Nations Development Programme (UNDP) has put in place four dedicated streams of work to support Bangladesh in their efforts to coordination, localization, design policy, plans and programmes for the sustainable future, access and generate finance, source and analyze data, and drive innovation and learning-supporting in integrating 17 SDGs.

In this context, the current volume of the journal is published. This volume of the Farm Economy contains the papers reviewed by the selected reviewers. The contributions from the learned authors of the articles included in this volume are highly acknowledged. This is the first regular issue of its kind. Become all the previous 16 issues of Farm Economy were published with the conference/seminar papers of the Bangladesh Agricultural Economists Association. The contributions from the members of the Editorial Board and the reviewers of the articles are also gratefully acknowledged for their scholastic efforts in finalizing the manuscript. Despite utmost efforts there may have some errors and omissions for which the editorial board bears the full responsibility.

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Rezoyana Kabir Rasha[1], Ripon Kumar Mandal[2] and Mohammad Mizanul Haque Kazal[3*]

Abstract

One of the most effective development strategies for improving child nutrition is women's empowerment. The key purpose of the present study is to investigate the effect of women's empowerment on child nutrition in Bangladesh. The data have been generated from the Bangladesh Integrated Household Survey (BIHS), 2015 that was published by the International Food Policy Research Institute (IFPRI). The analysis included a total of 3275 observations. Primarily, the method of ordinary least squares (OLS) is applied to assess the impact of women's empowerment on child nutrition. However, due to the limitations of the OLS, this relationship is estimated by using the instrumental variable regression. The data demonstrate that the child's height-for-age-z and weight-for-age-z scores are significantly and positively affected by the age of the household head, aggregate women empowerment score, gender parity gap, and food consumption score. As a result, it is apparent that as women's empowerment rises the nutritional status of their children also increases.

Keywords: Child nutrition, 5DS, Instrumental Variable, Endogeneity, Empowerment.

1. Introduction

Malnutrition among children is one of the major obstacles for poor peoples which also hindrance for economic development in Bangladesh. According to BER (2021), the child is mortality rate in Bangladesh is 21 (per 1000 live birth). Malnutrition in children is caused mostly by illness, a lack of care, a lack of enough healthy food, a lack of awareness and education among mothers, a lack of women's empowerment, and so on (Hossain, 2020; Melesse, 2021). Melesse (2021) revealed that women's knowledge and education on food security decline in child malnutrition. Therefore, women's empowerment increases their care for their children's nutrition, gives them the strength and authority to make effective decisions about their children's upbringing, and provides solid a grasp of their

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1. Introduction

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children's health and safety (Anwar *et al.*, 2013; Debnath and Bhattacharjee, 2016; Holland and Rammohan, 2019).

Women's empowerment is a continual development approach that enhances the inner power of women to become economically solvent, participate in many social organisations, speak in front of others, and acquire the power, energy, and voice to advocate for their rights (Anwar *et al*., 2013; Malapit and Quisumbing, 2015; Onah, 2021). Bhagowalia et al. (2010) found that a higher level of women's empowerment is associated with the greater long-term nutritional status of the children. Similarly, Malapit *et al.* (2015a) reported that women's empowerment had a positive impact on maternal and child nutrition. As a corollary, the evidence suggests that women's empowerment has a significant effect on child nutrition and maternal health.

Women make a substantial contribution to agricultural output, domestic tasks, and the care of their families and children (Bhagowalia *et al.*, 2010; Debnath and Bhattacharjee, 2016; Hossain, 2020). Malapit et al. (2015a) reported that women's participation in the workforce is increasing day by day in Bangladesh. According to Alkire *et al.* (2013), all five dimensions of women empowerment along with the ten indicators make women powerful and improve household food security. Likewise, Essilfie *et al.* (2020b), evaluated that women empowerment is positively aligned with child nutrition. Thus, the empowerment of women influences child nutrition. Finally, it appears that women's contributions to reducing household and child food security cannot be overlooked. Thus, it is essential to identify the impact of women empowerment on child nutrition and their growth.

The literature shows that women's empowerment has an impact on their children's nutritional status [z-score] (Bhagowalia *et al.*, 2010; Debnath and Bhattacharjee, 2016; Hossain, 2020; Melesse, 2021; Essilfie *et al.*, 2020b). Several studies have been undertaken by various researchers in various parts of the globe to examine the impact of women's empowerment on child nutrition. This impact can be positive or negative. The mechanism behind this positive or negative impact is the crucial factor that influence the growth of children. Still there is lack of studies that focuses on the impact of women empowerment on child in Bangladesh. As a result, it's crucial to investigate the impact of women's empowerment on child nutrition in Bangladesh using a large sample that is a representative of the population. Thus, the present study investigated on this ground and identified the impact of women empowerment on child nutrition. Finding the causal association between women's empowerment and children's height-for-age-Z score (stunting) and weight-for-age-Z score (wasting) seemed to be fascinating.

However, there are a bunch of factors that can influence women's empowerment (Malapit *et al.*, 2015b; Hossain 2020). These factors are the prime source of women empowerment that can strongly influence the empowerment of women

(Malapit *et al.,* 2015b). As the women are more empowered, the higher would their child nutrition (Hossain 2020). Therefore, these are the indicators of women's empowerment (Alkire et al., 2013; Holland and Rammohan, 2019). These indicators are originating from production, income, asset ownership, leadership, and time allocation dimensions of women empowerment (Melesse, 2021). There are ten indicators of women empowerment which combinedly forms the aggregate women empowerment score (Alkire *et al.,* 2013). Thus, it is essential to identify the impact of aggregate women empowerment score on child nutrition in Bangladesh. Different studies have been conducted in Bangladesh to identify the impact of women's empowerment on child nutrition (Hossain, 2020; Malapit *et al.,* 2015b). But still, there is a lack of studies on identifying the influence of women empowerment on child nutritional status by considering all the indicators of women empowerment. Thus, the present study focused to identify how the empowerment of women affects their child nutrition in Bangladesh. Consequently, the study assessed the effect of aggregate women empowerment score on child nutritional status (haz and waz scores) in Bangladesh. Finally, some policy recommendations were suggested based on the findings.

2. Methodology

Sources and Management of Data: The study's data is obtained from the Bangladesh Integrated Household Survey (BIHS), which was conducted by the International Food Policy Research Institute (IFPRI) applying the multistage random sample technique and published this harmonized dataset in 2015. The dataset includes data from households and communities, as well as information on farm production activities and the women empowerment index. The data is collected from the 7 divisions considering 64 districts of Bangladesh that represents 325 primary sampling unit. The dataset is being used as a pooled-cross section data that represented information from the same household in 2011 and 2015. A total of 3275 observations are included in the study after sorting and management of data. The missing values and blank observations are deleted from the dataset to ensure smooth analysis. Statistical software STATA is used to examine, sort, manage, and analyse the data.

Data Description: Height, weight, body mass index, height according to age, and weight according to age are some of the metrics that represent a child's optimal nutritional development (Debela *et al.,* 2020; Essilfie *et al.,* 2020b). Considering these parameters height for-age and weight for-age z-scores are taken as the key-dependent variable of the study. Child stunting and wasting, which are defined as haz and waz scores followed by Essilfie *et al.* (2020b) are analogous unique indicators. Different household-level variables, such as the household head's gender, age, education, and literacy, are also used as explanatory variables. Furthermore, the aggregate women empowerment score is regarded as an endogenous variable with

direct implications for infant nutrition. Various indicators of women's empowerment are also deployed as an instrument. Among different indicators of empowerment, ownership of an asset by the women, women's power to speak in front of the public, and women's authority over the use of their income are used as the instrument in model 1 and model 2 respectively. Table 1 shows the detailed definitions and descriptions of all the variables used in the research.

Table 1. Description of all the variables used in the study

Name of the Variables	**Variables definition and description**
Dependent variables/ Outcome variables	
Haz-score	Height-for-age-Z-Score of the children in the household
Waz-score	Weight-for-age-Z-Score of the children in the household
Explanatory variables	
Gender of the household head	If the gender of the household head is male = 1, otherwise = 0
Age of the household head	Age of the household head in years
Education of the household head (in years)	If the household head completed Pre-school = 1, class 5 = 5, S.S.C = 10, H.S.C or Diploma = 12, BA/B.Sc. = 14, BA/Fazil = 15, M. Sc = 16, reads in = 17, & never attend at a school = 0
Literacy of the household head	If the household head can sign only = 1, can read only = 2, and can't read or write = 3
Food consumption score (FCS)	Household food consumption score
Gender parity gap	Gender parity gap in the household. It is the difference between aggregate men and women empowerment scores or index
Endogenous variable	
Aggregate women empowerment score or aggregate women empowerment index	Women empowerment score or five-dimension score at the aggregate level. Aggregate women empowerment in an agricultural index is constructed in the dataset. It is a multidimensional index that is constructed with ten indicators from the five dimensions of women's empowerment (Alkire et al., 2013).

Table 1. Cont'd.

Name of the Variables	**Variables definition and description**
Women empowerment indicators	
Instruments	
Women's authority over the use of income	If the women have sole or joint control over the use of their income = 1, otherwise = 0
Asset ownership	If the women have sole or joint ownership of an asset in their household = 1, otherwise = 0
Speaking in front of the public	If the women have the power and self-confidence to speak in front of the public = 1, otherwise = 0
Women input into a productive decision	If the women have the power to take production decisions solely or jointly regarding different production matters = 1, otherwise = 0
Women's access to and decision on credit	If the women have access and decision on the use of credit solely or jointly = 1, otherwise = 0
Women group membership	If the women have a membership in a group or have the power to participate in a group = 1, otherwise = 0
Women leisure time	If the women have some time for leisure activities in the household = 1, otherwise = 0
The workload of the women	If the women have a workload in the household and do not get time for themselves = 1, otherwise = 0

Source: Bangladesh Integrated Household Survey (2015).

Table 2 demonstrates the sample summary statistics of all the variables. The average mean values of the children's height-for-age-z score and weight-for-age-z score are -1.74 and -1.60. This negative sign implies that optimal child nutrition and growth are lacking in Bangladesh. The findings show that males account for 99 percent of household heads. Similarly, the average age of the household head is 39.74 years, indicating that most of them are middle-aged. Meanwhile, the average gender parity gap between males and females is 0.09 points, and the average food consumption score is 63.49 points. In addition, the average overall score for women empowerment is 0.65. Likewise, 81 percent of respondents reported that women have sole or shared authority over how their income is spent. Furthermore, 78 percent of respondents stated that women have exclusive or partial ownership of their household assets. Women also have the power and confidence to speak in public, according to 44% of respondents. Finally, 74% of the respondent said women have a severe workload in the household.

Table 2. Sample summary statistics of all the variables (n= 3275)

Variables	Mean	Std. Deviation
Height-for-age (haz-score)	-1.74	1.40
Weight-for-age (waz-score)	-1.60	1.06
Body mass index (BMI)	-0.72	1.23
Gender of the household head	0.99	0.04
Age of the household head	39.74	12.31
Education of the household head (in years)	5.72	5.20
Literacy of the household head		
Can sign only	0.31	0.46
Can read-only	0.50	0.50
Cannot read and write	0.19	0.39
Aggregate women empowerment score (Five- dimension score-5DS)	0.65	0.19
Women input into a productive decision	0.74	0.44
Women control over the use of income	0.81	0.39
Ownership of assets by the women	0.78	0.41
Women's access to and decision on credit	0.52	0.50
Women speaking in public	0.44	0.50
Membership of a group by the women	0.26	0.44
Availability of leisure time	0.71	0.45
Women workload	0.74	0.44
Gender parity gap (GAP)	0.09	0.20
Food consumption score (FCS)	63.49	18.94

Source: Bangladesh Integrated Household Survey (2015).

Analytical techniques: The study employs both descriptive and econometric analytical approaches. To characterise the features of data, descriptive statistics are used. A multiple regression analysis leveraging the ordinary least squares (OLS) approach is used to analyse the influence of women's empowerment on child nutrition (OLS) followed by Sen and Begum (2015). Unfortunately, the OLS approach failed to uncover a causal link between women's empowerment and maternal nutrition. The value of R^2 in models 1 and 2 is very poor which indicates that the model goodness of fit is not good enough to explain the variation in the model. Although the value of R-squared are almost same in model 1 and 2 in OLS, but the IV coefficients are much higher than the OLS coefficients. Hence, the IV apprehended the downward bias. Moreover, OLS could be used since coefficients in OLS and IV are almost the same. Moreover, most of the variables have an insignificant relationship with the child's nutritional parameters. The problem of omit variable bias in the model, measurement error, and reverse casualty are all possible causes of OLS failure (Holland and Rammohan, 2019).

The researchers have applied all the diagnostic tests on both models before accepting the OLS to figure out the problems in the model. There is no collinearity

among the explanatory variables that have been used in the models (Appendix - table 1). Furthermore, the outcome of the Breusch-Pagan test of heteroskedasticity shows that models 1 and 2 have no problem with heteroskedasticity. Because the chi-square test statistic (0.98 and 1.47) results are not statistically significant ($p>0.05$). Furthermore, the outcome of the Ramsey-reset test statistic reveals that there is no presence of omitted variable bias in the first and second models. Because the value of the F-statistic (0.31 and 1.94) is not statistically significant (p-value = 0.82 and 0.12). Though the study did not apply the double log model to check for any further improvement in OLS using the data.

Empirical Model: Firstly, the method of ordinary least squares (OLS) is deployed to estimate the relationship between women's empowerment and child nutrition**.** The following model specification is used in the study followed by Holland and Rammohan (2019).

$$Y_1 = \beta_0 + \beta_1\, gender + \beta_2\, age + \beta_3\, education + \beta_4\, literacy + \beta_5\, AWE\ score + \beta_6\, gender\ parity\ gap + \beta_7\, food\ consumption\ score \ldots \ldots (1)$$

$$Y_2 = \beta_0 + \beta_1\, gender + \beta_2\, age + \beta_3\, education + \beta_4\, literacy + \beta_5\, AWE\ score + \beta_6\, gender\ parity\ gap + \beta_7\, food\ consumption\ score \ldots \ldots (2)$$

Where Y_1 and Y_2 is the dependent variable which denotes children's haz and waz scores for the regression model 1 and 2. Also, the variable literacy is the vector dummies of the literacy of the household head. AWE score is the aggregate women empowerment score.

Instrumental Variable (IV) Estimation: Due to the inconsistency in the OLS, the instrumental variable regression model is deployed to investigate the effect of women's empowerment on child nutrition. As the data are observed, there is a high probability of measurement error at the moment of data collection. There could be inaccuracies in the data, collected on a child's height, age, and weight. Secondly, women do not always respond spontaneously to questions in front of their husbands. As a result, all these factors point to the presence of endogeneity in the data. The instrumental variable regression (IV) technique can be used to measure the effect of endogenous variables. Thus, IV is used to control the problem of endogeneity. As a result, the researcher used the IV to determine whether there is a causal association between women's empowerment and child nutrition in Bangladesh.

Likewise, the equation of the OLS children haz and waz scores are taken as the outcome or dependent variables in models 1 and 2. In addition, household head gender, age, education, literacy, gender parity gap between males and females, and household food consumption score are considered as the explanatory variables. Similarly, the aggregate women empowerment score or index is used as the endogenous variable. Furthermore, women empowerment indicators such as ownership of an asset by the women, women's power to speak in the public, and

their authority over the use of income are taken as the instrument in model 1 and model 2 successively.

Diagnostic Test and Identification Checks: To validate the IV estimation and the acceptance of external and internal validity, the essential diagnostic tests are done. The results of the Durbin-Wu-Hausman test of endogeneity identify the presence of the endogenous variable in both models. As the value of the test statistic is significant (p-value = 0.03 and 0.09). Thus, the findings reveal that the variable is not exogenous. Therefore, the result of the weak identification test (Stock-Yogo-Week-ID-test) implies that the instrument is strong in both models as the value of the Cragg-Donald Wald F statistic (F = 236.74 and 523.77) is greater than ten. Moreover, the chi-square test statistic (0.88 and 0.07) of the overidentification test is insignificant (p-value= 0.34 and 0.79) in both models. Thus, the insignificant Sargan statistic of the overidentification test determines the instruments are strong in both models. Therefore, it is evident from the first stage regression that all the instruments- women's ownership of assets, women's authority over the use of income, and speaking in public are significantly affiliated with the aggregate women empowerment score (Appendix- table 2). It is apparent from the outcomes that IV estimates suit the present study and can identify the causal relationship between women's empowerment and child nutrition.

3. Results and Discussion

Table 3 illustrates the findings of the estimated coefficient of all the explanatory variables that are used in the method of ordinary least squares (OLS) and instrumental variable regression (IV). It is evident from column 5 of Table 3 that the age of the household head has a positive (0.003) and significant ($p<0.001$) effect on the child weight-for-age-z score (wasting) which is aligned with the findings of Essilfie et al. (2021a), and Rasha (2020). This output notifies that a one-year increase in the age of the household head would enhance the child was score by 0.003 points which means it would reduce child wasting. Because aged and experienced household head has good knowledge and awareness of their child's nutrition and health. Moreover, they are more concerned about their child's health.

The estimated coefficient of the aggregate women empowerment score is positively (1.96) and significantly ($p<0.01$) amalgamated with the child height-for-age-z score (stunting) which implies that as the aggregate women empowerment score rises, their child have scores would increase (Table 3, column 3). Thus, child stunting will be declined. This result is consistent with the findings of Cunningham et al., 2015; Malapit and Quisumbing, 2015; Mekonnen et al., 2021; Holland and Rammohan, 2019; Onah 2021; Rasha, 2020, Shafiq et al., 2019. It is manifested from Table 3 that a one-point increment in the aggregate women empowerment score would enhance the child nutrition (haz score) by 1.96 points. Consequently,

the more would be women are empowered, the higher would be their child haz score, and the lower would be the child stunting. Aggregate women empowerment score has a positive significant effect on child nutrition. Mother's education can play the vital role for the child health care which adds the value on child nutrition. When mother is educated, have the power to earn, have the power to speak for their right, have the power to make any decision irrespective of their children wellbeing, have the power to take any family decision, then it would have positive and influential impact for their children and family. Thus, higher women empowerment would generate higher positive output for their children.

Table 3. Results of the estimated coefficients from the method of OLS and IV regression

Variables	**Model 1** **Dependent variable:** Height-for-age Z score (haz-score)		**Model 2** **Dependent variable:** Weight-for-age Z score (waz-score)	
	OLS	**IV**	**OLS**	**IV**
	Coefficients	Coefficients	Coefficients	Coefficients
(1)	(2)	(3)	(4)	(5)
Gender of the household head	0.17	0.01	0.23	0.29
	(0.62)	(0.63)	(0.47)	(0.47)
Age of the household head	0.002	-0.00	0.003***	0.003***
	(0.00)	(0.00)	(0.00)	(0.00)
Education of the household head	0.01	0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
Literacy of the household head				
Can read only	0.04	0.05	0.04	0.03
	(0.10)	(0.10)	(0.07)	(0.07)
Can't read and write	-0.07	-0.05	-0.06	-0.07
	(0.07)	(0.07)	(0.05)	(0.06)
Aggregate women empowerment score (5DS)	0.75***	1.96***	0.27	-0.22
	(0.21)	(0.60)	(0.16)	(0.33)
Gender parity gap	0.48***	1.38***	0.28	-0.09
	(0.20)	(0.47)	(0.15)	(0.26)
Food Consumption Score (FCS)	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Constant	-3.06***	-3.63***	-2.60***	-2.37***
	(0.64)	(0.69)	(0.48)	(0.50)
R-squared	0.03	0.02	0.02	0.02
Adjusted R-squared	0.02		0.02	
F-statistic	11.06***	776.18***	10.43***	951.07***
Wald chi-square (IV)		81.19***		86.06***
No. of observations	3275	3275	3275	3275

Source: Bangladesh Integrated Household Survey (2015).

[N.B: Figures in the parenthesis indicate the standard error, *** indicates significance at a 1% level of significance]

The estimated coefficient of the gender parity gap between male and female aggregate empowerment score is positively (1.38) and significantly ($p<0.01$) linked with the child height-for-age-z score (stunting) which signifies that the gender parity gap between male and female increases the child haz score rises (Table 3, column 3). This is opposite to the findings of Seymour et al. (2019) but similar to the output of Malapit and Quisumbing (2015). In line with the literature, it seems that as the gender parity gap between male and female aggregate empowerment score declines, the child haz scores rises (Seymour et al., 2019). In Bangladesh, the society is male-dominated and male empowerment contributes remarkably to family and children consumption (Malapit et al., 2015b). This might be one of the reasons for the positive impact of the gender parity gap on child nutrition. However, the gender parity gap between male and female aggregate empowerment scores is insignificantly related to the child weight-for-age-z score (wasting).

The food consumption score has a positive (0.01 and 0.01) and significant ($p<0.01$) effect on the child's height-for-age-z score (stunting) and weight-for-age-z score (wasting) which notifies that the food consumption score rises the child haz and waz scores improve by 0.01 and 0.01 point (Table 3, column 3). Thus, it indicates that the larger would be the food consumption score, the higher would be the child's nutrition which exceedingly declines the stunting and wasting of children. This result is in line with the outcomes of Essilfie *et al.*, 2021a; Holland and Rammohan, 2019.

It is apparent from the findings of the present study that the age of the household head, aggregate women empowerment score, gender parity gap, and food consumption score are the main determinants or factors that affect the child nutrition in Bangladesh (Table 3). All these factors have a positive and significant effect on reducing child stunting except the age of the household head has a positive significant influence on declining infant wasting (Table 3). Besides, it can be said that the aggregate women empowerment score is the most influencing indicator that positively and significantly affected the child haz score (Table 3). The aggregate women empowerment score is the endogenous variable that has a direct impact on infant nutrition. Ownership of assets by the women, women's authority over the use of their income, and women's power and confidence to speak in front of the public is the key instrument that has a positive and significant effect on the aggregate women empowerment score at the first stage regression (Appendix table 2). Thus, this signifies that as the indicators of women empowerment rise consequently the aggregate women empowerment score will also be enhanced. These instruments have an indirect causal relationship with the child's nutritional status (haz and waz scores) which is consistent with the result of Jones et al. (2019), Sen and Begum (2015). It is diaphanous from the identification test that the instruments are strong enough to influence the aggregate women empowerment score. However, it is undeniable that the more would be women are empowered, the higher would be their child's nutrition.

The food consumption score has a positive and significant effect on both the haz and waz scores of the children in Bangladesh (Table 3). It is manifested from the literature that empowered women can positively and significantly contribute to their family's dietary diversity score (food consumption score) (Essilfie et al., 2021a; Mekonnen et al., 2021; Rasha, 2020). Because, empowered women are educated, more knowledgeable, aware, and more concerned about the diverse food consumption of their children and household member which especially enhances the food consumption score. Thus, the food consumption scores positively and significantly reduced the stunting and wasting of children in Bangladesh. The result from the instrumental variable regression can illustrate a causal relationship between women's empowerment and child nutrition.

4. Conclusion

Child nutrition and women empowerment are indispensable to each other. This paper sought to assess how women's empowerment influences the stunting and wasting of children in Bangladesh. It is manifested from the findings of the study that the aggregate women empowerment score is the most significant indicator that can influence the child's nutritional status in Bangladesh. Besides, asset ownership by the woman, control over the use of their income, and speaking in the public is the most influential indicators and significant instrument that have a positive impact on the aggregate women empowerment score. It is evident that as much as the women are empowered, the child stunting would be lower. Thus, women empowerment is playing a tremendous role in reducing child malnutrition in Bangladesh.

Due to the male-dominated society, a lack of women's power to engage themselves in productive activities, a lack of speaking power and voices for their rights, and societal obstacles hinder the growth of women empowerment in Bangladesh (Sen and Begum, 2015). Thus, it can be suggested that different awareness programs and community-involved participatory training programs should be provided by the local government authority to ensure higher participation of women in productive activities, making the society concerned about the benefits of women empowerment which generally enhances child nutrition. It is evident from the study that women empowerment has significant effect on diminishing the child malnutrition in Bangladesh.

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Appendix Table 1. Correlation matrix of all the explanatory variables used in the study

Variables	gender	age	education	5DS (AWES)	Gender parity gap	FCS
Gender	1.00	-0.00	-0.00	-0.01	0.05	0.002
Age		1.00	-0.10	0.07	0.03	0.16
Education			1.00	0.03	0.06	0.21
5DS (AWES)				1.00	-0.50	0.15
Gender parity gap					1.00	-0.06
FCS						1.00

Source: BIHS, 2015.

Appendix Table 2. Results of the first-stage regression of the estimated coefficient of the instrumental variable regression

Variables	Model 1 Dependent variable: Aggregate women empowerment score		Model 2 Dependent variable: Aggregate women empowerment score	
	Coefficient	Std. error	Coefficient	Std. error
Gender of the household head	0.13***	0.05	0.12***	0.04
Age of the household head	0.001***	0.00	0.001***	0.00
Education of the household head	0.002***	0.00	0.002***	0.00
Literacy of the household head				
Can read only	-0.01**	0.01	-0.01	0.01
Can't read and write	-0.01***	0.01	-0.01	0.01
Gender parity gap	-0.65***	0.01	-0.54***	0.01
Food consumption score	0.00***	0.00	0.00***	0.00
Women asset ownership	0.06***	0.004	0.07***	0.00
Women speaking in public	0.07***	0.003		
Women control over the use of income			0.15***	0.01
Constant	0.42***	0.05	0.33***	0.05
R-squared	0.68		0.72	
Adjusted R-squared	0.68		0.72	
F-value	776.18***		951.07***	

Source: BIHS, 2015.

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PRODUCTION POTENTIAL AND ECONOMICS OF BLACK GRAM-BORO RICE-FALLOW CROPPING SYSTEM IN OLD MEGHNA ESTUARINE FLOODPLAIN

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Abstract

An experiment was conducted at the farmers' field of Old Meghna Estuarine Floodplain Soils under the Agro-Ecological Zone (AEZ) 19 at Nikli, Kishoreganj, for two consecutive years 2019-20 and 2020-21 to evaluate the performance of Black gram-Boro rice-Fallow improved cropping pattern against a farmer's cropping pattern of Fallow- Boro rice-Fallow. Findings revealed that the mean crop durations of 185-189 days were required for one cycle in a year in an improved cropping pattern which implied that two crops based cropping pattern was agronomically feasible to replace the existing cropping pattern. Total grain yield in terms of rice equivalent yield (REY) of the improved cropping pattern was 9.742 t/ha/year which was 29.38% higher than that of the existing pattern (7.53 t/ha/year). The mean production efficiency of the improved cropping pattern (52.09 kg/ha/day) was 39% less than that of the existing pattern due to more time involved in the improved pattern and land-use efficiency of the improved cropping pattern (51.23%) which was 80% higher than that of existing cropping pattern due to less time involvement in existing cropping pattern. The gross return and gross margin were higher in the improved cropping pattern compared to the existing cropping pattern due to an additional yield of black gram and boro rice. Therefore, farmers in the Old Meghna Estuarine Floodplain region of Bangladesh could follow an alternate cropping pattern where lands remain fallow for 81-86 days after the floodwater receded for higher crop productivity and profitability.

Keywords: Production potential, Economics, Cropping system, AEZ-19

1. Introduction

Kishoreganj is quite different from other districts of Bangladesh for its unique natural beauty characterized by haors, rivers, plain land, and char areas. The total cultivated area of Kishoreganj is 386121 ha of which about 102057 ha of cultivated land are single-cropped, 50874 ha are double-cropped, and 55100 ha are tripled-cropped areas with a cropping intensity of 182% (DAE, 2020). The average cropping intensity in haor areas of Kishoreganj is about 104% (DAE, 2019) and the country is losing 0.49% of cultivable land every year for high population pressure and other purposes (Hasan *et al.*, 2013).

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Cultivable land is declining day by day so escalating cropping intensity with more production and bringing the barren land under cultivation is the pre-requisite for sustainable food security in Bangladesh. Thus, the increase of cropping intensity in the rice-based cropping system is becoming important for food security and poverty alleviation. For producing more food within a limited area, the most important options are to increase the cropping intensity and to increase the production efficiency of the individual crop by using optimum management practices (Mondal *et al.,* 2015). Flash flood comes late in the upper catena part of the haor which is under old Meghna estuarine floodplain areas but wakes up quickly and 10-15% of these areas become suitable for crop cultivation in the last week of September to the second week of October (Mohiuddin and Sarker, 2019). At that time, farmers are waiting for cultivating boro rice with irrigation by deep tube well up to December the second week to the first week of January. As a result, the vast area remains fallow for a long time about 80-90 days after flood water receded.

Black gram fits well in old Meghna estuarine floodplain areas during the fallow period to increase cropping intensity as well as crop productivity due to its short duration, drought tolerance, less care, and minimum input requirement (Mohiuddin *et al.,* 2018). Total cultivated area in Bangladesh is 9805360 ha of which 45%, 18%, and 10% are suitable, moderately suitable, and marginally suitable for black gram production (BARC, 2016). The potential adoption of black gram in the *fallow-boro rice-fallow* cropping system would generate employment and additional income for the farmers by utilizing fallow lands in old Meghna estuarine floodplain areas. Rapid population growth led to acute shortage of pulses in Bangladesh and importing pulses at huge foreign exchange to meet local demand is a major concern to the government but received little attention from farmers and policy makers (Hamjah, 2014; Mohiuddin *et al.,* 2018). On the other hand, pulse crops are the source of nitrogen and reduce nitrogen fertilizer requirement (McDonagh *et al.,* 1995). Inclusion of grain legumes plays an important role in increasing cropping intensity or even sustaining crop productivity along with improving the nutritional status of the people and maintaining soil health (Becker *et al*., 1995; Norman *et al*., 1984). Considering the above facts, pulse production should be increased rapidly to improve the national nutritional status along with less outflow of precious foreign currency.

Many studies on different cropping patterns are available in Bangladesh and India that an additional crop could be introduced without many changes or replacing the existing ones for considerable increases in productivity as well as the profitability of the farmers (Malavia *et al*., 1986; Khan *et al.,* 2005; Nazrul *et al*., 2013; Kamrozzaman *et al.,* 2015) while no work has been done to understand the inclusion of black gram in rice-based cropping systems with specific locations or districts of Bangladesh. The present study was undertaken to know the productivity and profitability of two crops based improved cropping pattern *Black gram-Boro rice-Fallow* in old Meghna estuarine floodplain areas.

Objectives:

i) to study the agronomic practices of *black gram-boro rice-fallow* cropping pattern;

ii) to examine the feasibility of *black gram-boro rice-fallow* cropping pattern in farmers' field condition;

iii) to estimate the productivity and profitability of the above improved cropping pattern against farmer's existing cropping pattern.

2. Materials and Methods

The study was carried out for two consecutive years 2019-20 and 2020-21 at a farmer's field, Kishoreganj (Latitude- 24° 16' 47.028″ N and Longitude-90° 56' 10.902″ E) located in Agro- Ecological Zone (AEZ)-19; under Old Meghna Estuarine Floodplain Soils. This trial was conducted to derive the economic consequences of two cropping patterns viz. IP: improved pattern (Black gram - Boro rice-Fallow) and FP: farmer's pattern (Fallow-Boro rice-Fallow) through the incorporation of high yielding varieties with improved management practices.

In the improved pattern, Black gram var. BARI Mas-3 was introduced against fallow period. Boro rice var. BRRI dhan29 was used in both farmers' patterns and improved patterns, respectively. The agronomic parameters and cultural operations for crop production under improved and farmer's practices are presented in Table 1. All field operations and management practices of both farmers and improved patterns were closely monitored and the data were recorded for agro-economic performance.

Agronomic performance viz. land-use efficiency, production efficiency, rice equivalent yield, and the benefit-cost ratio of cropping patterns were calculated. Land use efficiency is worked out by taking the total duration of an individual crop in a sequence divided by 365 days (Tomer and Tiwari, 1990). It is calculated by the following formula:

$$\text{Land use efficiency} = \frac{d_1 + d_2}{365} \times 100$$

Where d_1 and d_2 the duration of first and second crop of the pattern

Production efficiency: Production efficiency values in terms of Kg./ha/day were calculated by total production in a cropping sequence divided by total duration of crops in that sequence (Lal et al., 2017; Tomer and Tiwari. 1990).

$$\text{Production Efficiency} = \frac{Y_1 + Y_2}{d_1 + d_2} \quad kg/ha/day$$

Where, Y_1= Yield of first crop and d_1= Duration of first crop of the pattern; and Y_2= Yield of second crop and d_2= Duration of second crop of the pattern

Rice equivalent yield: For comparison between crop sequences, the yields of all crops were converted into rice equivalent yield (REY) on the basis of prevailing market price of individual crop.

$$\text{Rice equivalent yield (t/ha/yr)} = \frac{\text{Yield of individual crop} \times \text{market price of that crop}}{\text{market price of rice}}$$

The economic indices like gross return, gross margin, and marginal benefit-cost ratio were also calculated based on the prevailing market price of the product. The economic analysis involved the collection of data on prices and quantities of inputs used and output produced. The inputs used included seed, fertilizer, labour, and insecticides. The MBCR of the farmer's prevalent pattern and any replacement for it can be computed as the marginal value product ((MVP) over the marginal value cost (MVC). The Marginal of the prevalent pattern (F) and any potential replacement (E) for it was computed as (CIMMYT, 1988).

$$\text{Marginal Benefit Cost Ratio (MBCR)} = \frac{\text{Gross return (E)} - \text{Gross return (F)}}{\text{TVC (E)} - \text{TVC (F)}} = \frac{MVP}{MVC}$$

3. Results and Discussion

Results of the two years study of improved cropping pattern (Black gram -Boro rice- Fallow) and farmer's existing pattern (Fallow-Boro rice-Fallow) are presented in Table 1-5.

Grain and by-product Yield: The improved pattern took 185-189 days against 102-106 days due to the inclusion of black gram in the pattern. This indicates that black gram could easily be grown or fitted before boro rice. After two consecutive years of the study, the result revealed that the seed yields of BARI Mas-3 were 0.93 t/ha and 0.98 t/ha and that of stover yields were 1.4t/ha and 1.39 t/ha, respectively. The mean yield of black gram was observed at 0.96 t/ha. Although a 5.37% yield increase was observed in the second year might be due to less infestation of spodoptera litura than the previous year during the growing season. The grain yield of boro rice in the improved pattern was 7.40 t/ha in 1st year and whilst it was 7.25 t/ha in 2nd year. Mean grain and straw yields of boro rice were 7.33 and 3.68 t/ha. The yields of boro rice in farmer's practice were 7.2 and 7.1 t/ha, in 1st and 2nd year and mean grain and straw yield of boro rice were 7.15 and 3.8 t/ha respectively. It was observed that the improved pattern under the black gram-boro rice -fallow cropping pattern gave higher grain and by-product yield (Table 1). The average yield of Boro rice in the improved pattern increased by 3 and 2% over farmers' practice (FP) in the first and second year, respectively. The yield of the improved pattern was higher presumably due to the change of variety with improved production technologies and timely sowing of the component crops. The lower yield of grain and straw of boro rice in farmers' practice was due to the use of imbalanced fertilizer and poor management practice. Similar results in higher productivity were obtained by Nazrul et al. (2013), Khan et al. (2018), Khan et al. (2005) and Hossain and Wahhab (1992).

Farmers' cropping pattern Fallow-Boro rice-Fallow required 106 and 102 days field duration in the 1st and 2nd year. Contrary, the total field duration of the improved pattern black gram-boro rice-fallow was 189 and 185 days (excluding seedling age of rice) to complete the cycle in the 1st and 2nd year, respectively (Table 1). Thus, the turn-around period of 259-263 days was utilized in the farmer's existing pattern. The result indicated that black gram could be easily fitted in Fallow-Boro rice cropping pattern with an average of 178 days turn-around time in a year. Similar results were found by Khan et al. (2018).

Table 1. Agronomic practices of improved and farmers' existing pattern during 2019-20 and 2020-21

Parameter	Year	Improved Pattern		Farmers' Pattern
		Black gram	Boro rice	Boro rice
Variety	2019/20-20/21	BARI Mas-3	BRRI dhan29	BRRI dhan29
Sowing/ transplanting	2019-20	16 Oct. 2019	26 Jan. 2020	05-10 Jan. 2020
	2020-21	27 Oct. 2020	23 Jan. 2021	10-12 Jan. 2021
Seedling age (days)	2019/20-20/21	-	35-40	40-45
Seed rate (kg/ha)	2019/20-20/21	40	50	50
Planting method	2019/20-20/21	Broadcast	Line	Line
Spacing (Row×hill)	2019/20-20/21	Continuous	20cm × 15cm	20cm × 15cm
Seedling/hill	2019/20-20/21	-	2-3	3-4
Fertilizer dose (NPKSZnB kg/ha)	2019/20-20/21	20-18-20-10-0-02	140-18-53-08-03-02	115-40-63-14-0-0
Fertilizer application method	-	Entire N, P, K, S & B applied as basal after final land preparation	Full P,K,S & Zn were applied as basal. N was applied in three equal splits, 1st top dress was done after seedling establishment, 2nd one at early tillering stage and 3rd one at 5-7 days prior to panicle initiation stage	Full amount of P,K,S & Zn were applied as basal. N was applied in three equal splits, 1st top dress was done after seedling establishment, 2nd one at early tillering stage and 3rd one at 5-7 days prior to panicle initiation stage
Weeding (no.)	2019/20-20/21	Once	Twice at 15-20 and 35-40 DAT	Twice at 15-20 and 35-40 DAT

Parameter	Year	Improved Pattern		Farmers' Pattern
		Black gram	Boro rice	Boro rice
Irrigation (no.)	2019/20-20/21	Once	Several times	Several times
Insect/pest control	2019/20-20/21	IPM	IPM	Chemical
Harvesting time	2019/20	10 Jan, 2020	08 May, 2020	20-24 April, 2020
	2020/21	16 Jan, 2021	07 May, 2021	22-24 April, 2021
Grain yield (t /ha)	2019/20	0.93	7.40	7.20
	2020/21	0.98	7.25	7.10
Straw yield (t /ha)	2019/20	1.4	4.0	4.10
	2020/21	1.39	3.35	3.50
TAT (days)	2019/20	161	16	259
	2020/21	173	07	263
Field duration (days)	2019/20	86	103	106
	2020/21	81	104	102

Rice equivalent yield: The total productivity of improved and farmer's cropping patterns were evaluated in terms of rice equivalent yield (REY) and it was calculated from the yield of component crops. The mean rice equivalent yield revealed that the improved cropping pattern produced higher rice equivalent yield (9.74 t/ha/yr) over the farmer's (7.53 t/ha/yr) existing pattern (Table 2). Inclusion of black gram in *Rabi* season in improved cropping pattern increased REY of 29% compared to farmer's existing one. It was also due to the higher price of component crops in the improved pattern. These results are in agreement with that of Mondal *et al*. (2015) and Nazrul *et al*. (2017) who reported that total productivity increased by 67% over farmer's practice due to the inclusion of a third crop (mungbean) in the pattern.

Production efficiency: Maximum production efficiency (72.42) in terms of kg/ha/day was obtained from farmers existing cropping patterns (Table 2) because it takes less time. This result was found contradictory to that of Nazrul *et al*. (2013), Khan *et al*. (2006), and Khan *et al*. (2005).

Land utilization index (LUI): The land utilization index is the effective use of land in a cropping year, which mostly depends on crop duration. The land utilization index (LUI) indicated that the improved pattern used the land for 51% period of the year, whereas the farmers' pattern used the land for 28% period of the year (Table 2). Land use efficiency was 80% higher in improved patterns than in farmer's practices, mostly because the improved pattern occupied the field for a longer duration (185-189 days) than the farmer's pattern (102-106 days) in a year. As a result, labour utilization could be more in the improved cropping pattern than the existing one.

Table 2. Rice-equivalent yield, production efficiency and land utilization index of improved and farmer's cropping pattern during 2019-20 and 2020-21

Items	Improved pattern			Farmer's pattern		
	2019-20	2020-21	Average	2019-20	2020-21	Average
REY (t/ha/yr)	9.80	9.684	9.742	7.61	7.45	7.53
PE (kg/ha/day)	51.85	52.35	52.10	71.79	73.04	72.42
LUI (%)	51.78	50.68	51.23	29.04	27.95	28.49

REY= Rice equivalent yield, PE= production efficiency, and LUI= land utilization index

Cost and return analysis: The benefit-cost ratio of improved patterns and farmers' existing patterns are presented in Table 3. From the economic point of view, the gross return of the improved cropping pattern (Tk.194840/ha) showed its superiority by 29% over the farmer's existing pattern (Tk.150600/ha). The production cost of the improved pattern (Tk.101775/ha) was higher than the farmer's pattern (Tk.83740/ha) due to the inclusion of black gram and improve management which takes the extra cost of inputs of the production. The gross margin was substantially higher in the improved pattern (Tk.93065/ha) than in the farmer's pattern (Tk.66860/ha). The higher gross margin of the improved pattern (39%) was achieved mainly by higher yield advantages and the price of the component crops. The mean marginal benefit- cost ratio (MBCR) was found 2.5 which indicated the superiority of the improved cropping pattern over the farmer's pattern. The MBCR also showed that the inclusion of black gram in the existing pattern might be profitable and acceptable to the farmers.

Table 3. Cost and return analysis of improved and farmers' cropping pattern

Items	**Improved pattern**			**Farmers' pattern**		
	2019-20	2020-21	Mean	2019-20	2020-21	Mean
Gross return (Tk/ha)	196000	193680	194840	152200	149000	150600
TVC (Tk/ha)	100850	102700	101775	85500	81980	83740
Gross margin (Tk/ha)	95150	90980	93065	66700	67020	66860
MBCR	2.85	2.16	2.50	-	-	-

Price of input (Tk/kg): Urea-16, TSP-22, MOP-16, Gypsum-10, Zinc sulphate-130 and Boric acid-300, Black gram seed-85, rice seed-40; Selling price (Tk/kg)**:** Black gram-40, Boro rice-20 and Straw-2.

Disease and Pest infestations: Black gram crop was infested by spodoptera litura, leaf roller, and flea beetle which was controlled by spraying of tracer twice @ 0.4 ml/L water at 10-15 days interval, karate 2.5 Ec @1 ml/L water at 5-7 days interval. Boro rice was sporadically infested by rice stem borer, rice bug, rice brown plant hopper, and rice hispa. Furadan 5G @ 10 kg/ha was applied during final land preparation and Virtako 40WG @ 1.5 g/10L water was sprayed twice at 10 days intervals for controlling stem borer. Dursban @ 2 ml/L and Marshal 2 ml/L water were sprayed at 55 and 65 DAT for controlling other insects. The farmers are

willing to grow black gram after flood water receded with zero tillage and boro rice in the future. A good number of farmers are also willing to produce quality black gram seeds for their own and their areas.

4. Conclusion

The research findings indicated that the *black gram-boro rice-fallow* cropping pattern is applicable in some haor areas of Bangladesh and it can easily be fitted in the existing pattern with higher benefit. The inclusion of black gram in the pattern will increase pulses production in the country as well as increase cropping intensity and productivity in haor areas. The results of the two years trial indicated that the black gram (Var. BARI Mas-3)-Boro rice (Var. BRRI dhan29)-Fallow cropping pattern was more productive and profitable than the farmer's existing pattern Fallow- Boro rice (Var. BRRI dhan29)-Fallow. Thus, black gram can be successfully accommodated in the existing farmer's pattern with total crop duration ranging from 185 to 189 days in Nikli upazilla of Kishoreganj district to increase cropping intensity and system productivity with profitability. Furthermore, through this cropping pattern, the soil health may be improved and the farmers could cultivate year-round crop successfully and create employment opportunity for labour forces.

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PROFITABILITY AND RESOURCE USE EFFICIENCY OF *BORO* RICE PRODUCTION IN FAVORABLE AND SUBMERGENCE ECOSYSTEMS OF TANGAIL DISTRICT: A COMPARATIVE STUDY

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Abstract

The present study was conducted to estimate the profitability and resource use efficiency of *Boro* rice production in two ecosystems of Tangail district. A total of 80 farmers were interviewed randomly for data collection through a structured questionnaire. Data were analyzed with a combination of descriptive statistics, mathematical and statistical techniques. Profitability analysis revealed that producing *Boro* rice resulted in the maximum profit for the farmers at submergence ecosystem compared to favorable ecosystem. The Cobb-Douglas production function analysis indicated that output of *Boro* rice was positively and significantly correlated with labor, seed, TSP and irrigation at favorable ecosystem. The study also found that inputs like labor, seed, power tiller, irrigation, urea and pesticide have significant influence on increasing *Boro* rice production at submergence ecosystem. Resource use efficiency analysis showed that farmers inefficiently used their inputs for *Boro* rice production. Following problem facing index (PFI), low price of paddy and lengthy water logging condition were the main problems faced by the farmers. The study recommended that proper training and extension support should be made available by the government and non-government organizations to enhance the profitability and to ensure the optimum use of resources in *Boro* rice production.

Keywords: Favorable ecosystem, Submergence ecosystem, Profitability, Resource use efficiency.

1. Introduction

Bangladesh economy has been growing over the last three decades. Among the different sectors of economy, agriculture plays an important role to generate employment for its population by increasing productivity and growth. At present, agriculture contributes about 12.92% to the gross domestic product (GDP) (BBS, 2020). Although the contribution of agriculture sector to GDP has gradually been declining in recent years but still it is playing a major role in the economy of Bangladesh. About 40% of the total national labor forces are employed by the agriculture sector (BBS, 2020). Rice is not just the staple food, it is at the center of the overall life of the people of Bangladesh, whether it is culture, politics, or the

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economy. Rice alone constitutes 80% of the total food grains produced annually (BER, 2017). It is the principal source of agriculture GDP and livelihood to majority of the rural population which supplies 69.8% of the total caloric intake and more than 58% of the protein intake (FAO, 2015).

Bangladesh has a subtropical monsoon climate which may be described as unstable and unpredictable. There are six seasons in a year of which three namely winter, summer, and monsoon are prominent. Rice is grown in three seasons i.e.,*Aus, Aman* and *Boro* in Bangladesh. Among these, *Boro* is dominant for its higher production capability and its important role in gaining self-sufficiency in food grain. In terms of area under cultivation, rice comes first among the cereals contributing about 42% of the land during *Boro* season and it accounts for the production of 19.56 million tons of clean rice, which is around 54% of the total production of the country (BBS, 2020). On the other hand, by 2050 this country's population is estimated to exceed 215 million and the nation would have to grow additional 10.8 million tons of rice (Hussain, 2010). It is, therefore, a major challenge to provide sufficient food through diminishing land and many other scared supplies to feed the future with the ever-growing population of the country (Rahaman*et al.,* 2018). Rice production has been intensified through the introduction of high-yielding and hybrid *Boro* rice varieties, cultivated in the dry season using irrigation, as well as the increased application of fertilizer, pesticides, and better crop management. HYV *Boro* was found more efficient among all other main rice varieties (Local *Aman*, HYV *Aman*and HYV *Boro*) in Bangladesh (Regmi*et al.,* 2016).

Rice is cultivated in four different rice growing environments or ecosystems (IRRI, 1993). An ecosystem is a chain of interaction between organisms and their environment. In favorable ecosystem, the average temperature is required throughout the life period of the crop ranges from 21 to 37º C and having minimum rainfall is 115 cm. Favorable condition is also defined by the depth of water varying over 25 mm at the time of transplanting to as much as 150 mm for 10 weeks of the growing period. Submergence ecosystemis defined on the basis of duration, depth, and frequency. Flood causes submergence and damage to rice crops. Two types of environment cause submergence: flash flood and deep water. Flash flood submergence is defined by water levels rising rapidly and plants remaining submerged for 1-2 weeks. Deep water submergence is defined by water depths greater than 100 cm persisting for months (Kannan *et al.,* 2017). *B. Aman* and *B. Aus* are grown in deepwater and upland rice ecosystems, respectively. *Boro* and *T. Aus* are grown under the irrigated ecosystem. *T. Aman* is grown primarily under rainfed lowland conditions. However, *T. Aman* is also grown under deepwater environment where flood water exceeds 50 cm (Shelley *et al.,* 2016).

Although rice is considered as the main crop in Bangladesh and the country is ranked as the fourth largest rice producer in the world (FAO, 2021), it is not

produced with full efficiency.The increase in production is possible mainly through improvement in crop productivity which could be achieved by efficient utilization of available resources. Optimum use of resources could also increase the profit margin if the farmers are using inputs indiscriminately. The government of Bangladesh has given priority to the agriculture sector to increase the production of rice by giving subsidy to the farmers on different inputs such as fertilizer, irrigation, etc. The future of rice production in Bangladesh depends very much on the awareness of its profitability and how efficiently the farmers are using their resources.

The study can be supported by a modest number of literatures which are:Kamruzzaman and Uddin (2020) conducted a study on economic viability of *Boro* rice production in *haor* ecosystem of Kishoreganj district and found that *Boro* rice production was profitable and productivity index was very high; Subedi *et al.* (2020) carried out a study on profitability and resource use efficiency of rice production in Jhapa district of Nepal and revealed that optimum allocation of resources, cost on seed, chemical fertilizers, irrigation and pesticides/herbicides need to be increased and cost on human labor and tractor power should be decreased. Rasha *et al.* (2018) examined financial profitability and resource use efficiency of *Boro* rice production in some selected areas of Mymensingh district in Bangladesh and identified that seed, animal labor and power tiller, human labor, fertilizer and irrigation cost had a positive and significant effect on the gross yield of *Boro* rice production; and Sujon *et al.* (2017) evaluated financial profitability and resource use efficiency of *Boro* rice cultivation in some selected area of Bangladesh and found that human labor, irrigation, insecticide, seed and fertilizer had statistically significant effect on yield and growers allocated most of their resources in the rational stage of production. The existing literature indicates that plenty of research has been done on rice production including cost, return, profitability and resource use efficiency analysis in different areas of Bangladesh, but no systematic work has been done on *Boro* rice cultivation in different ecosystems. Therefore, the study was carried out to compare profitability and resource use efficiency of *Boro* rice cultivation between two ecosystems of Tangail district. The specific objectives of the study were: i) to estimate the comparative profitability in favorable and submergence ecosystems, ii) to analyze the factors affecting resource use efficiency of the production of *Boro* rice in two ecosystems.

2. Materials and Methods

2.1 Study areas and sample size

The study was conducted at four villages namely Singuria and Pachtikori from Ghatail upazilla; Betuajani and Ghugra from Nagorpur upazilla of Tangail district. Based on the rice ecosystem, upazillas were selected as favorable and submergence

ecosystems, respectively. A total of 80 farmers (i.e., 40 from favorable ecosystem and 40 from submergence ecosystem) were selected following random sampling technique for primary data collection. Primary data were collected from the respondents by using a questionnaire during June 2019 to August 2019. Focus group discussions (FGD) and key informant interviews (KII) were also performed for data collection. Secondary data sources like reports, publications, handouts, etc. relevant with this study were also examined.

2.2 Analytical techniques

Descriptive statistics: Descriptive statistics like sum, averages and percentages were calculated to identify the farmers' socioeconomic status for producing *Boro* rice in different ecosystems.

Profitability analysis: Profitability of *Boro* rice production per hectare from the view point of individual farmer was measured in terms of gross return, gross margin, net return and benefit cost ratio (Dilon and Hardaker, 1993). The formulas needed for the calculation of profitability is as below:

$GR = P \times Q$; $GM = GR - TVC$; $NR = GR - (TFC + TVC)$; $BCR = GR \div (TFC + TVC)$

Where,

GR = Gross return (Tk); P = Sales price of the product (Tk.); Q = Yield per hectare (metric ton); GM = Gross margin (Tk.); TVC = Total variable cost (Tk.); NR = Net return (Tk.); TFC = Total fixed cost (Tk.); and BCR = Benefit cost ratio.

A paired t-test was conducted to check whether the profitability of favorable and submergence ecosystems was significantly different or not. The hypotheses were as follows:

Null hypothesis (H_0): The net return from favorable and submergence ecosystems is indifferent

Alternative hypothesis (H_1): The net return from favorable and submergence ecosystems is different

Functional analysis: The input-output relationship in *Boro* rice production was analyzed with the help of Cobb-Douglas production function approach (Gujarati and Porter, 2008). To determine the contribution of the most important variables in the production process of *Boro* rice, the following specification of the model was used.

$$Y = a x_1^{b1} x_2^{b2} x_3^{b3} x_4^{b4} x_5^{b5} x_6^{b6} x_7^{b7} x_8^{b8} e^{ui}$$

The Cobb-Douglas production function was transformed into following logarithmic form so that it could be solved by ordinary least squares (OLS) method.

$\text{Ln } Y_i = B_0 + B_1 \text{ In}X_1 + B_2 \text{ In}X_2 + B_3 \text{ In}X_3 + B_4 \text{ In}X_4 + B_5 \text{ In}X_5 + B_6 \text{ In}X6 + B_7 \text{ In}X_7 + B_8 \text{ In}X_8$

Where,

Y=Profit (Tk./ha); B_0= Constant or intercept value; X_1= Cost of labor (Tk./ha); X_2= Cost of seed (Tk./ha); X_3= Cost of mechanical power (Tk./ha); X_4= Cost of urea (Tk./ha); X_5 = Cost of TSP (Tk./ha); X_6 = Cost of MoP (Tk./ha); X_7= Cost of irrigation (Tk./ha); X_8= Cost of insecticide(Tk./ha); Ln=Natural logarithm; and $B_1 \ldots\ldots B_8$ = Coefficient of the respective explanatory variables estimated.

Resource use efficiency: In order to investigate the resource use efficiency, the ratio of marginal value product (MVP) to the marginal factor cost (MFC) for each input was computed and tested for its equality to 1, That is,

$$\frac{MVP}{MFC} = r$$

Where,

r = Efficiency ratio;

MVP=Marginal Value Product; and MFC= Marginal Factor Cost.

Under this method, the decision rules are that, when:

r >1, the level of resource use is below the optimum level implying under-utilization of resources. Increasing the rate of use of that resource will help increase productivity.

r <1, the level of resources use is above the optimum level implying over utilization of resources. Reducing the rate of use of that resource will help improve productivity.

r =1, the level of resource use is at optimum implying efficient resource utilization.

The most reliable perhaps the most useful estimate of MVP is obtained by taking all input resources (X_i) and gross return (Y) at their geometric means (Dhawan and Bansal, 1977). All the variables of the fitted model were calculated in monetary value. As a result, the slope co-efficient of those independent variables in the model represent the MVPs, which were estimated by multiplying the production co-efficient of given resources with the ratio of geometric mean (GM) of gross return to the geometric mean (GM) of the given resources, that is,

$$MVP(X_i) = \beta_i \frac{\bar{Y}(GM)}{\bar{X}\,(GM)}$$

Where,

$\bar{Y}(GM)$ = Geometric mean of gross return (BDT);

$\bar{X}$ (GM) = Geometric mean of different independent variables (BDT);

β_i = Co-efficient of parameter; andi = 1, 2,……..n.

Problem facing index (PFI): To address the problems in producing *Boro* rice, problem facing index (PFI) was calculated using the following formula (Goswami, 2016):

$$PFI = (P_s \times 3) + (P_m \times 2) + (P_l \times 1) + (P_n \times 0)$$

Where,

P_s = Number of respondents facing the problems severely (weight assigned as 3);

P_m = Number of respondents facing the problems moderately (weight assigned as 2);

P_l = Number of respondents facing the problems at low level (weight assigned as 1); and

P_n = Number of respondents facing no problems (weight assigned as 0)

The problem facing score was computed for each respondent. The possible range of total score could be 0 (zero) to 120, while '0' indicating no problem and '120' indicating severe problem in *Boro* rice production.

3. Results and Discussion

3.1 Socioeconomic status of the respondents

As socioeconomic status of the *Boro* rice farmers, it is found that average household size of farmers was 5.0 in favorable as well as in submergence ecosystem, which was almost 1.2 times higher compared to the country's average of 4.1 (HIES, 2016). It is seen that most of the farmers (50.6 percent for favorable and 56.4 percent for submergence ecosystem) are middle aged belonging to the age group of 26-50 which pre-supposed that many of them are in their active age. Though 54.1 percent favorable farmers had crossed primary level education, majority of the submergence farmers (60.4 percent) were illiterate in the study areas. The results also show that most of the respondents (92.9 percent for favorable and 87.1 percent for submergence ecosystem) were engaged in agricultural activities in the study areas (Table 1).

Table 1. Demographic information of the farmers

Particulars	Favorable ecosystem	Submergence ecosystem	Particulars	Favorable ecosystem	Submergence ecosystem
Ave. household size (no.)	5.0	5.0	Literacy rate (% of farmers)		
Average age(% of farmers)			Illiterate	45.9	60.4
Below 25 years	1.2	6.9	Primary	21.2	14.8
26-50 years	50.6	56.4	Secondary	24.7	13.9
Above 50 years	48.2	36.7	Above secondary	8.2	10.9
Experience status (% of farmers)			Occupational status (% of farmers)		
Below 20 years	36.5	44.6	Agriculture	92.9	87.1
21-40 years	51.8	41.6	Others	7.1	12.9
Above 40 years	11.7	13.8			

Source: Field survey, 2019.

3.2 Land tenancy arrangements of the farmers

Most of the farmers (91.8 percent for favorable and 90 percent for submergence ecosystem) were small in the study areas which was higher than the national mean value of 76.7% (HIES, 2016). Average farm size of small and medium farmers was 0.37 ha and 1.71 ha, respectively in favorable ecosystem whereas it was 0.39 ha, 1.35 ha and 3.56 ha for small, medium and large farmers, respectively in submergenceecosystem (Table 2).

Table 2. Farmers land tenancy arrangements

Farmers' categories	% of farmers	Average farm size (ha)	Land tenancy arrangement (ha)		
			Own	Rented/ Leased-in	Rented/ Leased-out
Favorable ecosystem					
Small (<1.00 ha)	91.8	0.37	0.26(70.3)	0.01 (2.7)	0.10 (27.0)
Medium (1.01-3.00 ha)	8.2	1.71	1.08 (63.2)	0.40 (23.4)	0.24 (13.4)
Submergence ecosystem					
Small (<1.00 ha)	90.1	0.39	0.32 (82.0)	0.01 (2.6)	0.06 (15.4)
Medium (1.01-3.00 ha)	8.9	1.35	0.80 (59.2)	0.28 (20.7)	0.27 (20.0)
Large (above 3.00 ha)	1.0	3.56	3.56 (100)	-	-

Source: Field survey, 2019.

3.3 Varietal status of the rice producers

The varieties of rice cultivated by the farmers under different ecosystems were identified and presented in Table 3. It is found that most the farmers (68.67%) used BRRI dhan29 in *Boro* growing season at favorable ecosystem followed by BRRI dhan28 (74.0%) at submergence ecosystem. The results implied that farmers still cultivate older improved rice varieties. The findings are similar to ToritsejuBegho

(2021) where the author identified improved rice varieties, those with age of 20 years since release (e.g., BRRI dhan32, BRRI dhan30, BRRI dhan29, BRRI dhan28 and BRRI dhan27) recorded the highest proportion (65.9%) in the count of adopted improved rice varieties.

Table 3. Distribution of *Boro* rice varieties of the farmers

Variety	Percent of farmers responded	
	Favorable ecosystem	Submergence ecosystem
BRRI dhan29	68.67	26.00
BRRI dhan28	25.30	74.00
BRRI dhan81	4.82	-
Binadhan-7	1.20	-

Source: Field survey, 2019.

Table 4. Cost-return analysis of *Boro* rice production

Particulars	Favorable ecosystem		Submergence ecosystem	
	(Tk./ha)	% of total cost	(Tk./ha)	% of total cost
Variable costs				
Human labor	31292	40.86	30064	40.48
Power tiller	5261	6.87	6319	8.51
Seed/seedlings	5746	7.50	4951	6.67
Fertilizers	7158	9.35	7709	10.38
Irrigation	14563	19.02	12848	17.30
Insecticides and herbicides	3808	4.97	4012	5.40
i. Total variable cost (Tk./ha)	67828	88.58	65903	88.74
Fixed costs (Tk./ha)				
Land use cost	4872	6.36	5120	6.89
Interest on operating capital	3876	5.06	3245	4.37
ii. Total fixed costs (Tk./ha)	8748	11.42	8365	11.26
iii. Total costs (Tk./ha)	76576	100.00	74268	100.00
Return (Tk./ha)				
iv. Gross return (Tk./ha)	93466		105966	
v. Gross margin (Tk./ha)	25638		40063	
vi. Net return (Tk./ha)	16890		31698	
vii. Benefit cost ratio (BCR)	1.22		1.43	
t-test: Paired two sample for mean net return				
P(T<=t) two-tail	0.003			
t Critical two-tail	2.022			
Remark	Null hypothesis rejected at 1% level of significance			

Source: Authors' estimation based on field survey, 2019-2021.

3.4 Profitability of Boro rice production

The profitability of *Boro* rice production was estimated in terms of gross return, gross margin, net return and benefit-cost ratio. For calculating total production cost, variable and fixed costs were taken into consideration. It is apparent from

Table 4 that the highest total cost was incurred by the farmers at favorable ecosystem (Tk.76576/ha) compared to submergence ecosystem (Tk.74268/ha).Though total cost was higher at favorable ecosystem, apart from this it is seen that farmers obtained higher gross return (Tk. 105966) per hectare at submergence ecosystem due to better production of *Boro* rice compared to favorable ecosystem.The p-value of the paired t-test for mean net return was found 0.003, which confirmed the decision to reject the null hypothesis (at 1% level of significance) and to accept the alternative hypothesis that there was a significant difference in the profitability of *Boro* rice production between favorable and submergence ecosystems. The estimated BCR was higher at submergence ecosystem (1.43) compared to favorable ecosystem (1.22). Thus, the profitability analysis revealed that producing *Boro* rice resulted in the maximum profit for the farmers at submergence ecosystem compared to favorable ecosystem.This finding is supported by Uddin and Dhar (2020) where the authors found profitability and productivity of *Boro* rice, as well as water productivity, were comparatively high for focal farmers compared to control farmers.

3.5 Factors affecting production of Boro rice

In order to assess the individual effects of different inputs of *Boro* rice production, Cobb-Douglas production function model was used. The results as shown in Table 5 indicated that labor cost, seed cost and irrigation cost had positive impacts on producing *Boro* rice at favorable ecosystem as well as submergence ecosystem. It is seen that power tiller cost and urea cost had negative impacts at favorable ecosystem, while these two variables had positive impacts on profitability of *Boro* rice at submergence ecosystem.The values of standardized regression coefficients as presented in Table 5 demonstrate that TSP had the largest impact on *Boro* rice production at favorable ecosystem while insecticide had the largest impact at submergence ecosystem. This finding is relevant to Sujon *et al*. (2017) where the authors observed that human labor, irrigation, insecticide, seed and fertilizer had statistically significant effect on *Boro* rice yield. The co-efficient of determination (R^2) was found as 0.809 for favorable ecosystem and 0.795 for submergence ecosystem which implied that 80.9 and 79.5 percent variation of dependent variable has been explained jointly by the independent variables, i.e., the model is well fitted. The F-value of the equation was 23.37 and 21.74 for favorable and submergence ecosystems, respectively meant that all of the explanatory variables included in the model were important to explain the variation of the dependent variable. The model shows a decreasing return to scale (0.27 for favorable and 0.58 for submergence) which means that the outputs will increase in a lower rate compared to the rate of increase in all the production inputs.

Table 5. Estimated values of co-efficient and related statistics of the Cobb-Douglas Production function

Variables	Favorable ecosystem			Submergence ecosystem		
	Co-efficient (S.E.)	t-value	SRC	Co-efficient (S.E.)	t-value	SRC
Intercept	9.204*** (2.637)	3.49		7.189*** (1.179)	6.10	
Labor (X_1)	0.057* (0.031)	1.84	.087	0.049* (0.025)	1.96	.105
Seed (X_2)	0.018* (0.010)	1.80	.037	0.005* (0.003)	1.67	.009
Power tiller (X_3)	-0.122** (0.050)	-2.44	-.124	0.233** (0.097)	2.40	.297
Urea (X_4)	-0.042*** (0.012)	-3.50	-.057	0.136* (0.081)	1.67	.194
MoP (X_5)	-0.029 (0.054)	-0.54	-.227	-0.002(0.0027)	-0.74	-.025
TSP (X_6)	0.209* (0.115)	1.81	.342	0.009(0.009)	1.00	.020
Irrigation (X_7)	0.193* (0.109)	1.77	.251	0.067** (0.031)	2.16	.161
Insecticide (X_8)	-0.011(0.366)	0.03	-.078	0.081***(0.018)	4.50	.585
R^2	0.809			0.795		
F-value	23.37			21.74		
Return to scale	0.27			0.58		

Source: Authors' estimation based on field survey, 2019-2021.

Note: *, ** and *** indicate significant at 10%, 5%, 1% level, respectively.

Table 6. Resource use efficiency of *Boro* rice production

Variables	GM	MVP	MFC	MVP/MFC	Comments
Favorable ecosystem					
Return	79819.6				
Labor	28136.3	2.519	450	0.005	Over-utilized
Seed	2053.5	11.025	40	0.275	Over-utilized
Power tiller	4696.1	-32.062	4955	-0.006	Over-utilized
Urea	3156.8	-16.577	16	-1.036	Over-utilized
MoP	520.7	-68.193	16	-4.262	Over-utilized
TSP	2245.2	115.225	22	5.237	Under-utilized
Irrigation	12595.4	18.918	552	0.034	Over-utilized
Pesticide	1125.5	-11.432	163	-0.070	Over-utilized
Submergence ecosystem					
Return	91603.8				
Labor	23367.9	2.959	400	0.007	Over-utilized
Seed	2122.5	3.611	40	0.090	Over-utilized
Power tiller	5930.9	55.827	6230	0.008	Over-utilized
Urea	3298.3	58.588	16	3.661	Under-utilized
MoP	194.4	-13.141	16	-0.821	Over-utilized
TSP	2388.9	5.705	22	0.259	Over-utilized
Irrigation	11067.9	8.607	400	0.021	Over-utilized
Pesticide	2385.2	48.336	166	0.291	Over-utilized

Source: Authors' estimation based on field survey, 2019-2021.

3.6 Efficiency of resource use of Boro rice production

Resource use efficiency implies how efficiently the farmer can use their resources in production process. For determining resource use efficiency, eight input factors namely human labor, seed, power tiller, Urea, MoP, TSP, irrigation and pesticide were considered. It is apparent from the Table 6 that farmers had chances of increasing per hectare output of *Boro* rice by utilizing more TSP and Urea at favorable and submergence ecosystems. The study also found that farmers had no scope for the enhancement of yield by utilizing more labor, seed and irrigation as favorable ecosystem as well as submergence ecosystems.The ratio for power tiller, urea, MoP and pesticide under favorable ecosystem was negative which means additional input of these two factors bring no benefit but incur losses. Excessive supply of inputs was the one explanation for the farmer's overutilization of inputs. Another reason was the absence of proper knowledge on efficient resource management. The result was similar to Osti *et al.* (2017) where the authors exposed that organic manures, potassium fertilizer and human labor were over utilized and land was under-utilized in monsoon rice production. For spring rice, land and seed were under-utilized and potassium fertilizer, human labor and irrigation were over utilized.

3.7 Problems faced by the farmers producing Boro rice production

A range of problems were faced by the farmers in producing *Boro* rice in the study areas. The extent and frequency of the problems professed by the farmers was measured according to their perceptions. From farmers' experience point of view, six major problems were identified. It is evident that low price of paddy and lengthy water logging condition were the major problems which were ranked as 1st in both favorable and submergence ecosystems (Table 7). The findings seem to be consistent with Kamruzzaman and Uddin (2020) where authors found that lower price of output, early flash flood inundation and lack of short-duration and high-yielding variety were found the major constraints faced by the farmers in *haor* ecosystem.

Table 7. Problem facing index for *Boro* rice farmers

Identified problems	Frequently (3)	Occasionally (2)	Rarely (1)	Not at all (0)	PCI	Rank order
Favorable ecosystem						
Scarcity of labor	22	9	6	3	90	3
High price, low quality and non-availability of inputs	20	7	8	5	82	5
Lack of short-duration and high-yielding variety	20	8	7	5	83	4
Low price of paddy	25	8	6	1	97	1
Lack of storage and transportation facilities	20	10	7	3	81	6
Lack of training and extension support	24	7	6	3	92	2

Identified problems	Frequently (3)	Occasionally (2)	Rarely (1)	Not at all (0)	PCI	Rank order
Submergence ecosystem						
Scarcity of labor	22	10	6	2	92	3
High price, low quality and non-availability of inputs	20	10	6	4	86	5
Lack of short-duration and high-yielding variety	18	12	5	5	83	6
Lengthy water logging condition	26	8	4	2	98	1
Low price of paddy	24	9	4	3	94	2
Lack of training and extension support	20	12	5	3	89	4

Source: Authors' estimation based on field survey, 2019-2021.

Note: Calculation of PCI score for the problem of scarcity of labor

PCI score of favorable ecosystem farmers = (22×3) + (9×2) + (6×1) + (3×0)= 90

PCI score of submergence ecosystem farmers = (22×3)+(10×2)+ (6×1) + (2×0)= 92

PCI scores for rest of the problems were computed accordingly.

4. Conclusion

The study concludes that *Boro* rice production resulted in the maximum profit for the farmers at submergence ecosystem compared to favorable ecosystem in the study areas. Functional analysis implied that farmers could be augmented their net return with more investment on labor cost, seed cost and irrigation cost at both favorable as well as submergence ecosystems. Though farmers inefficiently used their maximum resources, *Boro* rice could be efficiently produced by increasing the use of TSP at favorable ecosystem and Urea at submergence ecosystem. The study exposed that low price of paddy and lengthy water logging condition were the major problem for the production of *Boro* rice. Considering the findings of the study, some essential policy recommendations have been arisen which are: short-duration and stress-tolerant rice varieties should be made available for enhancing profitability considering the submergence agricultural environment; effective training and extension services should also be extended for proper and optimum resource utilization.

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FINANCIAL AND ECONOMIC PROFITABILITY OF SELECTED SPICES CROPS IN BANGLADESH

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Abstract

The study was undertaken to estimate the financial and economic returns and competitiveness of selected spices crops in Bangladesh. A total of 1620 spices growers from nine upazilas of three districts were randomly selected for the study. Domestic resource cost (DRC) was estimated for evaluating the comparative advantage of selected spices crops. The study revealed that the gross margins of producing selected spices crops were positive. However, highest gross margin was estimated for garlic (Tk 229568/ha) followed by green chilli (Tk 212002/ha) and onion (Tk.188389/ha). Comparatively low net return was calculated for onion (Tk 130179/ha) than other two spices crops. The highest benefit cost ratio was found for green chilli (1.83) followed by onion (1.74) and garlic (1.71). The estimates of DRC showed that Bangladesh had comparative advantage in onion and garlic production as these estimates were less than one implied that the production of onion and garlic would be highly efficient for import substitution. Again, DRC for green chilli was also less than unity implied that the production of green chilli would be efficient for export promotion. Responded farmers mentioned that low market price at harvesting time and market syndicate were the major constraints to spices production. The constraints include fertilizer not working properly due to adulterations, crisis of labour at harvesting time and high wage rate in the study areas. Government should take initiatives for ensuring reasonable price at harvesting time. Mechanization should be introduced to the farmers' field for minimizing the labour crisis.

Keywords: Spices crops, Financial and Economic profitability, DRC, Import and Export parity

1. Introduction

Spices crop are important as food and medicine. The common use of spices is in cooking and seasoning of foods in order to bring out attractive color and natural taste of cuisines (Nahar, 2017). Spices can be described as that kind of plant that adds flavor, aromatic, aesthetic and therapeutic value treatment for food, drink and other items (Kumar *et al.* 2011). A number of natural ingredients are available in spices crops that boost human immunity (Islam et al. 2011). Globally, 109 kinds

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of spices are cultivated of which 27 types of spices are frequently used in Bangladesh (Prity, 2018). The spices demand in Bangladesh is growing steadily due to its diverse uses, changing human consumption patterns and rapid population growth (Huda et al. 2008; Mila and Parvin, 2019). The annual production of spices is 29.96 lakh metric tonnes in 2019-20 from a paltry 4.18 lakh tonnes in 2001-02. Conversely, the area coverage of spices was 10.47 lakh acres in 2019-20 from 6.23 lakh acres in 2001-02 (BBS, 2020). Although area coverage of spices and its production in Bangladesh are rising (Fig. 1), but the country has to expound nearly 4000 core BDT by importing during 2018-19 from different countries (BBS, 2019). Therefore, domestic production should be increased in the coming years in order to reduce import dependency. For this, information on financial and economic profitability of spices crops is very important. This will enable the government to redesign production, marketing and trade policies for spices in Bangladesh.

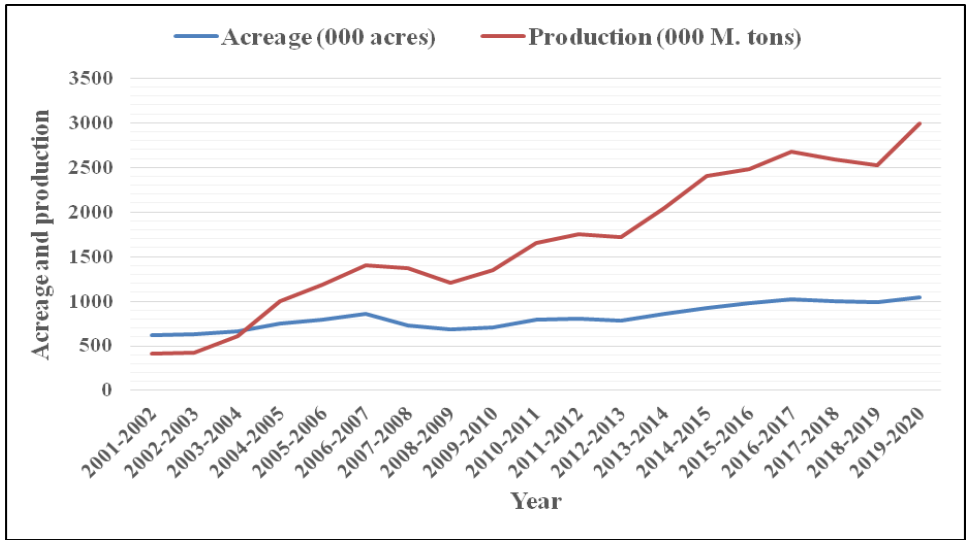

Fig. 1. Acreage and production of major spices in Bangladesh (Source: BBS, 2020)

Profitability data can be used to better understand and evaluate farm operations of different agricultural products. As a result, better farm-level decisions may be made, and as such marketing efficiency and performance can be improved. Due to scarcity of resources, production economists have begun to consider reallocating existing resources to generate more output with a given level of input combinations or to generate a certain level of output at the lowest possible cost without modifying the production technique. However, there is an insufficiency of data on how to use inputs efficiently in crop production. Likewise, analyzing productive efficiency in agricultural output is critical since it provides important information for making appropriate resource allocation decisions. Except for a few descriptive studies, econometric analysis is yet to be conducted to examine the production

function for crops cultivation and its potential for future improvement. To formulate appropriate planning for the sustainable development of agriculture sector, reliable data on crop production are urgently needed. Hence, the study may be very worthwhile in providing necessary socioeconomic information about a variety of crops to all stakeholders in the crop production sector.

The specific objectives of the present study were as follows:

i. to determine the level of input use and estimate the cost and return of selected spices crops cultivation at farm level;

ii. to estimate the economic returns and competitiveness of some selected spices crops in Bangladesh; and

iii. to identify problems and opportunities related to selected spices crops cultivation at farm level.

2. Methodology

Crops considered: Three spices crops namely onion, garlic and green chilli have been considered in this study.

Sampling design and data collection method: Both qualitative and quantitative data have been required for this study. Quantitative data have been collected through questionnaire survey at farm level in the selected areas and qualitative data have been assembled through secondary information. For questionnaire survey, both multi-stages and random sampling techniques have been adopted to select sample farm households for collecting primary data and information. Priority in selection of study areas was specified to the intensity of area coverage by respective crops and regional differences in Agro-ecological zones. In each selected location (district), 3 upazilas have been chosen purposively for the survey. The upazilas and villages have been selected by respective scientists and consultation with local DAE officials. A complete list of farmers growing different crops in all selected villages have been collected from local DAE offices. A total of 1620 farm households (180 for each location and for each crop) have been selected randomly for data collection.

Analytical technique: Collected data have been edited and scrutinized for analysis. Most appropriate, available and necessary descriptive methods, tools and techniques have been used for data analysis. Tabular and diagrammatic analyses have also been carried out. In this study, costs and returns analyses have been done on both variable and total cost basis. Per hectare profitability of growing selected crops from the viewpoints of individual farmers was measured in terms of gross return, gross margin and net return.

Measurement of Financial Costs and Returns: In this study, costs and returns analyses have been done on both variable and total cost basis. The following equation (Π) have been used to assess the financial profitability of selected crops.

$$\Pi_{ij} = \sum_{i=1}^{n} P_{ij}Q_{ij} - TC_{ij} = \sum_{i=1}^{n} P_{ij}Q_{ij} - (VC_{ij} + FC_{ij}) \text{ ----------(1)}$$

Where,

Π_{ij} = Profit or value addition from selected crop production

Q_{ij} = Quantity of crops of i^{th}farmers (kg/ha)

P_{ij} = Average price of crops of i^{th}farmers (Tk/kg)

TC_{ij} = Total cost (Tk/ha)

VC_{ij} = Variable cost (Tk/ha)

FC_{ij} = Fixed cost (Tk/ha)

i = Number of farmers (1,2,3……...n)

j = Number of crops (1,2,3.....25)

Per hectare profitability of growing selected crops from the viewpoints of individual farmers was measured in terms of gross return, gross margin and net return.

Gross return: Gross return was calculated by simply multiplying the total volume of output with its per unit of price in the harvesting period.

Gross margin: Gross margin calculation was done to have an estimate of the difference between total return and variable costs. The argument for using the gross margin analysis is that the farmers of Bangladesh are more interested to know their return over variable costs.

Net return: The analysis considered fixed cost (which included land rent and family supplied labour). Net margin was calculated by deducting all costs (Variable and Fixed) from gross return.

Measurement of Economic Costs and Returns

Measures of comparative advantage: Comparative advantage in the production of a given crop for a particular country is measured by comparing its border price with the social or economic opportunity costs of producing, processing, transporting, handling and marketing an incremental unit of commodity. The domestic resource cost (DRC) provides a measure of efficiency, with implications for the level of incentives offered to producers. Whether it is efficient for a country to produce a commodity as opposed to importing it, depends on the opportunity cost of domestic production relative to the value added it creates in foreign currency.

The DRC is the ratio of the cost in domestic resources and non-traded inputs (valued at their shadow prices) of producing the commodity domestically to the net foreign exchange earned or saved by producing the good domestically.

Formally DRCs is defined as

$$DRC = \frac{\text{Cost of domestic resource and non-traded inputs for producing per unit of output}}{\text{Value of tradable output} - \text{Value of tradable inputs}}$$

$$DRC = \frac{\sum f_{ij} P_j^d}{U_i - \sum a_{ik} P_k^b} \text{ ----------(2)}$$

Where,

f_{ij} = Domestic resource and non-traded inputs j used for producing per unit commodity i

P^d_j = Price of non-traded intermediate inputs and domestic resource

U_i = Border price of output i

a_{ik}= Amount of traded intermediate inputs for unit production of i

P^b_k = Border price of traded intermediate input

If DRC < 1, the economy saves foreign exchange by producing the good domestically either for export or for imports substitution. This is because the opportunity cost of domestic resources and non-traded factors used in producing the good is less than the foreign exchange earned or saved. In contrast, if DRC > 1, domestic costs are in excess of foreign exchange costs or savings, indicating that the good should not be produced domestically and should be imported instead.

Shadow Pricing of Inputs

- Land – Rental value of per unit of land will be applied for calculating the shadow price of land
- Labor – Market wage rate will be considered for shadow pricing because no substantial market imperfection exists in agricultural labor market
- Working capital – Interest rate for working capital
- Fertilizers– International prices will be used to calculate the import parity prices
- Seed – Actual market price

3. Results and Discussion

The aim of analyzing costs and returns is to determine the amount of profit a producer is making from a particular commodity production within the given technology and investment. This is important information in deciding on whether

to make an investment. The profitability of a commodity production crucially depends on its prices, cost of production, and availability of technology. Profitability depends on the costs involved in production and returns from its product. On the other hand, the amount of input use affects directly the cost. So, it is worthwhile to know the existing technology in terms of agronomic practices and input use in the area.

3.1 Financial and Economic Profitability of Onion

Pattern of input use for onion cultivation: Farmers in the study areas used various inputs for onion cultivation. They used on an average 290 man-days per hectare of total human labour for onion cultivation where family labour was 125 man-days and hired labour was 165 man-days. On an average, they sowed 8 kg seed per hectare of land. They applied on an average one-ton cowdung in each hectare of onion field. They applied Urea at the rate of 321 kg/ha, TSP 260 kg/ha, and MoP 217 kg/ha. (Table 3.1). In the study areas, farmers also applied zypsum (81 kg/ha), DAP (95 kg/ha), and zinc (12 kg/ha) for onion cultivation.

Table 3.1. Level of input use per hectare of onion cultivation

Particulars	Districts			All
	Pabna	Rajshahi	Faridpur	
Human labour (man-days)	289	295	286	290
Family	124	127	123	125
Hired	165	168	163	165
Seed (kg)	7	8	8	8
Cowdung (kg)	163	2749	229	1047
Urea (kg)	278	385	300	321
TSP (kg)	288	272	221	260
MoP (kg)	159	278	213	217
Zipsum (kg)	67	115	62	81
DAP (kg)	112	90	83	95
Zn(kg)	10	19	7	12

Source: Field Survey (2018-19).

Total cost of onion cultivation: The analysis revealed that total variable cost of onion cultivation was Tk. 120080 per hectare which was 69% of total cost of production (Table 3.2). The highest cost item was hired labour which accounted for about 27 % of the total cost. Cost of seed and irrigation accounted for about 8% and 6% respectively of total cost. The family labour and land use cost were Tk. 35358 and Tk. 18712 per hectare which accounted for about 20% and 11 % of total cost, respectively (Table 3.2). On average, the total cost of production was Tk. 174151 per hectare where 31% was fixed costs and 69 % was variable cost (Table 3.2).

Table 3.2. Per hectare cost of onion cultivation

Particulars	Districts				% of total cost
Variable costs:	**Pabna**	**Rajshahi**	**Faridpur**	**All**	
Land preparation	14403	13368	12928	13566	7.79
Hired labor	49476	50400	40806	46894	26.93
Seed	14409	12470	12470	13116	7.53
Cowdung	131	2199	229	853	0.49
Urea	4452	6159	4799	5137	2.95
TSP	8055	7616	6182	7284	4.18
MoP	2380	4176	3198	3251	1.87
Zipsum	2012	3443	1869	2441	1.40
DAP	3136	1440	2332	2303	1.32
Zn	768	1482	1318	1189	0.68
Irrigation	9533	11470	10461	10488	6.02
Insecticide	6528	9808	7723	8020	4.61
Weedicide	1730	1890	1084	1568	0.90
Growth hormone	1192	2766	886	1615	0.93
Sub-total	118205	128687	106285	117726	67.60
Interest on op. capital	2364	2574	2125.7	2355	1.35
Total variable cost (Tk./ha)	120569	131261	108411	120080	68.95
Fixed cost					0.00
Family labour	37182	38100	30792	35358	20.30
Land use cost	19960	19960	16217	18712	10.74
Total fixed cost (Tk./ha)	57142	58060	47009	54070	31.05
Total cost (Tk./ha)	177711	189321	155420	174151	100.00

Source: Author's own calculations from field survey (2018-19).

Table 3.3. Per hectare return from onion cultivation

Particulars	Districts			All
	Pabna	**Rajshahi**	**Faridpur**	
Yield (Ton)	14.19	18.12	12.63	14.98
Price (Tk./kg)	21	20	20	20
Gross return (Tk./ha)	297990	362400	252600	304330
Total variable cost (TVC)	120323	131261	96238	115941
Total fixed cost (TFC)	57142	92234	47009	65462
Total cost (TC)	177711	189321	155420	174151
Gross margin (Tk./ha)	177667	231139	156362	188389
Net return (Tk./ha)	120279	173079	97180	130179
BCR over total cost	1.68	1.91	1.63	1.74
Cost of production (Tk./kg)	12.52	10.45	12.31	11.76

Source: Author's own calculations from field survey (2018-19).

Financial profitability of onion: Per hectare average yield of onion was 14.98 ton and per kg average price was about Tk. 20. The average gross return and gross margin of onion cultivation were found Tk. 304330/ha and Tk.188389/ha respectively. Per hectare average net return was Tk. 130179 which was found to

be the highest in Rajshahi (Tk.173079) followed by Pabna (Tk.120279) and Faridpur (Tk.97180). BCR on total cost basis was found 1.74 which was also the highest in Rajshahi (1.91). It was estimated that, to produce one kilogram of onion, total cost incurred was Tk.11.76 (Table 3.3).

Table 3.4. Domestic resource cost (DRC) of onion (Import parity)

Particulars	Districts			All
	Rajshahi	Faridpur	Pabna	
A. Traded input (Tk/MT)	**1784**	**1744**	**1971**	**1833**
Urea	629	682	763	692
TSP	825	610	712	716
MoP	330	451	496	426
B. Non-Traded inputs and domestic resources (Tk/MT)	**10852**	**8849**	**10590**	**10097**
Human labour	6107	4884	5669	5553
Land preparation	1015	738	1024	925
Seed	1015	688	987	897
Manure	9	121	18	50
Pesticide	460	541	611	538
Irrigation	672	633	828	711
Int. on oprating capital	167	142	168	159
Land use cost	1407	1102	1284	1264
C. Output price (Tk/MT)	**27519**	**27519**	**27519**	**27519**
D. Value added (Tradable) (Tk/MT) (C-A)	25734	25775	25548	25686
E. DRC (B/D)-Import parity	**0.42**	**0.34**	**0.41**	**0.39**

Source: Author's own calculations

Economic profitability of onion cultivation: Domestic Resource Cost (DRC) indicates whether the domestic economy has a comparative advantage in producing onion crop relative to other countries. If the DRC is greater than one, it implies that the economy loses foreign exchange through domestic production of onion (in the sense that it uses more domestic resources than it generates net value added to tradable goods and services), while DRC is less than one implies that the production is efficient and make positive contribution to domestic value addition. The estimates of DRCs for onion crop for the year 2018-19 are presented in Table 3.4. The DRCs for onion crop was observed to be less than unity (0.39) implying that Bangladesh had comparative advantage in onion production for import substitution.

3.2 Financial and Economic Profitability of Garlic

Pattern of input use for garlic cultivation: Farmers in the study areas used various inputs for garlic cultivation. Farmers used on an average 268 man-days per hectare of total human labour for garlic cultivation where family labour was 138 man-days and hired labour was 130 man-days. On an average, they sowed 681 kg seed per hectare of land. They applied on an average 5.6 ton cowdung in the garlic

field. They applied Urea at the rate of 246 kg/ha, TSP 232 kg/ha, and MoP 186 kg/ha (Table 3.5). In the study areas, farmers also applied zypsum (77 kg/ha), DAP (129 kg/ha) and Zinc (17 kg/ha) for garlic cultivation.

Table 3.5. Level of input use per hectare of garlic cultivation

Particulars	Districts			All
	Pabna	Natore	Rajbari	
Human labour (man-days)	273	295	236	268
Family	156	139	120	138
Hired	118	156	115	130
Seed (kg)	695	675	672	681
Cowdung (kg)	2186	6151	8708	5682
Urea (kg)	224	283	231	246
TSP (kg)	226	229	242	232
MoP (kg)	194	197	166	186
Zypsum (kg)	104	57	71	77
DAP (kg)	64	92	230	129
Zinc (kg)	20	11	21	17

Source: Field Survey (2018-19).

Table 3.6. Per hectare cost of garlic cultivation

Particulars	Districts				% of Total cost
	Pabna	Natore	Rajbari	All	
Variable Cost:					
Land preparation	5613	3455	7774	5614	2.54
Hired labor	47280	54540	34440	45420	20.59
Seed	52125	50625	50400	51050	23.14
Cowdung	2186	6151	8708	5682	2.58
Urea	3841	4982	3897	4240	1.92
TSP	6363	6412	7247	6674	3.02
MoP	3331	3258	2634	3074	1.39
Zypsum	1252	684	1849	1262	0.57
DAP	2192	3171	7258	4207	1.91
Zinc	3175	1423	3037	2545	1.15
Irrigation	10225	12570	11472	11422	5.18
Insecticides	3865	4644	3897	4135	1.87
Sub-total	141448	151915	142613	145325	65.87
Interest on operating capital	2829	3038	2852	2907	1.32
Total variable cost (Tk./ha)	**144277**	**154953**	**145465**	**148232**	**67.18**
Fixed cost					
Family labour	62505	48597	35937	49013	22.21
Land use cost	20378	24949	24848	23392	10.60
Total fixed cost (Tk./ha)	**82883**	**73546**	**60785**	**72405**	**32.82**
Total cost (Tk./ha)	**227160**	**228499**	**206250**	**220637**	**100.00**

Source: Author's own calculations from field survey (2018-19).

Total cost of garlic cultivation: The study revealed that total variable cost of garlic cultivation was Tk. 148232 per hectare which was 67% of total cost of production (Table 3.7). The highest cost item was seed which shared about 23 % of the total cost. Hired labour cost accounted for about 21% of total cost and ranked second cost item. The family labour and land use cost were Tk. 49013 and Tk. 23392 per hectare which was accounted for about 22 % and 11 % of total cost respectively (Table 3.6). On an average, the total cost of production was Tk. 220637 per hectare where 33% was fixed costs and 67% was variable cost (Table 3.6).

Financial profitability of garlic cultivation: Per hectare average yield of garlic was 7.98 ton and per kg average price was about Tk.47.33. The average gross return and gross margin of garlic cultivation were found Tk.377800/ha and Tk.229568/ha respectively. Per hectare average net return was Tk.157163 which was found to be highest in Pabna (Tk.179390) followed by Rajbari (Tk.148600) and Natore (Tk.143501). BCR on total cost basis was found 1.71 which was more or less similar among the districts. It was estimated that, to produce one kilogram of garlic, total cost incurred about Tk. 28 (Table 3.7).

Table 3.7. Per hectare return of garlic

Figure in Tk.

Particulars	Districts			All
	Pabna	Natore	Rajbari	
Yield (Ton)	8.65	7.75	7.55	7.98
Price (Tk./kg)	47	48	47	47.33
Gross return	406550	372000	354850	377800
Total variable cost (TVC)	144277	154953	145465	148232
Total fixed cost (TFC)	82883	73546	60785	72405
Total cost (TC)	227160	228499	206250	220637
Gross margin	262273	217047	209385	229568
Net return	179390	143501	148600	157163
BCR over total cost	1.79	1.63	1.72	1.71
Cost of production (Tk./kg)	26.26	29.48	27.32	27.69

Source: Author's own calculations from field survey (2018-19)

Economic profitability of garlic cultivation: Domestic Resource Cost (DRC) indicates whether the domestic economy has a comparative advantage in garlic relative to other countries. If the DRC is greater than one, it implies that the economy loses foreign exchange through domestic production of garlic (in the sense that it uses more domestic resources than it generates net value added to tradable goods and services), while DRC is less than one implies that the production is efficient and make positive contribution to domestic value addition. The estimates of DRCs for garlic for the year 2018-19 are presented in Table 3.8. The DRCs for garlic was observed to be less than unity (0.27)

implying that Bangladesh had comparative advantage in garlic production for import substitution.

Table 3.8. Domestic resource cost (DRC) of garlic (import parity)

Particulars	Districts			All
	Pabna	Natore	Rajbari	
A. Traded input (Tk/MT)	**2554**	**3122**	**2933**	**2870**
Urea	832	1173	983	996
TSP	1063	1202	1304	1189
MoP	660	748	647	685
B. Non-Traded inputs and domestic resources (Tk/MT)	**23931**	**26912**	**23885**	**24909**
Human labour	12692	13308	9321	11774
Land preparation	649	446	1030	708
Seed	6026	6532	6675	6411
Manure	253	794	1153	733
Pesticide	447	599	516	521
Irrigation	1182	1622	1519	1441
Int. on operating capital	327	392	378	366
Land use cost	2356	3219	3291	2955
C. Output price (Tk/MT)	**95177**	**95177**	**95177**	**95177**
D. Value added (Tradable) (Tk/MT) (C-A)	92623	92055	92244	92307
E. DRC (B/D)-Import parity	**0.26**	**0.29**	**0.26**	**0.27**

Source: Author's own calculations

Table 3.9. Level of input use per hectare of green chilli

Particulars	Districts			
	Bogura	Jamalpur	Bhola	All
Human labour (man-days)	262	253	280	265
Family	95	88	102	95
Hired	167	165	178	170
Seedlings (no.)	22454	23952	26197	24201
Cowdung (kg)	2250	1980	2450	2227
Urea (kg)	375	360	378	371
TSP (kg)	350	325	495	390
MoP (kg)	201	215	205	207
Zinc sulphate (kg)	5	6	7	6
Boric acid (kg)	4	4	5	4

Source: Field Survey (2018-19)

3.3 Financial and Economic Profitability of Green Chilli

Pattern of input use for chilli cultivation: The human labour used for producing green chilli was found to be 265 man days per hectare of which 36% were family supplied (Table 3.9). The use of human labor was highest in Cumilla (280 man-days/ha) followed by Bogura (262 man-days/ha) and Sherpur (253 man-days). The average seedling used by the farmers was 24201/ha. On an average, farmers used

2227 kg of cow dung per hectare for producing green chilli.Green chilli farmers used different types of chemical fertilizers such as urea (371 kg/ha), TSP (390 kg/ha), MoP (207 kg/ha), Zinc sulphate (6 kg/ha) and Boric acid (4 kg/ha) in the study areas. Among the chemical fertilizers, TSP was used at a higher rate for producing green chilli in the study areas.

Cost of green chilli cultivation: The study revealed that on an average total variable cost of green chilli cultivation was Tk.134047 per hectare which was 71% of total cost of production (Table 3.10). The highest cost item was hired labour which accounted for about 31% of the total cost. Pesticides cost accounted for about 8% of total cost and ranked second in the study areas. The average cost of green chilli production was Tk 189701 per hectare of which 29% was fixed costs and 71% was variable cost (Table 3.12).

Table 3.10. Per hectare cost of green chilli cultivation

Figure in Tk.

Particulars	Districts				% of total cost
	Bogura	Jamalpur	Bhola	All	
Variable cost					
Land preparation	7484	7904	8982	8123	4.28
Hired labor	58450	57750	62300	59500	31.37
Seedlings	11227	11976	13099	12101	6.38
Cowdung	3375	2970	3675	3340	1.76
Urea	8250	7920	8316	8162	4.30
TSP	9100	8450	12870	10140	5.35
MoP	3216	3440	3280	3312	1.75
Zinc sulphate	750	900	1050	900	0.47
Boric acid	480	480	600	520	0.27
Irrigation	7550	6916	5988	6818	3.59
Bamboo stick	3421	4210	3850	3827	2.02
Pesticides	15550	13227	15250	14676	7.74
Sub-total	128853	126143	139260	131419	69.28
Interest on op. capital	2577	2523	2785	2628	1.39
Total variable cost	131430	128666	142045	134047	70.66
Fixed cost					
Family labor	33250	30800	35700	33250	17.53
Land use cost	21207	22454	23550	22404	11.81
Total fixed cost	54457	53254	59250	55654	29.34
Total cost	185887	181920	201295	189701	100.00

Source: Author's own calculations from field survey (2018-19)

Financial profitability of green chilli: The average yield of green chilli was 15.85 t/ha in the study areas while it was highest in Bogura (16.56 t/ha) followed by Bhola (15.55 t/ha) and Jamalpur (15.45 t/ha) (Table 3.11). The average gross return, gross margin and net return of green chilli were found to be Tk 346049/ha, Tk 212002/ha and Tk.156348/ha, respectively. Average benefit cost ratio was

found to be 1.83 on the basis of total cost. The average cost of producing per kg of green chilli was Tk.11.98 (Table 3.11).

Table 3.11. Per hectare returns from green chilli

Figure in Tk.

Particulars	Districts			All
	Bogura	Jamalpur	Bhola	
Yield (ton)	16.56	15.45	15.55	15.85
Price (Tk/kg)	21.55	21.45	22.5	21.83
Gross return	356868	331403	349875	346049
Total variable cost (TVC)	131430	128666	142045	134047
Total fixed cost (TFC)	54457	53254	59250	55654
Total cost (TC)	185887	181920	201295	189701
Gross margin	225438	202737	207830	212002
Net return	170981	149483	148580	156348
BCR over total cost	1.92	1.82	1.74	1.83
Cost of production (Tk/kg)	11.23	11.77	12.95	11.98

Source: Author's own calculations from field survey (2018-19)

Table 3.12. Domestic resource cost (DRC) of green chilli (Export parity)

Particulars	Districts			All
	Bogura	Jamalpur	Bhola	
A. Traded input (Tk/MT)	**1944**	**2013**	**2463**	**2140**
Urea	727	748	781	752
TSP	860	856	1295	1003
MoP	357	409	388	385
B. Non-Traded inputs & domestic resources(Tk/MT)	**9705**	**10211**	**11029**	**10315**
Human labour	5537	5731	6302	5857
Land preparation	452	512	578	514
Seedlings	678	775	842	765
Bamboo stick	207	272	248	242
Pesticide	939	856	981	925
Irrigation	456	448	385	430
Int. on operating capital	156	163	179	166
Land use	1281	1453	1514	1416
C. Output price (Tk/MT)	91042	91064	91062	91056
D. Value added (Tradable) (Tk/MT) (C-A)	89098	89051	88599	88916
E. DRC (B/D)-Export parity	**0.11**	**0.11**	**0.12**	**0.12**

Source: Author's own calculations

Economic profitability of green chilli: Domestic Resource Cost (DRC) indicates whether the domestic economy has a comparative advantage in producing green chilli crop relative to other countries. If the DRC is greater than one, it implies that the economy loses foreign exchange through domestic production of green chilli (in the sense that it uses more domestic resources than it generates net value added

to tradable goods and services), while a DRC less than one implies that the production is efficient and makes positive contribution to domestic value addition. The estimates of DRCs for green chilli for the year 2018-19 are presented in Table 3.12. The DRCs for green chilli was observed to be less than unity (0.12) implying that Bangladesh had comparative advantage in chilli production for export promotion.

3.4 Problems faced by the farmers in spices cultivation

Although the farmers in the study areas are cultivating onion, garlic and green chilli, so there were several problems to its higher production. The most acute problem for spices cultivation in all areas was low market price at harvesting time (75%). The other problems were lack of quality seed (25%) and low rate of seed germination (24%) might be due to adulterations, crisis of labour at harvesting time (27%) and high wage rate (13%). They also mentioned that due to severe infestation of insect (15%) and diseases (15%), spices yield drastically reduced and it led to heavy loss to the growers. They also opined the problems like, lack of storage related facility and high price of fertilizer (Table 3.13).

Table 3.13. Problems faced by the farmers in spices cultivation

Particulars	% Farmer responded			
	Pabna	Raj-shahi	Farid-pur	All
Seed related problem				
Lack of good quality seed	33	6	36	25
High price of seed	10	4	19	11
Adulterated seed	26	23	24	24
Fertilizer related problems				
High price of fertilizer	24	46	22	31
Adulterated fertilizer	21	19	24	21
Insect and disease related				
Infested with white fly	13	11	14	13
Leaf rust disease	15	11	12	13
Dandruff or early digestive disease	12	16	17	15
Attack by Fusarium fungus & leaves fall off	13	12	16	14
Labour related problems				
Crisis of labour	51	18	13	27
High wage of labour	13	14	12	13
Loan/Credit related problem				
Trouble in getting govt. loan	13	16	18	16
Store related problems				
Lack of technical knowledge of storing	14	10	12	12
Rotten when storing for several days	13	12	16	14
Marketing related problem				
Lower market price	74	76	74	75

3.5 Remedial measures for spices cultivation

- Government should take initiatives regarding reasonable price of selected spices at harvesting time
- Government should ensure the supply of good quality seed and fertilizer in time.
- DAE personnel (with the help of relevant scientists) should frequently visit to the farmer's field.
- Mechanization technology should be introduced to the selected spices cultivation to minimize labour crisis.

4. Conclusion

This study estimated financial and economic profitability of spices (Onion, Garlic and green chilli) cultivation in selected growing areas based on of net returns, gross margins and undiscounted BCRs. Results show that all the estimates of net returns, gross margins and the undiscounted BCRs are positive. This means that the production of spices crop were profitable for the farmers at the current market conditions. DRC indicates whether the domestic economy has a comparative advantage in spices production relative to other countries. The estimates of economic profitability used Domestic Resource Cost (DRC) for onion, garlic and green chilli were observed to be less than unity implying that Bangladesh had comparative advantage in production of onion and garlic for import substitution and green chilli production for export promotion. There are several constraints of selected crops to its higher production. The first and the foremost constraint for selected spices crops in all areas were low market price at harvesting time and market syndicate. Responded farmers mentioned that due to severe infestation of insect and diseases selected spices crops yield were drastically reduced and it led to heavy loss to the growers. The constraints include fertilizer not working properly due to adulterations, crisis of labour at harvesting time and high wage rate in the study areas. Government should have initiatives for ensuring reasonable price at harvesting time. DAE personnel should frequently visit the farmers field. Mechanization should be introduced to the farmers field for minimize the labour crisis.

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MARKETING AND VALUE CHAIN ANALYSIS OF GINGER: A STUDY IN SELECTED AREAS OF BANGLADESH

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Abstract

Ginger is one of the most common and popular high value spice crop and is widely used both in medicinal and culinary purposes. The study was undertaken to determine marketing system, marketing cost, margin, efficiencies and to examine the value chain of ginger aiming at determining the value addition in different steps of ginger marketing. A purposive and simple random sampling procedure was used in selecting primary data. Four major marketing channels were identified for domestic produced ginger marketing. Channel-3 was the most important supply chain through which 48 percent domestic produced ginger reaches to consumers. Marketing margin and profit were the highest in retailer than those of other intermediaries. Six actors like; farmer, local trader, trader, commission agent, wholesaler, retailer and consumer are identified who are involved in the ginger value chain activities. Farmer added the highest amount of value per unit of ginger and that of the lowest in wholesalers. Eleven marketing problems were identified, among them price fluctuation, high transport cost and lack of loan facilities were the major problems. It is therefore, recommended that government intervention is urgently needed to stabilize the price of ginger, loan facilities should be provided to the intermediaries and transportation cost should be kept reasonable.

Keywords: Ginger, marketing system, marketing efficiency and value chain

1. Introduction

Ginger has been used throughout recorded history for both medicinal and culinary purposes. Ginger is also used for the preparation of ginger oil, oleoresin, essences and tinctures (Bose *et al.*, 1999). It is a principal ingredient in the Bangladeshi kitchen as curry paste. More people are discovering its culinary splendor, and producers have found ginger to be a potentially highly profitable crop. Bangladesh produces 84.89 thousand metric tonnes of ginger per year that are mostly added in value chain activities (BBS, 2020). In most cases, poor storability and seasonality lead to market variations in quantity and quality of ginger and its associated price

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swings. The rising consumer price for ginger may be an indication of market inefficiency. The nonfarm dimensions of rural development – particularly in agricultural marketing and agro-processing often prove critical to successful agricultural growth (Abbott, 1986). Without well-functioning agricultural markets, productivity gains on the farm lead to temporary production surges and price collapses. Improved market access proves necessary for maintaining production incentives, permitting household specialization and enabling movement to high-value products and to value-added activities. Value chains provide a valuable visual framework for understanding the structural connective tissue linking small farmers with input suppliers, processors, traders and final consumers.

In highly competitive and increasingly global agribusiness markets, poor households must find niches in which they can compete effectively in the rapidly growing urban, rural and export markets. Yet the large agribusiness that increasingly drive change in agricultural value chains seek to reduce costs and raise profits, often by scaling up production and market share, reducing the number of suppliers they deal with and squeezing supplier prices (Reardon and Timmer, 2007). Marketing in developing countries such as Bangladesh is beset with a lot of problems, which constitute a bottleneck to the flow of goods and services. Such problems include seasonal variations, transportation of harvested produce, storage, processing, grading and communication (Ikechi, 2006). According to Arene (1999) efficiency is used to evaluate marketing performance. Performance can be achieved using the following approaches-marketing margin, net-returns and marketing efficiency ratios. Therefore, there is the need to assess the performance of the market to determine the efficiency of the ginger marketing system in Bangladesh. Despite the research and development efforts in improving the production and productivity of ginger in Bangladesh, little has been done to improve the performance of the entire ginger value chain.

But there is no policy to encourage farmers to produce exportable surplus, consequently, supplies are often unreliable. There is lack of information regarding markets for ginger, especially among the producers and traders. Farmers do not get fair price because of their low bargaining power, lack of market information, poor storage facilities, immediate cash need, etc. Therefore, the study was taken to measure the existing marketing system, marketing margin, marketing efficiency and finally to examine the value chain of ginger aiming at determining the value addition in different steps of marketing channel. The study is important to businessmen, farmers as well as to policy makers for planning future production, import, export, price stabilization measures, etc.

2. Methodology

Primary data were used for the study. For the collection of primary data, Nilphamari and Lalmonirhat districts were selected purposively depending upon the concentration of production and commercially marketing of ginger. In these study

areas, three types of markets such as primary, secondary and consumer market were selected. However, to examine the value chain of ginger aiming at determining the value added to marketed ginger in different steps of marketing channel, city markets of Dhaka and Rajshahi were selected. Purposive and simple random sampling techniques were used to pick a sample. A total of 80 farmers taking 40 from each area were selected randomly. Twenty four local traders (collectors), 30 traders, 10 commission agents, 20 wholesalers and 30 retailers were selected from the above selected areas including major consuming areas in Dhaka and Rajshahi. Two sets of pre-tasted interview schedule, one for farmers and the other for intermediaries were used for collection of data using survey method. Primary data were collected by face-to-face interview during 2016-17 cropping season.

Analytical technique

The collected data and information were reduced to tabular form which included classification of tables into meaningful results by using arithmetic mean, percentage and ratio. For ginger marketing, intermediaries involved in marketing channel were identified and marketing costs and margins, and profits of intermediaries were determined by using tables and flow diagrams. Value chain and value addition to ginger were shown by using flow channel and table. Except this the following analytical techniques were used for the study.

Cost and return Analysis: Following profit equation was employed to assess the profitability of production.

$$\pi = P_F.Q_F - (TVC + TFC)$$

Where, π=Profit of producer per hectare, P_F = per unit price of ginger (Tk/qt), Q_F = Quantity of ginger (Qt/ha), TVC = Total variable cost ginger, TFC = Total fixed cost of ginger

Marketing Efficiency: Efficient marketing plays an important role in increasing the producer's share in consumer's taka and maintains the tempo of increased production. Three indicators were used for measuring efficiency in different marketing channels. These indicators are (i) marketing cost; (ii) marketing margin and (iii) Percentage of producer's share of ginger

Marketing cost: The total marketing cost was determined by the following formula

$$Tc = Cp + \sum Mci$$

Where, Tc= Total cost of marketing, Cp= Producer cost of marketing

Mci= Marketing cost by the ith trader

Marketing margin: The absolute margin of the middleman, wholesaler, trader and retailers were determined by the following formula

$$MM = SP - PP$$

Where, MM= Marketing margin, SP= Selling price, PP= Purchase price

The cost of marketing was calculated and the low cost marketing channel was ranked I and that which was the highest cost as the last. The same approach was followed in ranking the margin of middlemen in each channel.

Producer's share: The producer's share was calculated by the following formula and the channel which was highest producer's share was ranked (1) and first and vice-versa.

$$\text{Percentage of producers' share} = \frac{P_{pi}}{P_{ri}} X100$$

Where, P_{pi}= Producer's share in the ith channel, P_{ri}= Average price at the retail level in each channel, i= Number of channels (i=1, 2....., n)

Marketing efficiency: Marketing efficiency is a complicated topic to be defined. It carries different meanings to different persons. Four methods like i) Shephred Method ii) Acharya and Agarwal Method iii) Composite Index Method and iv) Marketing Efficiency Index Method are usually used to calculate the marketing efficiency. However, Composite Index method was followed to estimate marketing efficiency for the present study. As per this method, the percentage of producer's price, marketing cost, marketing margin and marketing profit per 100 kg of ginger was calculated and these were assigned ranks. Total scores were found by adding the respective ranks in each channel. The mean scores were calculated for each channel. Where the mean score was less, it was efficient channel.

$R = \frac{R_i}{N_i}$, Where, R_i= Total value of ranks of all indicators (I_1, I_2 and I_3), N_i= Number of indicators

Value Addition by traders

Value Addition= Gross margin-Marketing cost

Gross Margin=Sale price-Purchase price

3. Results and Discussion

Marketing and value chain system of ginger: Marketing is the connecting link between the producers and consumers. Through marketing system, ginger being a semi perishable commodity, reaches the consumer in acceptable condition. The marketing system operates through a set of intermediaries performing useful commercial functions in a chain all the way from the producers to the final consumers.

An efficient marketing system is essential for earning fair profit for the ginger farmers and traders. In the study areas, the whole marketing of ginger has been broken down into various functions such as buying and selling, transportation, grading, storing, weighing, market information and pricing.

Involvement stakeholders and intermediaries: The major intermediaries performed marketing functions are farmer, local traders, traders, commission agent, wholesaler, retailer and consumer.

Farmer: The farmers of Nilphamari and Lalmonirhat, sell their ginger at home to local trader or at local market to local trader or trader. In few cases, the farmer sold their ginger to wholesaler, retailer and consumer in order to have good price. The farmer sold 74% of their ginger to trader and 18% to local trader. Farmer also sold a few amount of ginger to wholesaler (5%) and retailer (2%) through commission agent (Table 1).

Local trader: Local traders are usually operating in the ginger marketing system who purchases small quantity (400-600 kg) of ginger from farmer from their houses or from the local market and carry it to the terminal point and sell 100% of ginger to trader (Table 1).

Trader: Traders are professional ginger traders and they purchased 74% of ginger from farmer and 26% from local trader and sold their consignment to the wholesalers (44%) and retailers (56%) through commission agents (Table 1). Usually, they purchase ginger from the farmer in local market and bring their ginger to different commission agent's centre for sale. They are professional businessmen and have wide experience in ginger marketing.

Commission agent: The commission agents are main actors in the ginger distribution system. A commission agent arranges or negotiates sales for the sellers on commission basis. The commission agent has a fixed establishment and helps the traders to sell their products and charges usually a fixed commission of Tk.50.11 per 100 kg ginger for sellers and Tk.100.00 for buyer for the same amount of ginger. They provide short period storage facilities and also help to perform the function of grading. Sometimes the commission agents advance loan to traders on the condition that the traders have to sell ginger through them. Commission agents are also organized and they need license for operating the business.

Wholesalers: Wholesalers are the secondary traders who transact large volume of product. They purchased most of the ginger (95%) from trader through commission agent from district market and sold their entire product to district or upazila retailer. Wholesaler sold 100% of their ginger to retailer.

Table 1. Percent of domestic produced ginger transacted by value chain actors

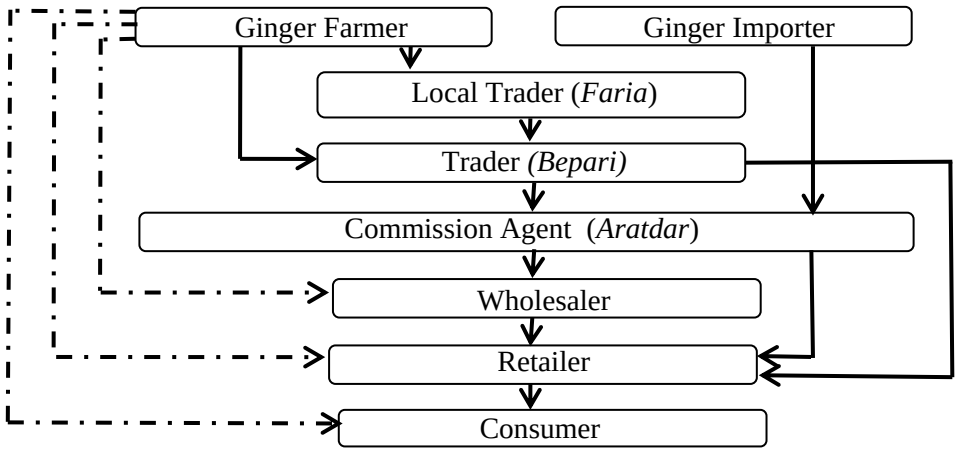
Value chain actor	Purchase from (%)					Sold to (%)				
	Farmer	Local trader	Trader	Wholesaler	Retailer	Local trader	Trader	Wholesaler cum CA*	Retailer cum CA*	Consu-mer
Farmer	100	-	-	-	-	18	74	5	2	1
Local trader	100	-	-	-	-	-	100	-	-	-
Trader	74	26	-	-	-	-	-	44	56	-
Commission agent	Commission agent negotiates between buyers and sellers of ginger and helps them at their own business premises on receipt of commission									
Wholesaler	5	-	95	-	-	-	-	-	100	-
Retailer	2	-	48	50	-	-	-	-	-	100
Consumer	1	-	-	-	99	-	-	-	-	-

Source: Field survey (2017) * Commission agent

Retailers: The retailers form the last link in the ginger marketing chain. They bought a large portion of ginger from wholesaler (50%) and traders (48%) through commission agent. Retailers sold the entire ginger to ultimate consumers (Table-1).

Marketing and Supply Channel of Ginger: Marketing channels are the alternative routes of product flows from producers to consumers (Kohls and Uhl 2005). The supply chain for ginger can involve a large number of stakeholders between farmer and the final consumer. The entire set of processes and activities required to produce a product and these deliver to a target market is considered as supply chain. Flow chart 1 showed the two ways distribution and supply chain of ginger. One is farmer produced which come to market after storage and processing. Other supply chain is where usually imported ginger is being distributed through marketing channel. Flow Chart 1 and Table 2 and Table 3 showed how ginger is being distributed from farmer or importer to ultimate consumers through intermediaries involved in supply chain of marketing system.

In the channel of ginger marketing in Bangladesh, the product moves from producer to ultimate consumer through a number of market intermediaries. There prevailed a several number of marketing channels of ginger in the study areas, which have been presented in Table 2. But all the channels were not equally important in the study area. Some channel handled only a negligible portion of supply of ginger. According to the volume of ginger handled and longevity or participation of the middlemen in the channel; the following four channels were identified as dominant in marketing of domestic ginger. So, the efficiency of the following four major channels was measured.



Flow Chart 1. Ginger marketing flow chart in Bangladesh (Solid lines are major flow and dotted lines are minor flow)

Table 2. Domestic produced ginger marketing channel in Bangladesh

Channel	Marketing channel	Ginger run (%)	Rank (I)
1.	Farmer→Local trader→Trader→ Commission agent →Wholesaler→ Retailer→ Consumer	18	III
2.	Farmer→Trader→ Commission agent →Wholesaler→ Retailer →Consumer	26	II
3.	Farmer→ Trader→ Commission agent → Retailer →Consumer	48	I
4.	Farmer→ Wholesaler→ Retailer →Consumer	5	IV
5.	Farmer→ Retailer →Consumer	2	V
6.	Farmer→ Consumer	1	VI

Source: Field survey (2017)

Table 2 showed, Channel-3 (Farmer → Trader → Commission agent → Retailer → Consumer) is the most important supply chain through which 48% domestically produced ginger reach to consumers. Twenty six percent (26%) of ginger runs through the Channel-2 (Farmer → Trader → Commission agent → Wholesaler → Retailer → Consumer) and 18% through Channel-1 (Farmer → Local trader → Trader → Commission agent → Wholesaler → Retailer → Consumer). Only 5% ginger run through the Channel-4 from farmer to consumer.

Marketing Cost, Margin and Profit of different Intermediaries: According to Kohls and Uhl (2005), marketing margin in a sense is the price of all utility adding activities and functions that are performed by the intermediaries. It is also termed as price spread as it represents the difference between the buying and selling price.

Total marketing margin is the difference between the price received by farmer and the price paid by the final consumers. Marketing margin and marketing cost are usually used to estimate the profitability of intermediaries involved in ginger marketing. However, marketing cost and marketing margin of respective categories of intermediaries are the main determinants of the profitability in marketing of ginger.

Table 3. Imported ginger marketing channel in Bangladesh

Channel	Marketing channel	Ginger run (%)	Rank (I)
1.	Importer→ Commission agent →Wholesaler→ Retailer →Consumer	44	II
2.	Importer→ Commission agent → Retailer →Consumer	56	I

Source: Field survey (2017)

Table 4. Marketing cost of involved in ginger trading in domestic market (Tk./100 kg)

Cost items	Farmer	Local trader	Trader	Commiss-ion agent	Whole-saler	Retailer	Total	% of total
Storage	6.11	5.12	6.25	-	10.21	-	27.69	2.28
Sorting	25.12	10.02	12.13	-	11.75	-	59.02	4.86
Weighing and Packaging	-	5.3	7.61	7.8	5.25	-	25.96	2.14
Loading and unloading	-	-	30.24	-	25.11	-	55.35	4.56
Transportation	25.24	22.11	105.17	-	50.41	40.15	243.08	20.04
Market tolls	20.23	15.18	8.5	10.03	12.32	12.16	78.42	6.46
Wage and salaries	-	15.3	25.21	15.11	21.34	-	76.96	6.34
Commission	-	-	50.11	-	100	100.15	250.26	20.63
House/shop rent	-	-	12.06	8.55	6.25	9.42	36.28	2.99
Electricity	-	-	1.52	1.52	1.32	0.13	4.49	0.37
Telephone bill	-	1.5	3.31	2.43	1.21	1.1	9.55	0.79
Personal expenses	8.12	8.14	15.03	10.5	8.23	7.21	57.23	4.72
Tips and donation	-	10	8.21	5.51	6.23	3.42	33.37	2.75
Wastage	-	50.12	52.34	-	25.21	105.02	232.69	19.18
Others	2.1	2.12	2.08	12	2.45	2.13	22.88	1.89
Total	86.92 (7.16)	144.91 (11.9)	339.77 (28.0)	73.45 (6.1)	287.29 (23.7)	280.89 (23.2)	1213.2 (100)	100

Source: Field survey (2017). Note: Figures within parenthesis indicate percentage.

Marketing cost at different levels of market

Marketing costs represent the cost of performing various marketing functions which are needed to transfer a commodity from the place of production to the ultimate consumers. The payment of commission makes the marketing cost higher for trader, wholesaler and retailer, respectively. However, marketing costs per 100

kg of ginger were estimated to be Tk.86.92, 144.91 and 339.77 for farmer, local trader and traders, respectively. On the other hand, wholesaler and retailer expensed Tk 287.29 and 280.89 as marketing cost for ginger marketing, respectively (Table 4). Channel-wise marketing cost is shown in Table 5. It was observed that Channel -1 incurred the highest marketing cost (Tk.1213.23/100 kg) followed by Channel-2 (Tk.1068.32/100 kg) and Channel-3 (Tk.781.03). Lowest marketing cost was found in Channel-4 and it was Tk.665.10 (Table 5). Highest numbers of intermediaries were involved in Channel-1 which was the main reasons for higher marketing cost.

Table 5. Marketing cost of indigenous ginger for different major channel (Tk./100 kg)

Cost Items	Channel			
	Channel 1	Channel 2	Channel 3	Channel 4
Storage	27.69	22.57	12.36	16.32
Sorting	59.02	49.00	37.25	36.87
Weighing and Packaging	25.96	20.66	15.41	5.25
Loading and unloading	55.35	55.35	30.24	25.11
Transportation	243.08	220.97	170.56	115.8
Market tolls	78.42	63.24	50.92	44.71
Wage and salaries	76.96	61.66	40.32	21.34
Commission agent's commission	250.26	250.26	150.26	200.15
House rent/Shop rent	36.28	36.28	30.03	15.67
Electricity	4.49	4.49	3.17	1.45
Telephone bill	9.55	8.05	6.84	2.31
Personal expenses	57.23	49.09	40.86	23.56
Tips and donation	33.37	23.37	17.14	9.65
Wastage	232.69	182.57	157.36	130.23
Others	22.88	20.76	18.31	6.68
Total	1213.23	1068.32	781.03	655.1

Source: Field survey (2017).

Marketing margin and profitability: In respect of market margin and profitability of intermediaries involved at different levels, there is a variation in market scenario for ginger marketing. Marketing margin was relatively higher in retailer (Tk.1820/100 kg) followed by traders (Tk.835/100 kg), local trader (Tk.690/100 kg) and wholesaler (Tk.674/100 kg), respectively. On the contrary, marketing profit was the highest for retailer (Tk.1539.11/100 kg) followed by local trader (Tk.545.09/100 kg), trader (Tk.495.23/100 kg) and wholesaler (Tk.386.71/100 kg), respectively. The marketing profit of trader was the lowest due to highest marketing cost and highest purchase price of ginger.

Table 6. Marketing margin and profit of different intermediaries for ginger (Tk./100 kg)

Particulars	Intermediaries			
	Local trader	Trader	Wholesaler	Retailer
Purchase price (PP)	6900	7590	8425	9099
Marketing cost (MC)	144.91	339.77	287.29	280.89
Sales price (SP)	7590	8425	9099	10919
Marketing margin (MM=SP-PP)	690	835	674	1820
Marketing profit (MP=MM-MC)	545.09	495.23	386.71	1539.11

Source: Field survey (2017)

Marketing Efficiency: Marketing efficiency is directly related to the cost involved in moving goods from the producer to the consumer and the quantity of services offered. If the cost incurred when compared with the service involved, is low, it will be efficient marketing. The improvement of marketing efficiency means the reduction of marketing cost without reducing the quantum of services to the consumer. Marketing efficiency is a complicated topic to be defined. It carries different meaning to different persons. The term marketing efficiency is seen in different perspectives by the marketing personnel and economist. Kohls *et al*. (2005) defined marketing efficiency as the maximization of input output ratio.

Farmer's share under different marketing channel of ginger: Farmer's share in consumer prices of ginger in different marketing channels was the highest in Channel-4 followed by Channel-3 and Channel-2 and was lowest in Channel-1. It indicated that if farmer would sell their ginger through Farmer→Wholesaler→ Retailer →Consumer, they would be most benefited. Unnecessary marketing tiers develops when there is market imperfection or producer-seller are unorganized and while there is lack of market information or the cost of gathering information is high.

Table 7. Farmer's share under different major marketing channel of ginger (%)

Particulars	Channel-1	Channel -2	Channel -3	Channel -4
Farmers' price (Tk./100 kg)	6894	6896	6904	6906
Consumer/retail price (Tk./100 kg)	10950	10920	10905	10901
Percentage of farmers' share (%)	62.96	63.15	63.31	63.35
Rank (I_1)	IV	III	II	I

Source: Field survey 2017

Marketing cost and margin of different channels of ginger: The Channel-1 of ginger marketing has incurred highest marketing cost whereas the lowest in case of Channel-4 (Table 8). It reveals if farmer sell their ginger through Farmer→Local

trader→ Trader→ Commission agent→Wholesaler→ Retailer→Consumer, the marketing cost becomes high (Channel-1). On the other hand, if farmer sell their ginger through Channel-4 (Farmer→ Wholesaler→ Retailer →Consumer) then the marketing cost is the lowest. The data reveals that the highest margin in Channel-1 and the lowest in Channel-4.

Table 8. Marketing cost and margins of different marketing channel for ginger (Tk./100 kg)

Particulars	Channel-1	Channel-2	Channel-3	Channel-4
Farmers price	6894	6896	6904	6906
Consumer price/retail price	10950	10920	10905	10901
Marketing margin (MM)	4056	4024	4001	3995
Rank (I_2)	IV	III	II	I
Marketing cost (MC)	1213.23	1068.32	781.03	655.1
Rank (I_3)	IV	III	II	I

Source: Field survey (2017)

Table 9. Marketing efficiency ginger under composite index method

Marketing Channel	Score as performance indicators				
	Farmer's share (%) (I_1)	Marketing margin (Tk./quintal) (I_2)	Marketing cost (Tk./ quintal) (I_3)	Total score	Rank
Channel-1	62.96 (4)	4056 (4)	1213.23 (4)	12	IV
Channel -2	63.15 (3)	4024 (3)	1068.32 (3)	9	III
Channel -3	63.31 (2)	4001 (2)	781.03 (2)	6	II
Channel -4	63.35 (1)	3995 (1)	655.1 (1)	3	I

Figures in the parenthesis indicate 'Rank'

Source: Field survey (2017)

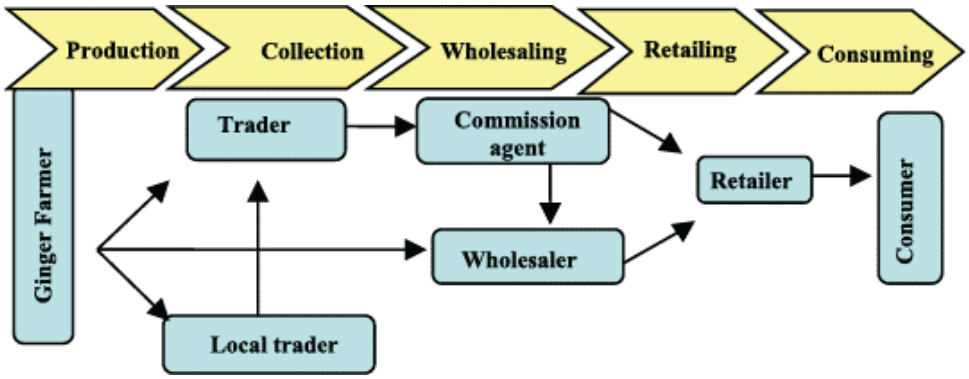
Efficiency of different marketing channels of ginger: The efficiency of different marketing channels was drawn as the basis of ranks of different performance indicators in different channels using composite index formula. The performance indicators revealed that the Channel-4 is more efficient than that of other channels (Table 9).

Value Chain Analysis of Ginger: Economic value chain analysis describes the range of activities required to bring a product to the final consumer and, in the case of international products, the extent to which intermediaries/agents gain from participating in the chain (Jacinto, 2004). A traditional food industry value chain consists of the producer, processor, wholesaler, exporter, importer, retailer and consumer. This study analyzed how market intermediaries operate along ginger value chains, and demonstrates how the revenue from ginger trade is distributed over the entire ginger value chain.

Value chain mapping: Value chain analysis plots the flow of goods and services up and down the chain, and between different chains. Mapping of value chains

obtains a clear understanding of the sequence of activities and the key actors and relationships involved in the value chain.

Figure 2. Value chains map of ginger in domestic market



In Bangladesh, ginger is produced mainly for the domestic consumption. Actors involved in the chain include the farmer, local trader, trader, commission agent, wholesaler, retailer and consumer, and products flow along the chain from one actor to another (Figure 2). The row at the top side showed different functions of the actors' respectively-production, collection, wholesaling, retailing and consuming. The diagram at the right side present all the actors involved—farmer, local trader, trader, commission agent, wholesaler, retailer and consumer, and the link and products flow between them.

Distribution of value addition: Each of the ginger value chain actors adds value to the product as the product passes from one actor to another. In a way, the actors change the form of the product through processing or improve the grade through sorting, cleaning or washing or create space and time utility. The distribution of value addition among the ginger value chain actors in Bangladesh is depicted in Table-10. Value addition is the difference in sales price and purchase price at each stage of the value chain. Ginger producers sold of Tk.6900/100 kg of ginger by adding a value of Tk.2062/100 kg which is about 40% of the total value added in Bangladesh. Local trader added value Tk.690 and that of trader Tk.835 per 100 kg of ginger which was 11.35 and 13.73% of the total value added, respectively. Wholesalers add the least (11.08%) and the retailers add Tk.1820/100 kg which is about 30% of the total value added (Table 10). The price change from producer's price and consumer price is 58%. The highest profit is earned by the retailers due selling high price of per unit of ginger to the consumer. The scale of operation of the retailers is small. On the other hand, the wholesalers make a small profit margin per unit of ginger handled but their operational scale is high making them the dominant value chain actors.

Table 10. Distribution of value addition among major chains of ginger (Tk./100 kg)

Value chain	Farmer	Local trader	Trader	Wholesaler	Retailer
Sale price	6900	7590	8425	9099	10919
Purchase price	4838	6900	7590	8425	9099
gross value added	2062	690	835	674	1820
% of total value added*	33.91	11.35	13.73	11.08	29.93

Value chain	Local trader		Trader	Wholesaler	Retailor	Consumer
Sale price	6900		7590	8425	9099	10919
Purchase price	4838	6900	7590	8425	9099	
Gross value added	2062	690	835	674	1820	
% of total value added*	33.91	11.35	13.73	11.08	29.93	

* Total value added=Tk.6081

Constraints in the ginger value chain: One of the merits of value chain approach is that it helps to clearly identify bottlenecks to the development of the chain right from input supply up until the consumption level in various ways. Table 11 summarized the constraints identified in this study which is common for all areas.

Table 11. Core constraints in ginger value chain

Input supply	Production	Marketing/ Trading	Processing	Retailing	Consumption
• Shortage of improved and quality seed • Damaged and spoiled seed due to poor transporting and handling	• Low yield • Poor disease control • Less targeted to seed production	• Perishability, • Low skill in post harvest management • Lack of storage facility	• Lack of processing facilities; • Low skill and technology for processing	• Lack of facilities; • Lack of capital	• Limited dishes/ recipes

Ten marketing problems were indicated by farmers in the study areas. Among them low price of ginger, price fluctuation, high transport cost, and lack of loan facilities were the major problem of farmer for marketing ginger in Bangladesh. Local trader reported price fluctuation, high transport cost, and lack of loan facilities were their main problem. Table 3.14 showed that value chain actor trader faced eight problems of which price fluctuation, high transport cost, lack of truck to transport and lack of loan facilities were their main problem. Cent percent traders cited that

price fluctuation and high transport cost are the major problems for ginger marketing. In the study areas, wholesalers indicated the main problem as price fluctuation, poor road and shortage of store house. On the other hand, retailers reported price fluctuation, poor road and perishability of ginger were their main problems (Table 12).

Table 12. Marketing problems of value chain actor for ginger marketing (% of respondents)

Marketing problem	Farmer (%) (N=80)	Local trader (%) (N=24)	Trader (%) (N=30)	Wholesaler (%) (N=20)	Retailer (N=30)
Low price of ginger	83	-	-	-	-
High seed ginger price	67	-	-	-	-
Price fluctuation	92	83	100	93	60
Bribery/donation	33	67	36	33	40
Lack of local market	29	28	-	-	-
High transport cost	83	89	100	53	33
Poor road	33	50	40	60	60
Shortage of truck to transport	-	-	89	47	43
Perishability	58	58	56	40	70
Shortage of store house	63	42	67	73	-
Lack of loan facility	85	78	93	43	50

Source: Computed from producer survey data;

Note: Multiple responses considered

Summary of Interventions

Input supply: Establish and/or strengthen cooperatives/groups that engage in ginger seed bulb production to achieve the economies of scale needed to meet producers' high demand for improved ginger seed. Introducing improved seed production and marketing system can significantly contribute to the solution. The ginger seed bulb producers can then be linked with ginger producers to create access to market for their business. Farmers continue to use local ginger variety from many times ago. Improved variety of ginger seed bulb replacement system should be put in place by involving the relevant stakeholders like Department of Agricultural Extension, NGO's, Research Institutions and Seed Producers. The system should enable farmers to replace the improved varieties at regular interval.

Storage facilities: Ginger is semi perishable agricultural product. In all the study areas lack of storage house and facilities for table and seed purpose ginger was raised by farmers and other actors as a priority problem. Low cost technology for

ginger storage should be developed and disseminates to the farmer. Except this, loan facilities should provided to farmer so, the farmer can made storage house for ginger.

Production: Producing diverse types of ginger varieties can create attractive market. From consumer surveys, it was learnt that preference for ginger varies from location to location and by consumer type. Institutions and restaurants prefer large sized ginger that can be easily peeled. Household consumers prefer medium sized pungent varieties. BARI Ginger-1 which is released from Spices Research Centre of BARI is a medium sized pungent variety. This variety is very preferable to consumer but seed is in short supply. BADC should produce huge amount of seed bulb of this variety; so that the farmer could get it easily. Ginger specific technical recommendations should be adequately disseminated to increase ginger production and productivity. The extension service should take up ginger as essential commodity and enhance its productivity.

Transportation: In the ginger market survey, it was observed that ginger is transported over long distance by packing gunny or netted bag. During loading and unloading, there is mishandling of the products which lead to quick spoilage and high loss. It is important to establish ginger transportation standards and enforce it;

Marketing: Market infrastructure should be developed in terms of quick transportation, proper storage and other physical facilities to reduce spoilage and damage. Organize and capacitate producers to enhance their negotiation power and skill. Create value chain forum at village level where the different value chain actors come together and discuss the problems of ginger value chain and solve them. Information technology (IT) service should be developed up to village. So, that the farmer and other value chain actor are able to know the market information easily.

Processing: Ginger processing facilities should be developed. Introduction of improved varieties of ginger will increase the supply. Along this, it is important to introducing ginger processing facilities that can induce consumption and also increase shelf life of the product. Involving the private sector in the enhancement of the processing of ginger can result in sustainability of the intervention.

Consumption: The demand for the product in the total consumption bundle of rural and urban consumers is small which means that the product fetches low price. The low consumption attributes to lack of knowledge to prepare different recipe, dishes, and products from ginger by most consumers in Bangladesh. Therefore, promotion of ginger utilization by demonstrating different ways of utilizing ginger for food can induce higher demand thereby motivating the producers to produce more.

4. Conclusion and Recommendations

The results of the study depicted that four major marketing channels were identified for domestic produced ginger marketing. Channel-3 was the most important supply chain of which through 48% domestic produced ginger reaches to consumers. Marketing costs per 100 kg of ginger were estimated at ranged from Tk.86.92 to 339.72 and marketing margin Tk.674 to 1820, respectively for different intermediaries. Marketing margin and profit were the highest in retailer than those of other intermediaries. Out of four marketing channel, Channel-4 was more efficient than those of other channels. Six actors like; farmer, local trader, trader, commission agent, wholesaler, retailer and consumer are identified who are involved in the ginger value chain. The study revealed that farmer added highest amount of value Tk.2062/100 kg ginger followed by retailer (Tk.1820), trader (Tk.835), local trader *(*Tk.690) and wholesalers (Tk.674) respectively. Eleven marketing problem were identified, among them price fluctuation, high transport cost and lack of loan facilities were the major and common problem for all kinds of intermediaries involved in ginger marketing in Bangladesh. A summary of the recommendations is given below-

Input supply: Establish and/or strengthen cooperatives/groups that engage in ginger seed bulb production to achieve the economies of scale needed to meet producers' high demand for improved ginger seed. Introducing improved seed production and marketing system can significantly contribute to the solution. The ginger seed bulb producers can then be linked with ginger producers to create access to market for their business. Farmers continue to use local ginger variety from many times ago. Improved variety of ginger seed bulb replacement system should be put in place by involving the relevant stakeholders like Department of Agricultural Extension, NGO's, Research Institutions and Seed Producers. The system should enable farmers to replace the improved varieties at regular interval.

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Centre of BARI is a medium sized pungent variety. This variety is very preferable to consumer but seed is in short supply. BADC should produce huge amount of seed bulb of this variety; so that the farmer could get it easily. Ginger specific technical recommendations should be adequately disseminated to increase ginger production and productivity. The extension service should take up ginger as essential commodity and enhance its productivity.

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Processing: Ginger processing facilities should be developed. Introduction of improved varieties of ginger will increase the supply. Along this, it is important to introducing ginger processing facilities that can induce consumption and also increase shelf life of the product. Involving the private sector in the enhancement of the processing of ginger can result in sustainability of the intervention.

Consumption: The demand for the product in the total consumption bundle of rural and urban consumers is small which means that the product fetches low price. The low consumption attributes to lack of knowledge to prepare different recipe, dishes, and products from ginger by most consumers in Bangladesh. Therefore, promotion of ginger utilization by demonstrating different ways of utilizing ginger for food can induce higher demand thereby motivating the producers to produce more.

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Appendix Table 1. Cost of ginger production in Bangladesh (Tk./ha)

Cost items	Small	Medium	Large	All
A. Variable cost	184312 (83.5)	182454 (83.0)	165038 (81.6)	177053 (85.2)
Land preparation	11440 (5.28)	13000 (5.92)	12480 (6.17)	12220 (5.88)
Sowing/Plantation	6500 (2.94)	7280 (3.31)	6240 (3.08)	6760 (3.25)
Manuring and fertilizer	2600 (1.18)	2080 (0.95)	1820 (0.90)	2080 (1.00)
Irrigation	260 (0.12)	520 (0.24)	260 (0.13)	260 (0.13)
Inter-cultural operation	46020 (20.85)	42900 (19.52)	41600 (20.56)	43420 (20.88)
Plant protection measures	1560 (0.71)	1300 (0.59)	1040 (0.51)	1300 (0.63)
Harvesting	32500 (14.72)	29900 (13.61)	28600 (14.14)	30420 (14.63)
Seed/seedlings	51000 (23.10)	51900 (23.62)	49500 (24.47)	50820 (24.44)
Power tiller/Ploughing	5850 (2.65)	5880 (2.68)	5820 (2.88)	5850 (2.81)
Irrigation	750 (0.34)	800 (0.36)	660 (0.33)	737 (0.35)
Manure	3030 (1.37)	3560 (1.62)	2907 (1.44)	3166 (1.52)
Urea	2880 (1.30)	3280 (1.49)	1728 (0.85)	2624 (1.26)
TSP	8558 (3.88)	8756 (3.98)	4730 (2.34)	7348 (3.53)
MP	6160 (2.79)	6120 (2.79)	3240 (1.60)	5180 (2.49)
Zink	600 (0.27)	400 (0.18)	400 (0.20)	400 (0.19)
Zypsum	710 (0.32)	650 (0.30)	580 (0.29)	650 (0.31)
Plant protection (Insecticides/fungicides)	3894 (1.76)	4128 (1.88)	3433 (1.70)	3818 (1.84)
Total variable cost	**83432 (37.79)**	**85474 (38.90)**	**72998 (36.08)**	**80593 (38.76)**
B. Fixed cost				
Lease value of land	33682 (15.26)	34547 (15.72)	34807 (17.20)	34345 (16.52)
Int. on op. capital	2765 (1.25)	2737 (1.25)	2476 (1.22)	2656 (1.28)
Total Fixed cost	36447 (16.51)	37284 (16.97)	37283 (18.43)	37001 (17.80)
Total cost (A+B)	**220759 (100)**	**219738 (100)**	**202321 (100)**	**214054 (100)**

Figures in the parenthesis indicate percentage.

Source: Field survey (2017).

Appendix Table 2. Per quintal cost of ginger production

Items	Small farmers	Medium farmers	Large farmers	All farmers
Seed ginger (kg/ha)	4610	4515	4390	4505
Total cost (Tk/ha)	220759	219738	202321	214054
Cost per quintal (Tk)	4789	4867	4609	4751

Source: Field survey (2017).

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FACTORS OF ADOPTION AND FARMERS' PERCEPTIONS ON IMPROVED LENTIL VARIETY CULTIVATION IN BANGLADESH

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Abstract

For a sector to be successful in bringing innovation at the farm level, an understanding of potential adopters and the factors influencing their adoption decision is important. Hence, this study investigated the determinants of adoption and explored farmers' perceptions on improved lentil variety cultivation at the farm level in Bangladesh. The study analyzed 360 household's data collected from 240 improved lentil variety adopters and 120 non-adopters spread in the six lentil growing districts namely Faridpur, Magura, Kushtia, Jhenaidah, Manikgonj, and Sirajganj. Along with descriptive statistics, the study used probit regression model for analyzing the data. About 71% of households adopted improved lentil varieties, and 29% used local cultivars. BARI Masur-8 was the highest adopted variety in the highly-intensive growing areas, whereas BARI Masur-6 and BARI Masur-4 were popular in the medium-intensive and low-intensive growing areas. Pulse training, profitability of production, farmers' innovativeness, and farmer's extension contact were the major factors of improved variety adoption. Most farmers wanted to increase improved lentil cultivation in the next year considering the higher yield and net benefits. On the contrary, a good proportion of lentil farmers also wanted to decrease lentil cultivation due to lack of suitable land, biotic and abiotic stresses, and seeds of improved variety.

Keywords: Factors of adoption, farmer's perception, improved lentil variety, Probit regression model, Bangladesh.

1. Introduction

Pulses are important food crops of Bangladesh as it supplies nutrition for human diet (Das et al., 2016.), provides feed for the animal (Miah et al., 2009), increase soil nutrient status by adding nitrogen, carbon and organic matter (Senanayake et al., 1987; Zapata et al., 1987; Sarker and Kumar, 2011), and improves farmers' livelihood by enabling additional income. The favourable climatic condition exists in Bangladesh for growing pulses. Different types of pulses are grown all over the country. The local production of pulses almost remained static in the last five years, causing a rise in imports of pulses to meet the growing demand. The cost for importing lentils has been increasing with an annual growth rate of 13.4% during the period from 2010-11 to 2019-20 to meet the growing demand (BBS 2015, 2018,

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2020). The per capita consumption of pulse in our country is only 15.7 g/day (HIES, 2016) which is much lower than the desirable intake of 50 g/day (DDP, 2013).

Lentils (*Lens culinaris*) are important protein-rich legumes. Among the pulse crops in Bangladesh, lentils placed the first position according to area coverage (40% of total pulse area) and production (45% of total pulse production). It is cultivated in different parts of the country covering 146.03 thousand hectares of lands producing 185.50 thousand metric tonnes per year with a productivity of 1.27 t/ha (BBS, 2022). It is the most consumed pulse in the country and also ranks first among the pulses in terms of consumers' preferences (Miah and Rahman, 1991; Afzal et al., 1999). The area and production of lentils were found fluctuating in nature, but the yield registered an increasing trend over the years. Figure 1 shows that the area and production of lentils started decreasing from 2000-01 and continued up to 2008-09 that might be due to susceptible crop and less remunerative in production. To halt this steady decline trend, Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have disseminated some improved lentil varieties and popularized them through different projects. Inclusion of these varieties in the cropping patterns replacing local by improved varieties might be increased the area, production, yield, and profitability of farmers. Hence the area, production, and yield of lentils further increased steadily from 2009-10 to 2019-20. However, the annual growth rates of the area decreased by 0.152%, while the growth rates of production (2.62%) and yield (2.77%) significantly increased during 2000/01-2019/20 due to the introduction of improved lentil varieties and technologies. However, various businesses and importers say that the country's yearly requirement for lentils is around 6-7 lakh MT (Daily Star, 2022). Therefore, the country has to import a huge amount of lentils every year to meet up the domestic demand.

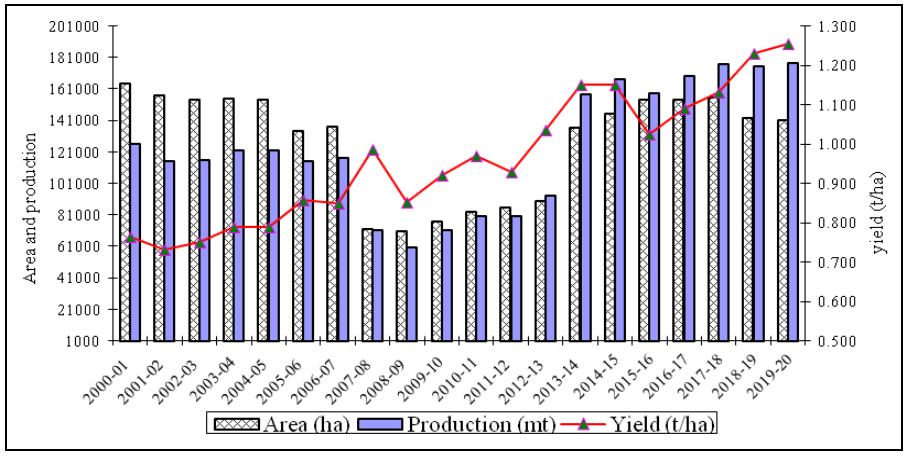

Figure 1: Trend of area, production, and yield of lentils in Bangladesh.

Source: Various issues of BBS (2021, 2016, 2011, 2006).

The scientists of BARI have been launching the pulse Research and Development program since 1991 and have developed nine improved lentil varieties along with their management technologies. BINA has also developed and disseminated seven improved lentil varieties since 2001. The lentil technologies so far developed have been disseminated in the farmers' fields through different agencies such as DAE, NGOs, and research institutes (*i.e.* BARI, BINA). The rate of adoption and sustainability of any crop depends largely on its profitability. The adoption decision involves a critical comparison of perceived benefits and costs associated with the technology (Uaiene, 2011). Economic viability is one of the important criteria for assessing the suitability of a new crop technology. Different studies conducted in the past (Miah et al., 2021a; Sarker et al., 2020; Matin et al., 2018; Tithi and Barmon, 2018; Hossain et al., 2016; Islam et al., 2015) revealed the suitability of improved lentil varieties adoption in terms of productivity and profitability for the adopting farmers.

The potential benefits of a new technology can only be realized when it is adopted and used properly. The variety-wise adoptions of any crop at the household level varied over time since their releasing periods are quite different. However, the current adoption status of BARI-developed improved lentil varieties are unknown to researchers and policymakers. Because a limited number of studies exist on the adoption of BARI improved lentil varieties (Miah et al., 2004; Miah et al., 2009; Rahman et al., 2012) in Bangladesh with varied conclusions. Most of these studies were conducted on a limited sample size covering a narrow geographical location. However, due to various unknown reasons, many farmers in the country are still reluctant to adopt these improved varieties that need to be explored. Again, an understanding of potential adopters and the factors influencing their adoption decision is important for a sector to be successful in bringing innovation at the farm level. However, the results of the present study will guide producers, research institutions, and policymakers in making prudent and informed decisions about allocating researches for technology development and the widespread cultivation of improved lentils in Bangladesh. With this view in mind, the study was undertaken to: (i) know the adoption status of improved lentil varieties at the farm level, (ii) explore the factors affecting the adoption of improved lentil varieties, and (iii) know the perception of farmers towards lentil cultivation.

2. Materials and Methods

2.1 Sampling design

A multi-stage sampling procedure was followed to select study areas and sample households. Based on the crop concentration index, the study was conducted in purposively selected six lentil growing districts of Bangladesh, taking Faridpur and Magura districts from highly-intensive growing areas, Kushtia and Jhenaidah districts from medium-intensive growing areas, and Manikgonj and Sirajganj

districts from low-intensive growing areas. Again, in each district two *Upazilas* (administrative unit) and from each *Upazila* one/two Agricultural Blocks (ABs) were purposively selected for collecting data and information from the sample farmers. The *Upazilas* and ABs were chosen in consultation with Agricultural Extension Officer, Sub-assistant Agriculture Officer (SAAO), and the local scientists of Bangladesh Agricultural Research Institute (BARI). Finally, two lists of lentil growing farmers (adopter and non-adopter farmers) were prepared separately for each AB, and then a total of 30 farmers, taking 20 farmers from adopters and 10 from non-adopters were randomly selected from each *Upazila* for interview. The adopter farmers were those who cultivated improved varieties of lentils and non-adopting farmers cultivated only local varieties of lentils. Thus, the total numbers of adopting and non-adopting sample farmers were 240 and 120 respectively (Table 1).

Table 1. Distribution of sample lentil growing farmers in the study areas

Study area	District	Adopter	Non-adopter	All category
Highly-intensive growing area	Faridpur	40	20	60
(*CCI value = 5.54-11.31)	Magura	40	20	60
Medium-intensive growing area	Kushtia	40	20	60
(CCI value = 1.09-4.87)	Jhenaidah	40	20	60
Low-intensive growing area	Manikgonj	40	20	60
(CCI value = 0.02-0.83)	Sirajganj	40	20	60
All areas		240	120	360

* Crop concentration index (CCI) = (Total area under lentils ÷ Total cropped area) × 100 (Miah et al. 2021a) Source: Field survey (2021)

2.2 Data collection procedure

Data for the present study were collected by interviewing sample lentil growers with the aid of a pre-designed and pre-tested interview schedule during the period from March to April 2021. Both trained enumerator and researcher collected primary data. Concerning this study, secondary data on lentil area and production were collected and used to supplement the study.

2.3 Analytical techniques

In most cases, a tabular method of analysis supported with appropriate statistical parameters was used to present the study results. The following econometric model was used in this study.

Probit model: A Probit model has been used extensively by agricultural economists for analyzing farmers' adoption and diffusion of agricultural interventions. In many studies (Miah et al., 2004; Akter et al., 2010; Miah et al., 2015), this model was used to find out the factors of modern variety adoption or examine the role of intervention of development. The Probit model is based on a

cumulative normal distribution function which is symmetric around zero with variance equal to 1. The maximum likelihood estimation method was followed to run the model using STATA software.

Within the area of econometrics, the commonly illustrated Probit model is in the following form (Sevier and Lee, 2004) shown in equation (1):

$$\Pr(y = 1|x) = \beta_0 + \beta_n X + \varepsilon \quad \text{..... (1)}$$

The following equation (2) represents the final Probit model used in this study.

$$\Pr(y = 1|x) = \beta_0+\beta_1 \ln X_1+\beta_2 \ln X_2+\beta_3 \ln X_3+\beta_4 \ln X_4+\beta_5 \ln X_5+\beta_6 \ln X_6+\beta_7 \ln X_7+\beta_8 \ln X_8 +\beta_9 \ln X_9+\beta_{10} \ln X_{10}+\varepsilon \quad \text{---------- (2)}$$

Where,

$\Pr(y = 1|x)$ = Adoption of improved lentil varieties (If adopted= 1; Otherwise= 0)

β_0 = Intercept

β_i = Coefficients of the respective variables (i = 1, 2, 3 ----------10)

X_1 = Farm size (decimal)

X_2 = Farmer's age (year)

X_3 = Education (year of schooling)

X_4 = Training on pulse cultivation (No./life time)

X_5 = Active family member (No./HH)

X_6 = Household income (Tk./year)

X_7 = Net profit from lentil production (Tk./ha)

X_8 = Farmers' innovativeness (Score)

X_9= Farmers' extension contact (Score)

X_{10}= Suitable land for lentil (decimal)

ε = Error term

3. Results and Discussion

3.1 Adoption of improved lentil varieties

Since 1991, BARI has developed nine improved lentil varieties for farm-level cultivation. The Department of Agricultural Extension (DAE) has been involved in disseminating improved lentil varieties across the country. The responding households (*n=360*) were asked to tell the total number of farmers who cultivate the improved and local varieties of lentils in their areas. It was reported that 70.8% of the lentil growing households in the entire study areas cultivated different improved varieties of lentils, whereas the share of local variety was 29.2%. However, the rate of adoption of improved lentil varieties was much higher in the

medium-intensive growing areas compared to high- and low-intensive growing areas might be due to the intensive demonstration of improved lentil varieties. The adoption of improved lentil varieties was found to be very low (41.5%) in the low-intensive growing areas might be due to the less demonstration of improved lentil varieties (Table 2). The overall adoption situation indicates the wider scope of disseminating improved lentil varieties in the study areas.

Table 2. Rate of adoption of improved lentil variety in the entire study areas

Type of variety cultivated	Highly-intensive growing area		Medium-growing area		Low-growing area		All growing area	
	HH*	%	HH*	%	HH*	%	HH*	%
Improved	672	73.3	374	84.7	119	41.5	1165	70.8
Local	245	26.7	67	15.3	168	58.5	480	29.2
All types	916	100	442	100	287	100	1646	100

Note: * indicates the total number of households cultivated lentils in the entire study areas

The variety-wise adoption of lentils at the farm level has been presented in Table 3. The study reveals that the most adopted lentil variety in the study areas is BARI Masur-6 (24.4%) which is followed by BARI Masur-8 (21.9%) and BARI Masur-4 (13.9%). The variety-wise adoption scenario varies from location to location. BARI Masur-8 is the most adopted variety in the highly-intensive growing areas due to its higher demonstration by the Pulses Research Centre of BARI which is located near to the study areas, whereas BARI Masur-6 and BARI Masur-4 are the most popular in the medium-intensive and low-intensive growing areas due to less demonstration. The variety adoption is likely to influence by different factors which are stated in section 3.2.2.

A limited number of studies exist on the adoption of improved varieties of lentils in Bangladesh with varied conclusions. The adoption of different lentil varieties varied from location to location over time since the releasing periods of the varieties and influencing factors are different. Miah et al. (2004) noted that 44% of the sampled farmers had adopted improved pulses and the highest adopted variety was BARI Masur-4 (97%) in six pulse growing areas, while Sarker (2011) noted that 100% of sampled farmers had adopted improved varieties of lentils. Again, Miah et al. (2009) stated that 32% of traditional lentils was replaced by different improved BARI and Binamasur varieties up to 2007. In 2011, Rahman et al. (2012) noted that 98% of total lentil areas were planted to BARI lentil varieties in Jhenaidah and Jashore districts, and the highest adopted varieties were BARI Masur-3 (49%) and BARI Masur-4 (47%). The adoption share was only 1% for BARI Masur-5 and -6. An expert elicitation revealed that the highest adopted variety in Bangladesh was BARI Masur-6 (30%) followed by BARI Masur-4, -3, and -5 (Rashid et al., 2018).

Table 3. Adoption of different lentil varieties by the respondent farmers

Variety/cultivar	Highly-intensive growing area		Medium-intensive growing area		Low-intensive growing area		All area	
	N	%	N	%	N	%	N	%
BARI Masur-8	69	57.5	10	8.3	-	-	79	21.9
BARI Masur-7	-	-	10	8.3	13	10.8	23	6.4
BARI Masur-6	11	9.2	55	45.8	22	18.3	88	24.4
BARI Masur-4	-	-	5	4.2	45	37.5	50	13.9
Local cultivar	40	33.3	40	33.3	40	33.3	120	33.3
All	120	100	120	100	120	100	240	100

Source: Field survey, 2021

The total land devoted to lentil cultivation was 64,228 ha in the study areas in which 71.4% of areas were covered by BARI lentil varieties, 11.9% covered by BINA lentil varieties, and 15.4% by local cultivars. BARI Masur-7 and -8 planted to the highest area among different improved varieties (Table 4). Again, the highest proportion (79.8%) of lentil area was planted to BARI lentil varieties in the low-intensive growing areas followed by medium-intensive (77.4%), and highly intensive growing areas (70.2%). Some Indian lentil varieties were also covered 11.3% of medium-intensive growing areas (Jhenaidah and Kushtia district).

Table 4. The area devoted to cultivating different lentil varieties in the study areas, 2019-20

Variety	Highly-intensive growing area		Medium-intensive growing area		Low-intensive growing area		All growing area	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
BARI Masur-9	754	1.4	-	-	-	-	754	1.2
BARI Masur-8	17749	33.0	637	8.5	55	1.9	18442	28.7
BARI Masur-7	3742	6.9	1100	14.7	25	0.9	4867	7.6
BARI Masur-6	14078	26.1	3222	43	532	18.4	17832	27.8
BARI Masur-5	250	0.5	700	9.3	-	-	950	1.5
BARI Masur-4	-	-	94	1.3	953	33.0	1047	1.6
BARI Masur-3	1201	2.2	48	0.6	739	25.6	1988	3.1
BINA Masur-8	5188	9.6	127	1.7	-	-	5315	8.3
BINA Masur-6	2330	4.3	-	-	-	-	2330	3.6
Indian variety	-	-	843	11.3	-	-	843	1.3
Local cultivar	8557	15.9	719	9.6	585	20.2	9860	15.4
All variety	**53850**	**100**	**7489**	**100**	**2888**	**100**	**64228**	**100**

Source: Local DAE Office, 2021

Tasty and easily boilable (91%), higher demand and market price (85%), and the availability of seed (63%) were the major reasons for cultivating local varieties (Miah et al., 2021). The non-adopting farmers have been traditionally cultivating local varieties of lentils for a long time and they may not be conscious enough for

cultivating improved lentil varieties. The area coverage scenario of local variety indicates the need for 3

2 Determinants of adoption of improved lentil varieties

The adoption of improved lentil varieties was likely to be influenced by different socio-economic factors. The results depicted in Table 18 show that the explanatory variables included in the model can explain about 70% of the variation in adopting improved lentil varieties. Among different variables, farm size, training on lentils, net profit, innovativeness, and contract with different extension sources had a positive and significant influence on the adoption of improved lentil varieties in the study areas (Table 5).

***Farm size*:** The land is the most important asset for farm households because they mostly depend on the land. The average farm size of adopters and non-adopters was 1.15 ha and 1.07 ha respectively. Adopting households appear to have shared-out, mortgaged-in, and mortgaged-out land holdings slightly lower than non-adopting farmers, but their shared-in and leased-in land were much higher compared to non-adopter farmers (Miah et al., 2021b). Farm size had a positive and significant influence on the adoption of improved lentil varieties in the study areas. The marginal coefficient of farm size is positive and significant at 10% level implying that if farm size is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 17.61%.

Training on lentils: Farmer's training on crop production is important because it can improve their technical skills regarding crop production practices. About 75% of non-adopters had no training exposure on lentil cultivation in their life. The highest proportion of adopting (48.3%) and non-adopting farmers (22.5%) received 1-3 training on lentil cultivation. About 7% of adopters participated in 7-10 training in their life (Miah et al., 2021). The marginal coefficient of training is positive and significant at 1% level implying that if the number of training is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 31.26%. The result is supported by different studies conducted in the past (Islam et al., 2013; Akter et al., 2010).

Net profit: Net profit is one of the vital factors that influence the potential users of any technology at farm level. Sserunkuuma (2005) found that the profitability of improved maize variety significantly contributes to decision-making involving the use of land management technologies. However, net profit in this study had a positive and highly significant impact on the adoption of improved lentil varieties at farm level.

Innovativeness: Agricultural innovation is considered an important aspect of farming all over the world (Avermaete *et al.,* 2003). It is one of the best means of achieving competitive advantage and revenue growth in a rapidly changing environment (OECD, 2011; World Bank, 2006; Milestad *et al.*, 2012). Farmers' innovativeness is often claimed to be an important determinant of the adoption of new technology, increasing productivity and higher income for the farm families

(Eneji *et al*., 2012). However, eight different innovative practices were considered in this study. All these practices were assigned different values (0 for no practice and 3 for regular practice) according to their importance. The total score was measured by adding all the values. The farmer with higher score value indicates more advanced towards different innovative practices. The marginal coefficient of innovativeness is positive and significant at 1% level implying that if the score of innovative practices is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 24.28%.

***Extension contract*:** Farmers with good extension linkage have more responsive to up-to-date information regarding modern agricultural technologies than non-linkage farmers. Therefore, extension linkage should have a positive effect on the adoption of improved lentil technologies at the farm level. Ten different extension Media were considered in this study. The possible total scores for extension contact were ranged from 0 to 40. The total score of extension contact was much higher for adopters compared to non-adopters implying that the adopters of improved lentil varieties were more advance in communicating with different extension Media compared to non-adopters (Miah et al., 2021). The marginal coefficient of extension contact is positive and significant at 10% level implying that if the score of extension contact is increased by 100%, the probability of adoption of improved lentil varieties would be increased by 8.87%. The result is supported by different studies conducted in the past (Miah *et al.,* 2004; Miah *et al*., 2015; Begum *et al.,* 2020).

Table 5. The marginal effect of the variables determining adoption of improved lentil varieties among respondent farmers

Explanatory variable	Coefficient	Marginal effect (dy/dx)	Standard Error	z-statistic	Probability (P>|z|)
Constant	-36.9606***	--	5.0389	-7.340	0.000
LnFarmSize (decimal)	0.5509	0.1761*	0.0935	1.880	0.060
LnAge (year)	0.2319	0.0741	0.1513	0.490	0.624
LnEducation (year)	-0.0850	-0.0272	0.0520	-0.520	0.601
LnTraining (Score)	0.9779	0.3126***	0.0816	3.830	0.000
LnActiveMember (No.)	0.0917	0.0293	0.0990	0.300	0.767
LnIncome (Tk/yr)	-0.0778	-0.0249	0.0661	-0.380	0.706
LnNetProfit (Tk/ha)	3.4079	1.0895***	0.1493	7.300	0.000
LnInnovativeness (Score)	0.7593	0.2428***	0.0777	3.120	0.002
LnExtContact (Score)	0.2774	0.0887*	0.0521	1.700	0.089
LnSuitableLand (decimal)	-0.4012	-0.1283*	0.0693	-1.850	0.064

Note: Number of observation = 360; LR chi-square (10) = 319.53; Log likelihood = -69.3825; Prob>chi^2 = 0.000; Pseudo R^2 = 0.6972. '***' and '*' represent significant at 1% and 10% level respectively. A higher score value represents the higher probability of improved variety adoption.

3.3 Farmers' decision towards future lentil cultivation

The respondent farmers were asked to mention the probability of expanding their cultivated area for lentil cultivation. In this regard, 72% of adopters and 58.3% of non-adopters showed their willingness to increase lentil cultivation in the next year. About 8% of adopting and 18% of non-adopting farmers wanted to decrease the lentil area in the next year. The proposed area increase for cultivating improved and local lentils will be 42 and 47 decimal respectively (Table 6). A good percentage (21-24%) of respondent farmers keep their lands unchanged for lentil cultivation. The farmers who wanted to decrease or unchanged their present lentil areas in future should be encouraged to expand their lands for improved lentil cultivation to increase their benefit and improve soil fertility.

Table 6. The willingness of farmers to increase lentil cultivation in the next year

Type of change	Adopter (*n=240*)			Non-adopter (*n=120*)		
	n	%	Proposed area (dec)	n	%	Proposed area (dec)
Increase	172	71.7	41.6	70	58.3	46.6
Decrease	18	7.5	27.7	21	17.5	33.8
Remain unchanged	50	20.8	--	29	24.2	--

Their justification and eagerness behind increasing lentil cultivation in the future were reasoned with anticipation of securing higher yields, preferable lentil prices, less infestation of disease and insects, and lower cultivation costs. The other reasons for increasing lentil cultivation are shown in Table 7.

Table 7. Reasons for increasing land for lentil cultivation in the next year

Causes of increasing	Adopter (*n=172*)			Non-Adopter (*n=70*)		
	n	%	Ranking	n	%	Ranking
1. More profitable than other crops	98	57	1	38	54	2
2. Higher yield	95	55	2	12	17	6
3. Less infestation of disease and insects	92	54	3	7	10	8
4. Need low input and less care	90	52	4	28	40	3
5. Higher demand or price	61	36	5	47	67	1
6. Short-duration crop	28	16	6	10	14	7
7. Meet up family demand	15	9	7	17	24	4
8. Availability of suitable land	7	4	8	5	7	10
9. Availability of seed in the market	5	3	9	15	21	5
10. Get boiled easily	--	--		7	10	9
11. Others	11	6	10	8	11	11

Note: Other causes included meet seed demand, cultivate as intercrop crop or chance crop, cultivate new lands, creates fertilizer, etc.

Some adopting and non-adopting lentil farmers mentioned various reasons for not expanding their lentil area in the next year. They opined that suitable/cultivable land was scarce and they need to grow other crops. The

unavailability of good seed was the 3rd and 5th ranked problem of adopters and non-adopters respectively. The 4th ranked problem was the infection of diseases that discouraged them to expand lentil cultivation in the future. Seventy-two percent of non-adopters wanted to reduce the cultivation of local lentils only because of their low yield (Table 8).

Table 8. Reasons for decreasing lands for lentil cultivation in the next year

	Adopter (n=18)			Non-Adopter (n=21)		
Causes of decreasing	n	%	Ranking	n	%	Ranking
1. Scarcity of cultivable land	15	83	1	18	86	1
2. Other crops need to be grown	11	61	2	14	67	3
3. Unavailability of good seeds	8	45	3	4	19	5
4. Infection of diseases	3	17	4	10	48	4
5. Low yield	2	11	5	15	72	2
6. Others	7	39	6	6	29	6

Note: Other causes included lack of irrigation facility, labour shortage, lack of training, adverse weather, lack of good seeds, etc.

3.4 Facility demanded by farmers for increasing lentil cultivation

Many respondent farmers suggested that some facilities need to be created for them to expand their lentil area soon. All of their demanded needs are displayed in Table 9. High-yielding and disease-resistant varieties are pre-requisites for expanding lentil cultivation throughout the country. The highest proportion of adopters (17%) and non-adopters (31%) in the study areas mentioned the need for high-yielding and disease-resistant varieties. Training is an important tool that enhances the knowledge and skill of the farmers. It is noted that 13% of respondent farmers were approached to provide hands-on training regarding lentil production. As farmers require liquid money at the time of cultivation, institutional credit facilities should be made available at the proposed period to enable farmers to increase the volume of production. On average 8% of respondent farmers wanted easy access to institutional credit facilities consisting of feasible and soft terms and conditions in conjunction with the overwhelming high interest rates on non-institutional credit. The availability of cultivable land is a significant element for growing or expanding areas for lentils. About 7% of lentil farmers wanted to expand their cultivation for the next year if they could manage additional cultivable land on lease or mortgage with low cost. Irrigation is an important input for crop production as it helps increase crop productivity to some extent. Most of the study areas are facilitated with irrigation but, some improved lentil farmers (6%) are still distressed over the disparity of inadequate irrigation facilities. As a result, they demanded immediate support in the emphasized facilities in the study areas.

Table 9. Facilities demanded by the lentil farmers for increasing lentil cultivation

Causes of decreasing	Adopter (*n=240*)		Non-Adopter (*n=120*)		All category (*n=360*)	
	n	%	n	%	n	%
Need high yielding and disease-resistant variety	41	17	39	33?	80	22
Required training	31	13	17	14	48	13
Need hassle-free credit facility	16	7	12	10	28	8
Need low-cost lease land	18	8	7	6	25	7
Assurance of fair price of lentil	15	6	9	8	24	7
Adequate irrigation facility	14	6	--	--	14	4

4. Conclusion

This study was conducted to assess the adoption of improved lentil varieties, and the profitability and bottlenecks of its cultivation at the farm level. It revealed that improved lentil variety adoption is encouraging in the study areas except for low-intensive growing areas, but still, there are ample opportunities of spreading these varieties among pulse farmers. Training on pulse cultivation, the profitability of production, farmers' innovativeness, and the extension contact of farmers are the major factors of adoption in the study areas. The yield of improved variety is much higher than local cultivars. The highest yield was found in medium-intensive growing areas due to the use of better variety and higher levels of inputs. The cultivation of improved lentils is highly profitable from the financial point of view but moderately profitable from an economic perspective. Although the domestic production of improved lentils has a comparative advantage, the production of local cultivars has no comparative advantage due to lower production, higher production costs, and the lower import price of lentils. The overall production problems were not severe as opined by the lentil farmers of improved and local varieties. However, the infection of diseases and some abiotic stresses are the major bottlenecks of lentil cultivation. Farmers' perceptions reveal that most of the respondent farmers wanted to increase lentil cultivation in the next year considering the higher yield and net benefits of improved lentils. Oppositely, a good portion of lentil farmers also wanted to decrease lentil cultivation due to lack of suitable land, biotic and abiotic stresses, and seeds of improved variety.

It is vital to encourage farmers to cultivate and expand their lands for the cultivation of improved lentil varieties to improve soil fertility, increase the comparative advantage of production, raise the benefit of farmers, and achieve self-sufficiency in pulses in Bangladesh. For achieving these targets, Government ensure the adequate supply of high-yielding and disease-resistant seeds of improved lentil varieties at the farm level and provide hands-on training to the farmers on lentil cultivation and crop management practices. The Field Service

Wing of DAE should take initiatives through their related projects in this issue in association with national research institutes (*i.e.* BARI, BINA) and BADC. The agricultural extension services should be more strengthened for disseminating the improved lentil technologies among farmers. The appropriate measures for reducing the wage rate of labour and ensuring the irrigation facility may be the stimulus of expanding lentil cultivation in the study areas. Finally, the ongoing pulse research should be strengthened for evolving high-yielding new lentil varieties along with improved management technologies.

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DETERMINANTS, CHALLENGES AND OPPORTUNITIES OF PULSES CROP IN SOUTHERN CHAR LAND AREAS OF BANGLADESH

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Abstract

Assessing the determinants, challenges and opportunities of pulses crops in southern char land areas like -Madaripur, Shariatpur and Barishal was made through an extensive field survey during 2018-2019. The study showed that education, family members, farm size, experience, and training are the significant determinants of willingness to cultivate more pulses crop. The study revealed that pulses production is becoming challenging due to losses of agricultural char land, adverse climatic condition, lack of technological knowledge, attack of insect and diseases, lack of quality seeds, problems regarding marketing of pulses crop. But still there are lots of opportunities to grow more pulses with the fulfillment of the following criteria like proper utilization of fallow char land, use of flood or salt tolerant varieties, use of quality seed, adoption of new technology, and ensuring fair price of pulses crops.

Keywords: Determinants, Challenges, Opportunities, Pulses, Southern Char Land.

1. Introduction

Pulses are important food crops in Bangladesh. Being rich in proteins, vitamins, and minerals, pulses are an important part of the diet of South Asian people (Mandal *et al.*, 2021). Growth duration, photo-thermal response, and response to low input make pulse crops the best fit for the rice-based cropping system in Bangladesh. About a dozen of pulse crops are grown in Bangladesh of which lentil, grass pea, mungbean, cowpea, chickpea, and black gram are the major ones (Depenbusc *et al.,* 2021). Pulses are grown almost throughout the country and their cultivation is mainly concentrated in the Gangetic floodplain. However, the productivity of these crops, in general, is much lower compared to yields obtained in many other pulse growing countries in the world due to various biotic, abiotic, and socio-economic factors (Farnworth *et al.,* 2020). In Bangladesh, 80 % of pulses produce during the Rabi season along with 16 % in Kharif and 4 % in late rabi. In the case of pulses production, grass pea occupied the highest percentage of the land area followed by lentil 24%, mungbean (23%), black gram (7%), cowpea (7%), chickpea (1%), and field Pea (1%) (AIS, DAE, 2014-15). In Bangladesh

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daily requirement for pulses is about 45g/day/person whereas consumption is only 14g/day/person. The annual demand for pulses crop is about 25 lakh metric tons against the annual production of 8.24 lakh metric tons which shows an annual deficit of around 16 lakh metric tons (AIS, DAE, 2014-15). With the increasing population, Bangladesh is trying to use all types of unused land for agriculture. Char land is players a very important role in the agriculture sector. Char is a tract of land surrounded by the waters of an ocean, sea, lake, or stream; it usually means, any accretion in a river course or estuary. It includes all types of bars including both lateral (point-bars) and medial (braid-bars). In the dynamics of erosion and accretion in the rivers of Bangladesh, the sand bars emerging as islands within the river channel (island chars) or as attached land to the riverbanks (attached chars), often create new opportunities to establish settlements and pursue agricultural activities on them. There is a little distinction between island chars, which are surrounded by water year-round, and attached chars, which are connected to the mainland under normal flow. Once vegetated such lands are commonly called chars in Bangladesh. It is estimated that in 1993 the total area covered by chars in Bangladesh was 1,722 sq km. Bangladesh Bureau of Statistics (BBS) report of 1997 suggests that in the lower reaches, where land is more fertile, cropping intensity in the chars appears to be between 150 and 185, which is quite similar to the average intensity of 165 for the entire country. However, the island and attached chars appear to be less productive than adjacent mainland areas. The major reasons for this are the relatively less favorable soil conditions in some of the chars, uncertainties caused by erosion, and frequent floods. Although both river water and groundwater are abundantly available in chars, irrigated crops are scarce in many of the chars except for the ones within the upper Meghna river. Pulses crop in char land has some problem and as well as lots of opportunities. So the study is undertaken to identify the determinants, challenges and opportunities of pulses crop on char land and make some policy recommendation on the basis of the study.

2. Materials and Methods

The study was conducted in three southern districts namely Madaripur, Shariatpur, and Barishal from October, 2018 to May, 2019. Zanjira and Bhedarganj upazila from Shariatpur, Madaripur sadar and Shibchar upazila from Madaripur district and Babuganj and Barishal sadar from Barishal district were selected for the study. A total of 150 farmers taking 50 from each district were selected through simple random sampling. Necessary information was collected through the survey method with the help of a pre-tested interview schedule by field investigators in collaboration with DAE personnel under the direct supervision of the researchers. Collected data were summarized, analyzed, and tabulated. Statistical tools like average, percentage and ratio, and logit model were used in presenting the results.

Logit model for the determination of pulses crop production

The logit regression model was used to find out the determinants of the willingness of the farmers to cultivate pulses crops in the future time. The logit regression model is one of the binary choice regression models in which a dichotomous regression variable is considered as the dependent variable. The logit model was chosen for this study because it guarantees that the estimated probability lies between 0-1 and they are not linearly related to the explanatory variables. The logit model is based on the cumulative logistic distribution function expressed below

P_i= E(Y= $\frac{1}{X_i}$) = $\alpha + \beta_i$ ….. ……. (1)

P_i= E(Y= $\frac{1}{X_i}$) = $\frac{1}{1+e^{-z}}$ ….. ……. (2)

For ease of exposition

$Z_i = \alpha + \beta_1 X_1 + \beta_2$ …… X_n

Where Pi = Probability of willingness to cultivate pulses crops

The log of odd ratio or logit is

Logit Li = (Probability of not willingness to cultivate pulses crops / Probability not to cultivate) = Zi+Ui

In order to obtain the Zi there need a dichotomous response variable Yi (dependent variable). If the dependent variable is 1 then the farmer is willing to cultivate pulses crop and when it is zero then the farmers will not cultivate.

Seven (7) explanatory variables were included in the model to find out the determinants of willingness to cultivate pulses crops. The independent variables are specified as follows:

X_1 = Age

X_2 = Education

X_3 = Family members

X_4 = Farm sixe

X_5 = Experience

X_6= Alternative income sources

X_7= Training

U = Error term

According to Gujrati (1995) the marginal probabilities of factors determining the willingness and the elasticity of probability of willingness were estimated based on expressions derived from the logit model is

$\frac{dp}{dx} = \beta_i[P\ (1 - p_i)]$

$E_p = \beta_i \overline{X_\iota}$ (1-P_i)

Where,

β_i = Estimated logit regression coefficient with respect to the ith factor

Pi = Estimated probability of willingness to cultivate

$\overline{X}_i$ = Arithmetic mean

E_p = Elasticity of probability of willingness to cultivate

The method section does not specify which model the author used to measure the challenges of pulse production.

3. Results and Discussion

Socioeconomic characteristics of responded household

Age of the farmers: It was found that the highest percentage (37 %) of farmers was in the age group of 31-45 years followed by age group up to 30 years (23%) and 46-60 years (34%) and age group above 60 years has the lowest percentage (7 %) (Table-1).

Table 1. Socioeconomic characteristics of the farmers (% of farmers responded)

Characteristics	Madari-pur	Shariat-pur	Barishal	All areas
Farmers Age (% of farm household responded)				
Up to 30 years	35	22	12	23
31-45 years	31	38	41	37
46-60 years	29	33	39	34
Above 60 years	5	7	8	7
Education level (% of farm household responded)				
Illiterate	25	26	41	31
Primary	43	51	39	44
Secondary	18	13	9	13
SSC	9	8	8	8
HSC	4	2	2	3
HSC and above	1	0	1	1
Land ownership pattern (ha)	1.39	1.77	2.17	1.78
Farmers category according to Farm size (% of farm household responded)				
Small (0.02-1.0 ha)	68	71	68	69
Medium (1.01-2.0 ha)	30	22	26	26
Large (2.01 ha-above)	2	7	6	5
Family members description (No.)				
Family members	5.10	5.30	4.65	5.02
Men	2.15	2.80	2.20	2.38
Women	1.90	1.20	1.34	1.48
Marital Status (%)				
Unmarried	44	31	27	34
Married	56	69	73	66

Source: Author's calculation

Education level: On an average, 31% farmers were illiterate and others having variable levels of academic background. Among the educated farmers 44 % had primary level of education, 13 % had secondary level and 8% had education at SSC and 3% had education at HSC and 1 % had education at above HSC (Table 1).

Farmer's category and farm size: Average farm size is 1.78 ha where the highest (2.17 ha) in Barishal and the lowest (1.39 ha) in Madaripur. On an average small farmers was 69%, medium was 26 % and large was 5 %.(Table 1).

Family size and marital status: Average family size was 5.02 persons. In Madaripur it was 5.10 and in Shariatpur it was 5.30 and in Barishal it was 4.65. Number of male members (2.38) was higher than female members 1.48. Among the responded farmers 65 % were married and 36 % were unmarried (Table 1).

Table 2. Coefficient of logit model for determination of willingness to cultivate Pulses crop

Determinant	Coef.	Std. Err.	Z	P>z	Marginal effect
Age (X_1)	0.044	0.036	1.24	0.215	0.010
Education (X_2) ***	0.903	0.241	3.74	0.000	0.208
Family members (X_3) ***	0.919	0.341	2.70	0.007	0.213
Farm size (X_4) **	0.017	0.007	2.44	0.015	0.004
Experience (X_5) ***	2.411	0.818	2.95	0.003	0.525
Alternative income sources (X_6)	-1.186	0.762	-1.56	0.120	-0.274
Training (X_7) *	4.185	1.012	4.13	0.000	0.778
Constant	-21.30501	4.99	-4.27	0.000	-
Number of observations	150	-	-	-	-
LR chi^2 (7)	149.10	-	-	-	-
Prob > chi^2	0.000	-	-	-	-
Pseudo R^2	0.7203	-	-	-	-
Log likelihood	-28.94	-	-	-	-

Sources: Author's analysis

Factors for the determination of pulses crop production: The factors which determine the willingness to cultivate pulses crop is shown in Table-1. The result shows that education, family members, farm size, experience, and training were the significant determinant. Education, family members and experience is significant at 1% level. Farm size and training are significant at 5 % and 10 % level, respectively. The value of marginal effect for education was 0.010 which indicates that probability of willingness to cultivate pulses crop will increase with the increase in education level. The value of marginal effect for family members was 0.208 which indicates that the probability of willingness to cultivate pulses crop will increase with the increased number of family members. The value of marginal effect for farm size is 0.004 which indicates that the probability of willingness to cultivate pulses crop will increase with the increase of farm size. The value of marginal effect for experience was 0.525 which indicated that the

probability of willingness to cultivate pulses crop would increase with the increases of experience. The value of marginal effect for training was 0.778 which indicates that the probability of willingness to cultivate pulses crop would increase with the increase of training. Age and alternative income sources have no significant impact (Table-2).

Challenges of pulses crop production

Losses of agricultural char land: Bangladesh has lost about 1 million ha of productive arable land from 1983 to 1996 (BBS, 1999). That is about 80,000 ha of agricultural land per year are going out from crop production. Besides, this every year agricultural char land was going under water due to river erosion, which is hampering the production of pulses along with others crops. About 52 % of the total farmers responded that some part of their land has lost due to river erosion in the last two decades. Major factors responsible for land loss are human settlement and river erosion.

Adverse climate conditions: Adverse climate condition hampers the pulses production dramatically. On an average 87 % of the total farmers replied that heavy rainfall during the production period of pulses seriously hampers the production. About 57 % of farmers of Barishal said the problem of an early flash flood along with 18% and 22% of farmers' of Madaripur and Shariatpur, respectively. Nearly 76 % of farmers of Barishal said that they can't cultivate pulses at the right time due to late joe (optimum condition of soil for plant growth) condition in the same way 59 % and 53 % of farmers of Madaripur and Shariatpur responded on the same. The highest percentage (91 %) of farmers of Barishal said that foggy weather hampered the pulses seedling which in turn contributes to low yield and in Madaripur and Shariatpur it was about 79% and 87 %, respectively (Table-3).

Production problem: About 92 % of farmers of Shariatpur said that they had no idea about modern pulses variety even though they had never tried to know the availability of a modern variety of pulses crop. In the same way, 88 % and 81 % of farmers of Madaripur and Barishal replied to this. Around 93 % of farmers of Barishal said they get low yield due to a lack of quality seed along with the Madaripur and Shariatpur farmers. The farmers of Shariatpur (72 %) replied that due to insect attacks they are reducing their chickpea land to other crops. 67% and 54 % of farmers of Madaripur and Barishal said about the problem of insect attacks (Table 3).

Improper use of chemical fertilizers and low management Practices: Organic matter content of soils is much below the critical level of 1.5% (Karim, Z. 1997). Our responded farmers normally use urea more or less in recommended doses. Because of high prices, they can not apply other fertilizers at the recommended amount. Chemical fertilizers are not normally integrated with organic manures. It

is thus evident that farmers virtually do not use balanced fertilizers that are necessary for high productivity. The table shows all the farmers in all areas did not use recommended doses of fertilizers for pulses production (Table-4). Besides, low management practices like no weeding, as well as no intercultural operations also hamper the pulses production.

Table 3. Problems/challenges of pulses crop on the char land (%farmer responded)

Particulars	Madaripur	Shariatpur	Barishal	All areas
Adverse climate condition:				
Heavy rainfall	87	82	92	87
Early flash flood	18	22	57	32
Late joe condition	59	53	76	63
Foggy weather	79	87	91	86
Production problem:				
No idea about modern variety	88	92	81	87
Lack of knowledge of modern production technology	79	83	78	80
Lack of quality seed	76	87	93	85
Insect attack	67	72	54	64
Diseases infestation	74	62	79	72
Financial problem:				
Lack of capital	56	61	67	61
Lack of credit facilities	23	32	43	33
High price of input	78	69	85	77
High labour wage	83	79	84	82
Marketing problem:				0
Low produce price at harvest	96	93	95	95
Lack of storage facilities	34	45	58	46
Lack of knowledge about modern storage system	28	43	36	36
High transportation cost	23	29	39	30
High market toll	23	19	33	25

Source: Author's Calculation

Financial problem: About 67 % of farmers of Barishal responded to the problem of lack of capital in the initial stage of pulses production along with the farmers of Shariatpur (61%) and Madaripur (56%). On average, 33 % of farmers responded on the lack of credit facilities at easy terms from either GO or NGOs. About 77% of farmers of all areas said about the higher price of agricultural input and 82 % on high labour wage. It should also be noted here that about 90% of farmers of Bangladesh are small and marginal (below 2.5 acres). They are very often constrained by finance and thus they cannot afford cost for management. They have very limited access to institutional credit because of collateral requirement. At present, only 27% of farmers received institutional credit (BBS, 2007). The amount of credit again is quite inadequate and not advanced in time. They are also not eligible for microcredit from NGOs that deal mainly with landless farmers (Table-3).

Table 4. Level of input use pattern

Types of input	Madaripur	Shariatpur	Barishal	Average
		Lentil		
Human labour (no.)	63	61	59	61
Own	30	28	29	29
Hired	33	33	30	32
Seed (kg)	37	38	41	39
Fertilizers (kg)				
Urea	43	31	35	36
TSP	28	24	21	24
MoP	23	11	14	16
		Mungbean		
Human labour (no.)	-	59	63	61
Own	-	22	25	24
Hired	-	37	38	38
Seed (kg)	-	33	28	31
Fertilizers (kg)	-			
Urea	-	42	38	40
TSP	-	27	26	27
MoP	-	21	23	22
		Chickpea		
Human labour (no.)	58	66	68	64
Own	27	30	29	29
Hired	31	35	39	35
Seed (kg)	45	48	43	45
Fertilizers (kg)				
Urea	41	35	29	35
TSP	48	31	27	28
MoP	32	19	22	26
		Grasspea		
Human labour (no.)	51	47	48	49
Own	32	25	29	29
Hired	19	22	19	20
Seed (kg)	54	57	60	57
Fertilizers (kg)				
Urea	31	33	28	31
TSP	16	21	9	15
MoP	12	15	8	12
		Blackgram		
Human labour (no.)	44	-	-	44
Own	27	-	-	27
Hired	17	-	-	17
Seed (kg)	61	-	-	61
Fertilizers (kg)	-	-	-	-
Urea	27	-	-	27
TSP	16	-	-	16
MoP	7	-	-	7

Sources: Author’s estimation

Problems regarding marketing of pulses crop: Productive farmers of Bangladesh mainly belong to small and marginal categories. These farmers do not have any farmer's association or farmer's co-operative to bargain for fair prices for their produce. They are thus forced to sell their produce at low prices to intermediaries. Our responded farmers also responded on different marketing related problems like low price of produce during harvest (95%), lack of storage facilities (46%), lack of knowledge about modern storage systems (36%), high transportation cost (30%) and high market tool (25%) (Table 3).

Opportunities of pulses crop production

Protection and proper utilization of char land: Char land is the potential area for pulses production. Due to its slope structure rain water can't stand, and can't affect pulses crops, while in the main land rain water affect pulses crops as there are poor drainage system in many areas. So, it is essential to review the present char land use policy with the relevant experts, professionals, and farmers' representatives. The policy should also be put into operation immediately to stop further loss of arable land. Khas char lands that are arable should not be diverted for housing and other infrastructure without government plan. Such lands should be distributed to landless farmers and be used for agricultural purposes that would helpful for pulses production as well as other agricultural crops.

Adoption/mitigation to adverse climate condition: The pulses varieties should be introduced and disseminated in the char area after necessary testing. More diseases and insect resistant varieties of pulses need to be developed. It is also necessary to use biotechnology or gene transfer technology to develop varieties tolerant to salinity, flood, and drought. There is also a need to develop and disseminates of HYVs in pulses and technologies in these areas.

Research and expansion of alternative cropping pattern: In the study areas as well as other areas there are lots of opportunities for some pulses to adapt along with other crops and hence can increase the cropping intensity. Research should be conducted on location wise varietal development as well as cropping pattern. The potential pulse based cropping pattern in Madaripur is 1. Lentil+B. Aus+Blackgram 2. Lentil+Mungbean+B.Aus 3. Garlic/others robi crops+Mungbean+B.Aman. In Shariatpur the potential pulse based cropping pattern is 1. Wheat+B. Aus+ Blackgram, 2. Lentil/Rabi crops+Mungbean+B.Aus. In Barishal, the major potential cropping pattern is 1. lentil+Mungbean+Aman, 2. Khesari+Aman+Blackgram. More locationwise research on cropping patterns would be more helpful in this case.

Fertilizer management as well as proper intercultural operation: Farmers should encourage the use of balanced fertilizers, chemical fertilizers must be integrated with organic manures. Farmers should gradually reduce their dependence on the use of chemical fertilizers to maintain soil fertility. Besides they are not aware of

the proper intercultural operation. The proper intercultural operation would increase the pulses yield.

Pest and diseases management properly: In Bangladesh, different insects and pests are becoming resistant to respective chemicals. More resistant varieties should be developed using both conventional breeding and biotechnology to control the pests. Besides, this different prevention and controlling measures should be developed. It is also necessary to expand biotechnology and IPM practice to the economic crops like pulses.

Strengthening quality seed production at farmers as well as institution level: In the study areas, most of the farmers were not aware of modern pulses varieties and quality seed. To meet the quality pulses seed requirement BADC's current seed production programme needs to be strengthened. To achieve this, the present breeder's seed programme of NARS institutes should be expanded. Besides, private sector and NGOs are to be supported by the government for the production of quality seeds by providing credit on easy terms. Likewise, farmers need to be motivated to produce quality seeds. For this, they should be given massive training on seed production, preservation, and processing.

Ensure credit facilities: During the pulses cultivation season, farmers usually tend to take a loan from the village mohajon at high interest rate instead of the financial institution because of its complexities. In the National Agricultural Policy (1999), Ministry of Agriculture proposed an institution named "Agricultural Credit Foundation" the following the model of "Palli Karmo Sahayak Foundation" (PKSF). Major objective of the foundation was to meet the demand for credit by marginal and small farmers. The foundation was supposed to be established during the Fifth Five-Year Plan. Unfortunately, the institution has not been established even 8-9 years after the implementation of the national agricultural policy. Under the circumstances, a new Institution/Foundation following the model of PKSF should be established along with necessary manpower and other facilities to cater to the needs of these farmers. They must have an access to the credit of the institution without any collateral requirement. The credit should be disbursed before planting time and realized at the end of the cropping season or after the harvest of the crops. The institution must have an in-built provision for a strong monitoring unit to monitor the use of credit at regular intervals by its staff.

Fair price of produces: In most cases pulses as well as other crop's price is volatile. Sometimes farmers get return which could not cover cost of cultivation. Government is urged to procure the produces directly from the farmers raising the present ceiling to at least 10% of the total production. Storage facilities may at the same time be established in rural areas. Alternatively, government might encourage establishing farmers' cooperatives to ensure fair price of their crop produces. To make the cooperatives successful, traditional top-down approach must be avoided. The cooperatives should not be run as a commercial profit-

making entity. Formation of "Agricultural Prices Commission" by the government is also suggested for fixing the prices of farmers' produces which would ensure fair price and hence improve the livelihood of the farmers, besides different value added services in pulses would be helpful to get a fair price.

4. Conclusion and Recommendations

Pulses are the important winter season crop. Besides, mungbean grow well in Kharif -1 and Blackgram grow well in Kharif-2. Education, family members, farm size, experience, and training were the significant determinant of the willingness of the farmers to cultivate more pulses crops. Bangladesh is showing a deficit in pulses production. Bangladesh has to import two third of the total pulses requirement which need huge foreign currency. It became an urgent need to increase the production of pulses crops. There are lots of challenges to increase the pulses yield like losses of agricultural char land, adverse climatic conditions, lack of technological knowledge of pulses production, imbalance fertilizers use and low management practices and marketing problems were the major challenges. But yet there are lots of opportunities like proper utilization of fallow char land, use of flood or salt tolerant varieties, use of quality seed, adoption of new technology, and ensuring fair price of pulses crops. The following recommendations can be helpful to increase the pulses yield. Special policy need be formed and should be enacted and put into operation immediately to stop further loss of arable land. Khas lands that are arable should not be diverted for housing, ensure fair price of pulses crop through fixing the floor price, encourage the use of balanced fertilizers, chemical fertilizers integrating with organic manures. Besides these, it is important to ensure quality seed to the farmer's level, facilitate community based training system of improved pulses production technologies, strengthen research on the development of different stress tolerant variety of pulses, and develop location-wise appropriate pulse based cropping pattern. Encourage the farmers to cultivate pulses crops through cooperatives which would minimize the cost of pulse production along with strengthening the bargaining power of the farmers for their product through forming cooperatives. Upazila Agricultural Office could be a medium to form these types of cooperatives.

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PRODUCTIVITY AND PROFITABILITY OF LOCAL CULTIVAR OF BRINJAL AND CHILLI IN CHATTOGRAM DISTRICT

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Abstract

The study was carried out in nine villages covering 110 farmers of *Potha Begun* and *Halda Morich* under Hathazari Upazila in Chattogram district to examine the productivity, profitability and perceptions to those cultivars. Results revealed that farmers used excessive fertilizer doses in both crops. The yield was recorded at 43.62 tons/ha for *Potha Begun* where the harvested yield loss was estimated at 7.29% due to infestation of pests and diseases. The yield of *Halda Morich* was found to be 7.94 tons/ha as green Chilli and 1.98 tons/ha as dried Chilli. The per kilogram average farm-gate price of *Potha Begun* was Tk.30.19, green Chilli Tk.42.8, and dried Chilli Tk.310.88. The gross margin was calculated Tk.848468 for *Potha Begun* and Tk.294628 for dried Chilli, and Tk.18,850 for green Chilli. The BCR was found to be 2.81 for *Potha Begun* and 1.92 for dried Chilli. The per kg cost of production was calculated Tk.15.32 for *Potha Begun*, Tk.45.63 for green Chilli, and Tk.182.9 for dried Chilli. Regular training of farmers on fertilizer and pest and disease management will increase its productivity.

Keywords: Local cultivar's, Brinjal, Chilli, Productivity, Profitability, Chattogram.

1. Introduction

Brinjal is one of the most important vegetables in Bangladesh. It has all kinds of nutritional values. It is a combination of Vitamin A, C, E, and Iron. It is also a powerful antioxidant. Having a lot of iron, it helps to eliminate anemia. Vitamin A provides nutrition to the eyes and works against all eye diseases. Brinjal also contains a lot of calcium and magnesium which is very beneficial for teeth and bones, a lot of dietary fiber which helps in digestion of food and helps in relieving constipation. Brinjal is good for those who have high levels of bad cholesterol in their blood. However, for those who have arthritis, or asthma and allergies, there are some restrictions on purple.

Brinjal is cultivated in 34973 hectares of land in Bangladesh producing 530610 metric tons of fresh brinjal (BBS, 2020). Brinjal is cultivated in 5983 hectares of land in Chittagong division which is 17.1 percent of the total land under brinjal cultivation of the country. On the other hand, the total brinjal production in

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Chittagong division is 46016 metric tons which is 0.86 percent of the total brinjal production in the country. There are 180 types of brinjal cultivars in the country. From these cultivators, scientists collect and develop new varieties through selection process. In many cases hybridization is also required. Bangladesh Agricultural Research Institute (BARI) has so far developed 22 high yielding varieties of brinjal including 4 Bt brinjals.

The local cultivar of brinjal called Potha Begun is very popular in Hathazari. Its price is higher than other brinjals available in the locality due to its higher demand. The production potential of Potha Begun is also high which leads higher farm income. The price of Potha begun in the market varied from Tk.40/kg to about more than Tk.100/kg with an average price is about Tk.70/kg. This is undoubtedly a potentially lucrative cash crop. Such a profitable crop should be brought into the mainstream of research. The yield of this cultivar is close to the yield of brinjal variety developed by BARI. There is a research need to develop improved management practices of this brinjal cultivar. The study will provide necessary information for carry out such research.

On the other hand, Chilli is one of the most important spice crops in Bangladesh, has many nutritional values. Green chillies are rich in antioxidants and protect against fever, cold and cough etc., and increase immunity. According to doctors, there is use of raw pepper as medicine for many ailments. Raw peppers contain adequate amounts of vitamin A and C. Raw peppers lower blood cholesterol, protect the gums and hair, and help keep bones, teeth, and mucous membranes healthy. And among the favorite food, many Bengalis can think of fried dried chillies or red chillies. Vitamin E in chillies works to reduce pain. The phytonutrients in red chilli work to prevent colon cancer and breast cancer. As red chillies contain sufficient amount of vitamin A, it also helps in increasing eyesight.

Many farmers in Bangladesh make a living by producing only chilli. Bangladesh Agricultural Research Institute (BARI) has so far developed four high yielding varieties of pepper. All those varieties are being cultivated along with the local cultivars of the country. However, extensive expansion of varieties is required. Chilli was planted in a area of 96804 hectare during 2018-19, with a total production of 149473 metric tons (BBS, 2020). Of this, 19535 metric tons was produced in 16695 hectare of land in Chittagong Division which is 17.2 percent and 13 percent of the total area and production respectively. The national average yield of chilli is 1.544 tons/ha. Average yield of chilli in Chattogram is 1.65 ton/ha which is slightly higher than the national average yield.

Locals have named it Halda Chili because it is widely cultivated in the Halda river basin of Hathazari Upazila in Chattogram. It is also known as Hathazari chilli. The distinct features of this chilli is that it is less salty, the taste increases when the curry is cooked, it has a sweet taste, the color of the curry is reddish and attractive, disease infestation is less, yield is higher, the demand is higher and therefore the

price is higher. This chilli is mostly sold by the farmers as dried chilli. These chillies can be stored in polythene bags at normal temperature for 2/3 years. Due to these reasons, the farmers are more interested in cultivating this chilli.

It is widely cultivated in Mandakini, Chipatli, Nangalmora, Gumanmardan, Garduara, Mohammadpur, Alampur, Chandrapur and Charia of Hathazari Upazila. It is known that about one thousand farmers in the upazila cultivate this chilli in 250 hectares of land every season. Despite the high quality of this chilli, it has not yet been recognized as an improved variety by any research institute. This is undoubtedly a potentially lucrative high-value cash crop. Such a lucrative crop should be brought into the mainstream of research. Giving it more advanced management through research will increase productivity. This will increase the income of the farmer manifold. There is a research need to develop improve management practices of this chilli cultivar. The study will provide necessary information for carry out such research.

The specific objectives of the study were to estimate the input use, productivity, and profitability of brinjal and chilli cultivars; to know the farmers and consumers perceptions for cultivating those cultivars; and to derive policy implications.

2. Materials and Methods

Selection of study areas: A multi-stage sampling technique was followed to select the study area. In the first stage, the Chattogram district was selected purposively to address the local cultivars scenario in the district. In the second stage, one Upazilas were selected purposively as there one wide area of local Chilli and Brinjal cultivation. In the third stage, nine villages were selected purposively from the Upazila for data collection. Based on the availability of local cultivars, specific locations were selected in consultation with Upazila Agriculture Officer (UAO), Sub-Assistant Agriculture Officer (SAAO), local progressive farmers, and local leaders in the respective area. Five villages namely Alipur, Pacchim Dewan Nagor, Maddom Pahartoli, Chandrapur and Maddom Mirer Khil were selected purposively from Hathazari Upazilas for local cultivar of brinjal (*Potha Begun*). On the other hand, four villages namely Dakkin Naggolmora, Uttar Mekhol, Mojafforpur, Chipatali, and Kazirkhil were purposively selected from the same Upazila for the local cultivar of Chilli (*Halda Morich*).

Sampling techniques: There is no safe general rule as to how large sample size must be for the use of normal approximation in computing the confidence limit (Cochran, 1999). When the population size is known and the researchers are careful of the heterogeneity problem, any number (equal to or) greater than the statistically large sample (of 30 sample units) may be appropriate (Freund and Williams (1983). A proportionate random sampling technique was adopted for selecting the sample size for each crop. In this process, a sampling frame was constructed by 100 growers for each crop. After that, the proportionate sampling was done equally for the two crops.

By applying this technique, due to resource limitations, a total of 110 sample households were selected for the study. Uddin et al. (2010) followed the same sampling procedures for their study.

Data collection procedure: Both primary and secondary data were used in this study. Secondary data and information were collected through reviewing related literature, relevant documents/reports, BBS, and the internet. Primary data were collected from sample households using a semi-structured questionnaire. Five experienced Sub-Assistant Agriculture Officers and Scientific Assistants from each location were engaged for data collection. Before starting data collection, a discussion meeting on the questionnaire was held among data collectors. The data collection period was from March to May 2021. Researcher himself monitored the data collection and cross-checked the collected data at the field level.

Analytical techniques: Descriptive statistics such as mean, standard deviation, percentage were used to analyze the primary data. The mean comparison and significance test were done by One-Way ANOVA using SPSS. In the ANOVA technique, the F-value was used to judge whether there is a significant difference or not among the locations and samples. The productivity was measured by the average yield of both crops and multiplied by average farm-gate price. Profitability of crop production was analyzed based on gross return, gross margin, and benefit-cost ratio. Land use cost was calculated based on the per hectare value of leased land for four months.

$$\text{Gross return, } GR_{ij} = Y_{ij}P_{ij}$$

Where,

GR_{ij}= Gross return (Tk/ha) of j^{th} crop for i^{th} farmer

Y_{ij}= Quantity of j^{th} crop produced (kg/ha)for i^{th} farmer

P_{ij}= Price of j^{th} crops (Tk/kg) received by the i^{th} farmer

Net return= Gross return – Total cost (total variable cost+ total fixed cost)

Gross margin= Gross return- Total variable cost

3. Results and Discussion

Socioeconomic characteristics of respondents

The socioeconomic characteristics of the respondent farmers are presented in Table 1. The average age of the Brinjal and Chili farmers were respectively 40.87 years and 49.84 years indicating that farmers involved in local cultivar production were fairly young. A similar result was obtained by Uddin et al. (2020) who reported an average age of 45.4 years for farmers in Hathazari, Chattogram. One hundred percent of the respondents were male implying a sense of family responsibility. Half of the respondents of Brinjal farmers (50.0%) had the secondary level of education while more than half of the respondents of Chilli farmers (52.0%) had primary level education. This might enhance their adoption

of local cultivars. Kehinde (2005) noted that education was the key to enhancing productivity among farming households as it promotes their understanding of modern technologies.

The major occupation of the respondents was agriculture (100%) in the study areas. Occupations of the respondents may influence the adoption of new technologies. The secondary occupation was reported to be business for Brinjal (42.1%) and Chilli (18.0%) farmers in all locations. The average household size was 6.05 persons for Brinjal, whereas it was 5.61 for Chilli which was higher than that of the national average of 5.0 (BBS, 2018). The mean difference of the household size varied insignificantly among the locations ($F= 1.51$; $p \leq 0.303$) for both crops. The average cultivated land per household was recorded as 0.533 and 0.591 hectares for Brinjal and Chilli, respectively. Nearly 53% of Brinjal farmers and 44% of Chilli farmers were owner-cum-tenant in the study areas (Table 1).

Table 1. Socioeconomic and demographic characteristics of the respondents

Sl. No.	Particulars	Local cultivars	
		Brinjal (*Potha Begun*)	Chilli (*Halda Morich*)
1.	Age of respondents (years)	40.87	49.84
2.	Level of education (%):		
	- Can't read & write	15.8	4.0
	- Primary	28.9	52.0
	- Secondary	50.0	40.0
	- Higher Secondary	5.3	2.0
	- Graduate & above	-	2.0
3.	Occupation (%): (multiple response)		
	- Agriculture	100.0	100.0
	- Business	42.1	18.0
	- Service	26.3	2.0
	- Day labourer	21.1	2.0
4.	Family size (Person/family)	6.05	5.61
5.	Cultivated land (ha/hh):	0.533	0.591
6.	Types of farmers (%):		
	- Owner cultivator	7.90	36.0
	- Tenant	39.5	44.0
	- Owner cum tenant	52.6	20.0

Production related information

Production related information includes plot size, the number of seedling use, spacing maintained, the sources of seedling, treatment use, planting time, the number of spraying, harvesting period, the duration of harvesting, yield ratio in case of Chilli, and the number of other varieties/cultivars grown in the locality (Table 2). Results revealed that the average plot size of the cultivars was 0.078 ha for Brinjal and 0.061 ha for Chilli which was (14.6%) and (10.3%) of the total cultivated land of the

respondent, respectively. The use of an appropriate number of the seedling is an important issue for raising the productivity of crops. The average number of seedlings used for Brinjal was 38499. and that for chilli was 87011 per hectare. Most of the seedlings were produced by themselves and some portions were collected from neighbors and relatives. Farmers did not maintain recommended spacing for those cultivars. They planted the seedlings very closely to avoid the risk of seedling mortality. The highest number of respondents of Chilli (62.0%) and Brinjal (55.3%) opined that before plantation of the seedlings in the main fields, the seedlings were treated with fungicides as per the advice of SAAOs in the respective locations. The prevalence of diseases and pests in cultivars is a common phenomenon. Controlling these problems, farmers usually spray different types of insecticides. The frequency of sprayed pesticides was 17.6 times and 3.6 times in Brinjal and Chilli respectively for controlling pests and diseases. The average duration of crops was estimated at 182.4 and 105.4 days for Brinjal and Chilli respectively. It is important to note that 4 varieties/cultivars of Brinjal were grown in the locality. These were: BARI Begun-2, BARI Begun-4, and other two local cultivars. On the other hand, 3 cultivars of Chilli were found to be grown in the study areas. These were Comilla Morich), Hybrid Chilli, and one local cultivar (Table 2).

Table 2. Production related information of the local cultivars of Brinjal and Chilli

Sl. No.	Particulars	Local cultivars	
		Brinjal	Chilli
1.	Average plot size (ha/farm)	0.781	0.612
2.	Use of seedlings (No./plot)	3007 (38499/ha)	5270 (87011/ha)
3.	Spacing maintained:		
	- Plant to plant (Inches)	6.61	6.40
	- Row to row (feet)	2.65	1.70
4.	Sources of seedling (%):		
	- Owned source	92.1	70.0
	- Relatives	-	2.0
	- Neighbors	5.3	28.0
	- Local bazar	2.6	-
5.	Whether the seedlings are treated?		
	-Yes (%)	55.3	62.0
	- No (%)	44.7	58.0
6.	Planting time (Months)	Srabon-Poush	Kartic-Agrahaion
7.	No. of spraying during production	**17.6**	3.6
8.	Duration of harvests (Days)	182.4	105.4
9.	No. of harvest per month	6-7	-
10.	Yield ratio: Ripe Chilli : Dry Chilli	-	4:1
11.	No. of other varieties/cultivars grown	3-4	2-3

Input use in local cultivar production

The rationale and efficient use of input is a prerequisite for enhancing the productivity of crops. Respondent farmers applied cow-dung (as organic fertilizer), chemical fertilizer (i.e. Urea, TSP, MoP & gypsum), and pesticides (Furadan) into the crops. The applied amounts of input were higher than the recommended doses for HYV Brinjal and Chilli (BARI, 2019). Farmers actually used the excessive dose of fertilizers for their ignorance (Table 3).

Table 3. Input use in producing local cultivars of Brinjal and Chilli

Sl. No.	Inputs	Quantity	
		Brinjal	Chilli
1.	Seedling (no./ha)	38499	87011
2.	Cowdung (ton/ha)	13.53	4.61
3.	Urea (kg/ha)	480.16	455.70
4.	TSP (kg/ha)	350.16	301.65
5.	MoP (kg/ha)	333.88	204.41
6.	Zypsum (kg/ha)	156.5	26.06
7.	Furadan (kg/ha)	52.23	-

Production cost of local cultivars

Variable cost: In this study, variable costs included human labour used for land preparation, tractor operation, cost of seedlings, weeding cost, manure & fertilizer cost, insecticide cost, irrigation, and harvesting cost. The study revealed that the total variable cost of local cultivar Brinjal (*Potha Begun*) cultivation was at Tk.468359/ha which was 90.9% of the total cost of production. On the other hand, it was Tk.321067/ha (88.6% of total cost) for Chilli (*Halda Morich*) cultivation.

Fixed cost: The leased value of land was considered as the fixed cost of production. The land-use costs were estimated at Tk.46,638/ha per year for Brinjal and Tk.41,291 for chilli. The percent shares of fixed cost to the total cost of production were estimated at 9.1% for brinjal and 11.4% for chilli.

Total cost: The total cost of production included the variable cost and fixed cost incurred for producing those local cultivars. On average, the total cost of production was estimated at Tk.514997/ha for Brinjal and Tk.362358/ha for Chilli. However, the cost of production per kg of brinjal was Tk.15.32 and Tk.45.63 for green chilli and Tk.182.9 for dried chilli (Table 4).

Table 4. Per hectare cost of production of local Brinjal and Chilli cultivars

Sl. No.	Cost items	Cost of production (Tk/ha)			
		Brinjal (*Potha Begun*)		Chilli (*Halda Morich*)	
		Taka	% of total	Taka	% of total
A.	Total Variable Cost	468359	90.9	321067	88.6
1.	Labour cost for land preparation	39629	7.7	19789	5.5
2.	Cost of tractor use	18719	3.6	28390	7.8
3.	Seedlings cost	38499	7.5	43506	12.0
4.	Weeding cost	74877	14.5	50093	13.8
5.	Fertilizer cost				
	Cowdung @ Tk.1.0/kg	13530	2.6	11290	3.1
	Urea @ Tk.17.65/kg	8475	1.6	7298	2.0
	TSP @ Tk. 34.05/kg	11923	2.3	9833	2.7
	MoP @ Tk. 17.88/kg	5969	1.2	5174	1.4
	Gypsum @ Tk. 14.58/kg	2282	0.4	467	0.1
	Furadan @ Tk.150/kg	7835	1.5		
6.	Insecticide cost	54304	10.5	11546	3.2
7.	Irrigation cost	32872	6.4	31942	8.8
8.	Harvesting cost	120773	23.5	75228	20.8
	Sub-total:	429687	83.4	294557	81.3
9.	Interest on operating capital @9%	38672	7.5	26510	7.3
B.	Fixed cost	46638	9.1	41291	11.4
1.	Land used cost	46638	9.1	41291	11.4
C.	Total cost [A+B]	514997	100.0	362358	100.0
	Total cost (Tk/kg)	15.32		45.63 (green) 182.90 (dry)	

Productivity and profitability of local cultivars

The average marketable yield of brinjal was 43.62 tons/ha and the average farm-gate price was Tk.30.19/kg. The gross return, gross margin, and net return were calculated at Tk.1316827 Tk.848468 and Tk.801830 respectively for the local cultivar of brinjal. The BCR of this crop was found to be 2.56 and 2.81 based on total cost and variable cost, respectively. It implies that the production of the crop is highly profitable at the farm level. However, the average cost of production per kilogram of local brinjal was estimated at Tk.15.32. The wastage of brinjal due to diseases and insects infestation alone was 7.29% of the total yield (Table 5).

In the case of the local cultivar chilli, the average yield was found to be 1.981 tons/ha (dried chilli). The total yield of green chilli was estimated by using the conversion factor of dried chilli (1:4). Thus, the yield of green chilli stood at 7.942 tons/ha. The average farm-gate prices of dried chilli and green chilli were Tk.310.8 and Tk.42.8 per kilogram, respectively. In most cases, respondent farmers harvest ripe chillies and sell them after drying. It was opined that a very negligible number of farmers sold green chilli due to meet up their urgent cash

needs. Green chillies are opined not to be good for eating because of their less salty and fleshy nature. The gross return, gross margin, and net return were calculated at Tk.615695, Tk.294628 and Tk.253337, respectively for dried chilli. The BCR of dried chilli was estimated at 1.70 and 1.92 over total cost and variable cost, respectively (Table 5).

Table 5. Productivity and profitability of the local cultivars of Brinjal and Chilli

Sl. No.	Yield and return	Amount (Tk/ha)	
		Brinjal (*Potha Begun*)	Chilli (*HaldaMarich*)
A.	Marketable yield (ton/ha)	43.618	7.942 (Green Chilli) 1.981 (Dry Chilli)
B.	Average farm-gate price (Tk./kg)	30.19	42.8 (Green Chilli) 310.8 (Dry Chilli)
C.	Gross return*	1316827	339917 (Green Chilli) 615695 (Dry Chilli)
D.	Total variable cost	468359	321067
E.	Total fixed cost	46638	41291
F.	Total cost [D+E]	514997	362358
G.	Gross margin[C-D)	848468	18850 (Green Chilli) 294628 (Dry Chilli)
H.	Net return[C-F]	801830	253337 (Dry Chilli)
I.	Benefit-cost ratio (BCR): Total cost basis (C/F) Variable cost basis (C/D)	2.56 2.81	1.70 (Dry Chilli) & 0.93 (Green Chilli) 1.92 (Dry Chilli)& 1.05 (Green Chilli)

*__Note__: As per Krishi Projokti Hatboi, 2019 the productivity of Brinjal of BARI developed varieties ranges 40-60 ton/ha and Chilli varieties 10.22 ton/ha (Green Chilli) and 2.5-3.0 ton/ha (Dry Chilli)

Farmers' perception for cultivating local cultivars of Brinjal and chilli

Respondent farmers stated various reasons for cultivating local cultivars of brinjal and chilli in the study areas (Table 6). According to the farmer's opinion, the market demand for this brinjal cultivar (*Potha Begun*) is very high because its taste is quite delicious when cooked as a vegetable. The price is higher than the other varieties of Brinjal due to its higher demand. The yield is also relatively good due to the longer harvesting period. The infestations of diseases and insects are medium. The storage capacity of this cultivar is also good. Moreover, farmers can easily produce seedlings from their stored seeds.

In the case of Chilli cultivation, they stated that the market demand is very high because it increases the taste of curry and makes curry very attractive (radish). It is also less hot compared to other varieties of chilli. Again the cultivar is relatively disease-resistant and high-yielder. Moreover, it can be stored for 2-3 years at home condition due to its longer shelf-life. So it can be sold later at a higher price. Many respondent farmers also told that the chilli of this cultivar is heavier than the other

varieties of chilli due to the content of more seeds and thick skin. Some farmers opined that they can easily produce seedlings in the field using their own seeds. For the reasons discussed above, the respondent farmers are cultivating this chilli cultivar (*Halda Marich* or *Hathazar Morich*) in the study areas.

Table 6. Farmers perception for cultivating local cultivars of Brinjal and Chilli

Sl. No.	Causes	% of respondents	
		Brinjal (*Potha Begun*)	Chilli (*Halda Marich*)
1.	Local market demand is very high	94.2	78.0
2.	Price is relatively high in the market	88.3	74.0
3.	Attractive colour after cooking	-	52.0
4.	Enhances the taste of the curry	76.1	76.0
5.	Comparatively high yielder	78.8	74.0
6.	Less diseases infection & pests infestation	66.3	70.0
7.	Easy to produce seedlings from stored seeds	84.2	94.0
8.	Good storability of these cultivars	68.3	89.0
9.	High seed contents make chili heavier	-	14.0

Consumer's perceptions to the local cultivars of brinjal and chilli

The consumers of local brinjal cultivar opined that this Brinjal gives a different taste to the curry. The fruit quality of the brinjal is high due to the medium infestation of insects. The market price of this brinjal is high due to higher market demand. It does not rot easily if kept at room temperature In the case of the local cultivar chilli (*Halda Morich*), more or less similar statements were depicted by the consumers. Most consumers stated that local chilli makes curry attractive and less hot. The fruit quality of the chilli is high due to the medium infestation of insects. The buying price is of this chilli is high due to higher market demand. It is available in the local market. The storage capacity of dried chilli is very high up to 2-3 years at room temperature. The level of consumers' responses regarding this local chilli cultivar is shown in Table 7.

Table7. Level of consumer's perceptions to the local cultivars of Brinjal and Chilli

Sl. No.	Parameters	Brinjal			Chilli		
		Very high	High	Medium	Very high	High	Medium
1.	Buying price	-	√	-	√	-	-
2.	Taste	√	-	-	-	√	-
3.	Colour	-	-	√	√	-	-
4.	Quality of fruits	-	√	-	-	√	-
5.	Infestation by disease & pest	-	-	√	-	-	√
6.	Availability	√	-	-	√	-	-
7.	Storage capacity in room temperature	-	-	√	√	-	-

Problems of cultivation of brinjal and chilli

In the case of local cultivar Potha Begun (Brinjal), the highest percent (88.8%) of respondents opined that they faced the problems of different pests attack like fruit & shoot borer, mite, sucking pests (Aphid, Trips), whitefly, cutworm, etc. in the brinjal field. In the case of disease prevalence, damping-off disease in the seedling stage, fruit rot, bacterial wilt, fruit rot, leaf rot, and leaf curl was observed in the field moderate to a slightly high level (Table 8). In order to escape from these problems, most of the farmers sprayed pesticides. Additionally, some farmers used sex pheromone traps, lighting traps, cleaning the field, remove the infected plants, and organic fertilizer. In the case of the local cultivar *Halda Morich* (Chilli), about 78.0% of respondents claimed that they faced some pest attacks by fruit borer, cutworm, thrips, Aphid, mite, and whitefly etc. About 64.0% of respondents faced some problems due to disease prevalence in their chilli field (Table 8). Usually, they observed fruit rot, anthracnose, leaf rot, bacterial leaf spot, and leaf curl occurred in the field. They took similar remedial measures as stated in the brinjal cultivar.

Table 8. Problems faced by the respondent farmers during cultivation of local cultivars

Sl. No.	Particulars	% of respondents	
		Brinjal (*Potha Begun*)	Chilli (*HaldaMarich*)
1.	Infection of diseases	72.4	64.0
2.	Infestation of insects-pests	88.8	78.0
3.	Lack of irrigation	34.3	20.0

Table 9. Storage and marketing of local cultivars of Brinjal and Chilli

Sl. No.	Particulars	% of respondents	
		Brinjal (*Potha Begun*)	Chilli (*HaldaMarich*)
1.	Storage:	-	
	Using plastic/GI sheet drum	-	90.0
	Using plastic sac	-	56.0
2.	Marketing:		
	At farmgate level to the *Faria/Bepari*	68.4	87.0
	At local market by carrying themselves	31.6	56.0

Note: Multiple responses, so that not necessarily equal to 100 for each response.

Storage and marketing of brinjal and chilli

About 90.0% of respondents reported that they stored dried chilli in plastic or GI sheet-made drums for getting better prices later. About 56% of framers used plastic sac for storing the dried chilli. In the case of marketing of those cultivars, the highest number of chilli farmers (87.0%) sold their harvested crops at the farm gate to the *Faria* and *Bepari* (local traders) and the rest was sold in the local market. In

the case of brinjal, the farmers sold 68.4% of their brinjal at the farm gate and the rest amount sold at the local market (Table 9).

Policy Intervention for improving the local cultivars

Farmers are getting higher benefits from these local cultivars. So, it is necessary to improve these cultivars for getting sustainable higher income of the farmers. In the short-term, it is essential to develop a package for controlling diseases and pests, provide training on improved management practices for enhancing the productivity of those cultivars including quality seed /seedlings production and need to develop fertilizer management packages since most of the farmers used excessive dose of fertilizers. The nutrition aspect also promulgates to the consumers for creating more demand for these cultivars. In the long-term, a new variety needs to be developed maintaining the original features of those cultivars. Disease and pest management for raising productivity of the cultivars are important issue for the farmers. Both the farmers cultivating brinjal and chilli require training on modern production technology, fertilizer management, etc. The percent of respondent's responses on the research need issues are shown in Table 10.

Table 10. Research needs for the improvements of the local cultivars

Sl. No.	Particulars	% of respondents	
		Brinjal (*Potha Begun*)	Chilli (*HaldaMarich*)
1.	Disease and pest management for raising productivity	94.4	80.0
2.	Provide training on modern production technology	67.5	81.0
3.	Research for enlarging the size of chilli	47.0	60.0
4.	Explore nutritional facts of the chilli	16.3	24.0
5.	Fertilizer management	78.0	58.4

4. Conclusion

It might be concluded that the local brinjal cultivars *Potha Begun* and chilli cultivar *Halda Morich* are very much popular in the region and profitable crops. The farmers of those cultivars face some problems during their cultivation. Most respondent farmers need its improvements for getting the higher financial benefits. There is scope to improve the productivities of studied local cultivars, efficient use of fertilizers, reducing the number of spraying in brinjal, and controlling the infestation of pests and diseases. Researchers can take initiative to develop new varieties keeping the quality of these two cultivars. Before developing new varieties, improved production management technologies including pests and

diseases control, and fertilizer management should be developed and disseminated among the farmers. It is hoped that this potential crop will emerge as a source of income for the farmer through quality research.

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AGROFORESTRY PRACTICES IN BANGLADESH: PERSPECTIVES ON KNOWLEDGE, PERCEPTION, AND ECONOMIC BENEFITS

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Abstract

Agroforestry is one of the sustainable land management techniques, involving a combination of different agricultural, horticultural, and forestry practices to maximize productivity and sustainability of land. In disadvantaged locations such as char lands, a well-planned interacting land use system incorporating woody perennials in line with the farmers' needs can lead to a successful and sustainable farming system to dwindle poverty and eventually improve the food security. Agroforestry practices can serve this purpose in developing agro-based economy like Bangladesh. This study therefore is undertaken to reveal the farmer's knowledge on agroforestry practice, willingness to practice agroforestry and to examine the economic benefits of adoption of agroforestry. Following multistage random sampling technique, a total of 240 farm households were selected from certain char areas of Mymensingh, Jamalpur and Sherpur districts of Bangladesh. Socioeconomic characteristics of sample farmers were explored in terms of age, education, gender, farm experience, land ownership, etc. Farmers' knowledge, willingness, and adoption level of agroforestry were also examined. The majority of the farmers in the survey are aware with agroforestry practices (65%), but just a handful have actually used them. The farmers who adopted agroforestry practices or interested to adopt, expect support (cash or kind) from project or government. The tree species under agroforestry include Akashi, Eucalyptus, Mahogani, Mango, Jackfruit, Guava, Lemon, and Coconut. Financial or investment analysis of agroforestry adoption was done for several combinations of trees and vegetables.

Keywords: Agroforestry adoption; climate change; sustainable agriculture; Bangladesh.

1. Introduction

The predicted growth in world population from 7.4 billion in 2017 to 9.7 billion in 2050 (UN, 2019) has drawn a lot of attention as a factor influencing global food demand (Fukase & Martin, 2020). Between 2010 and 2050, total worldwide food demand is predicted to rise by 35% to 56%, while the number of people at danger

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of hunger is expected to rise. Moreover, the predicted growth in food production and its consequences for land use change, biodiversity, and environmental issues are strongly reliant on global food demand and consumption predictions (van Dijik *et al*., 2021; Hossain *et al.*, 2022).

Because of the increase in demand for agricultural resources as diets shift away from starchy staples and toward animal-based goods and fruits and vegetables, this growth convergence might have significant ramifications for global food consumption and agriculture (Fukase & Martin, 2020). This shift in diets have taken attention of all of the scientist and researchers all over the world. This event necessitates the invention of such method or system which can meet the future global demand of food as well as reduce environmental issues. Agroforestry can be the solution of solving such problems in the present context. Agroforestry can be identified as a promising option to meet society's demands and sustainable development models due to its benefits not only to the economy and society but also to the ecology (Jahan *et al.*, 2022). In developing nations, agroforestry is being encouraged to increase the productivity and sustainability of existing agriculture, particularly where monocrops are farmed on marginal areas (Nath et al., 2016). Agroforestry has many positive effects on farmers' livelihood through maximizing crop yields, reducing food insecurity, increasing income as well as improving farmers ability to cope with the effects of climate change by improving rain use efficiency and yield stability under rain-fed agriculture (Meijer *et al.*, 2014). Moreover, Agroforestry is a sustainable land management approach with an integration of agriculture, horticulture and forest to maximize productivity, profitability, minimization of resource and environmental risk. Agroforestry has gained popularity in recent years due to its potentiality to boost production, improve rural household security, and deliver regional environmental benefits (Jahan *et al.*, 2022). Agroforestry can be identified as a promising option to meet society's demands and sustainable development models due to its benefits not only to the economy and society but also to the ecology. Agriculture is progressing to the next level of sustainability thanks to agroforestry, which stimulates and executes bio-diverse (Jahan *et al.*, 2022).

As the population is rising quickly in Bangladesh, the quantity of land available for the development of new dwellings, factories, roads and highways, brickfields, hospitals, educational institutions, religious institutions, and other infrastructure is decreasing. On the other hand, because of increasing population demand of food is increasing too. As a result, one of the most common natural phenomena influencing the planet is forest conversion for alternative human benefit, which results in ecological devastation and global warming (Slingo *et al.*, 2005). Again, for ecological stability and sustainability, a country's total land area must have 25% forest land. Bangladesh, however, only has 17% of the land under forests, which are unevenly spread (BBS, 2013). This is very threatful for our country's overall

ecology. The only method to expand the forest is to plant trees, as there is no way to grow natural forest acreage to meet household demand for wood and fuel. Agroforestry, the technique of cultivating trees and crops on the same ground, with or without animals, is an important land-use system in developing countries (Jahan *et al.*, 2022) Homestead, cropland, farm boundary, roadside, railway side, embankment side, charland, coastal area, deforested area, institutional premises, riverside etc. are major venues for agroforestry practices. The scope of agroforestry is wide in Bangladesh (Nath *et al.*, 2016).

The Bengali name "Charland" means "Riverine Island" and refers to a mid-channel island that forms periodically from the riverbed as a result of accretion. Every year a large percentage of the char gets flooded and this situation threatens the livelihoods of people dependent on agriculture. Based on the potential and availability of land and the scope for improving productivity and benefits through agroforestry, char land areas are identified as a priority for research and development. Charland is the most important location for practicing agroforestry methods among them. Jamalpur, Sirajgonj, Noakhali, Bogra, Rangpur, and Mymensingh are the largest char-populated districts in Bangladesh. A vast number of people live in these char areas and rely on char-based farming systems for their livelihood. As a result, an integrated approach with crop and trees is required to increase productivity, maintain ecological balance, and improve the socioeconomic status of the Charland people (Rahman *et al.*, 2021). Agroforestry research and development has resulted in the advancement of scientific and technological advances (Brockington *et al.*, 2015). Because of their ability to mitigate the negative effects of intensively managed systems, agroforestry systems are gaining popularity in temperate climates. (Tsonkova *et al.*, 2018). Fruit-tree-based agroforestry is now popular that contributes to increasing total productivity and food security. The adoption and dissemination of new technologies depend on the diffusion of information through farmers interaction with extension agencies (Nath et al., 2016). Also, the uptake of agricultural innovation by smallholder farmers are less because of environmental degradation and climate change, lack of economic resources resulting in productivity. (Meijer *et al.*, 2014).

Several studies have addressed the adoption of agroforestry systems in different parts of the globe (Mfitumukiza *et al.*, 2017; Bayene *et al.*, 2019; Oduniyi and Tekana, 2019; Dhakal and Rai, 2020). Some studies also conducted in Bangladesh focusing on agroforestry adoption (Rasul and Thapa, 2006; Rahman *et al*., 2012; Sharmin and Rabbi, 2016; Saha *et al*., 2018); however, none of these studies was done focusing specifically on farmer’s knowledge, and perceptions regarding Agroforestry. Also, it finds in details data on support for agroforestry, perception towards agroforestry which ultimately help to adopt new technology like agroforestry. Besides, this study also makes an attempt to explore the respondents’ willingness and economic benefit of agroforestry in Bangladesh. To the best of our knowledge, this is the only study to figure out the farmer’s knowledge, and

perceptions regarding agroforestry in Bangladesh by collecting substantial primary data for robust findings. Thus, this study will contribute to the further research on agroforestry. Despite the fact that this research focused on Bangladesh, the findings may be generalized to other countries with comparable socioeconomic backgrounds.

2. Data and Methodology

2.1. Study areas and data collection

The present research is based on field level primary data collected from selected respondents through farm survey method. Keeping this view in mind, the researchers took paramount care for using proper methods in all aspects of this research within the encirclements of limited resources, materials and time. The current study was conducted in three Bangladeshi districts: Mymensingh, Jamalpur, and Sherpur. The research region is in Bangladesh's agro-ecological zone nine, often known as the Old Brahmaputra Floodplain.

Data collection was done by personal interviews. To collect the required data, a semi-structured interview schedule was created. A few Focus Group Discussions (FGDs) were performed before the interview schedule was created to learn about farmers' general perceptions and grasp of agroforestry. The input received during the FGDs was useful in planning the interview schedule. The interview schedule included information on household socioeconomic status, cropping patterns, cost and return statistics, and farmers' overall perceptions of agroforestry operations. Before finalizing the interview schedule, it was pre-tested with 10 farmers, and we made changes based on the results of the pre-test. Random sampling techniques were used to acquire data. Eighty samples were gathered from each district of Mymensingh, Jamalpur, and Sherpur, for a total sample size of 240. Two training programmes were conducted under this study to build capacity of the enumerators to collect accurate and adequate information and to manage, analysis and report data.

During data processing following steps had been taken.1) data entry and cleaning 2) coding 3) data validation 4) summarizing and scrutinizing the data for analysis. The socioeconomic information of the sample farmers particularly the family size and composition, age, literary level, occupation, land ownership pattern, and its distribution, their resource endowments etc were collected to understand the socioeconomic factors that are responsible for the adoption of agroforestry practices.

2.2. Empirical method

This part contains the study technique, which includes the description of descriptive statistics as well as the data analysis model. The descriptive statistics was used to depict the findings of socio-demographic profile of the respondents,

knowledge, perception and witlessness to adopt the agroforestry practice. The investment analysis was conducted to show the economic benefit of adopting agroforestry practice. We considered three popular combination of tress to show the best tree mix in an agroforestry practice. The benefits indicate the returns from agroforestry project sales i.e., quantity sold multiplied by the price of wood and non-wood items. Variable costs (e.g., land preparation, seedlings, planting, management, pruning, harvesting), overhead costs (e.g., cost of planning and compliance), capital costs (e.g., land purchase, machinery, depreciation), and opportunity costs (e.g., reduced gross margin from displaced livestock or cropping enterprises on land planted to trees) may all be included in the financial analysis. The financial analysis was conducted using discounted net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR). The discounting rate employed in this study is 10%. This indicates that the farmer thinks that if the money were not invested in the agroforestry project, the greatest alternative rate of return would be 10%. To put it another way, the opportunity cost of capital is 10%.

Mathematically, the NPV is calculated as:

$$NPV = \sum \left(\frac{B_i - C_i}{(1+r)^t}\right) = PVB - PVC \quad (1)$$

where B_i is the benefit in time t, C_i is the cost in time t, r is the selected discount rate, and t is time. The NPV is the difference between the present value of the benefits (PVB) and the present value of the costs (PVC). The monetary value and net present value are expressed in Bangladeshi Taka (BDT).

The BCR is a calculation that estimates the return on investment in an agroforestry project. It is calculated as:

$$BCR = \frac{NPV\ benefits}{NPV\ costs} \quad (2)$$

The discounted benefits of the project surpass the expenses if the ratio is larger than one. If it's less than one, the discounted costs outweigh the benefits, and the project should be thoroughly evaluated before moving forward (possibly accounting for unmeasured additional advantages).

The IRR of an agroforestry project represents the real rate of return on investment. We may use the IRR to compare various investments because it also provides us the discount rate. The IRR is calculated by continuing the process until the discount rate produces a net present value that is negative (NPV). Modern spreadsheets provide an IRR function investment that automates this iterative process and allows us to rapidly compute the IRR for a series of net cash flows in our project.

3. Results and Discussion

Sociodemographic Characteristics of Farmers

Farmers and their family members' socio-demographic features primarily highlight the wide range of interconnected social traits that have a significant impact on their economic activities, living conditions, and decision-making process. These qualities frequently influence a farmer's production strategy. Socioeconomic features may be viewed from a variety of perspectives, based on a variety of factors such as their socioeconomic status and the socioeconomic environment in which they live. Table 1 presents the socio-demographic profile of the selected respondents.

The respondents' age has a significant role in their willingness to participate in any income-generating activity. All of the sample farmers in the research region were divided into four age groups: those aged 20 to 30, 31 to 40, 41 to 50, and those aged above 50. The research reveals that the majority of the farmers in the research regions are either young (20-30 years old) or experienced (above 50 years old). In Mymensingh, 33.8%, 35% in Sherpur, and 27.5% of the selected farmers in Jamalpur, were in the 20-30-year-old age range. Only Mymensingh had the lowest 7.5% in the age range 31-40 years, while Jamalpur and Sherpur had the lowest in the age bracket 41-50%. Finally, the age group of more than 50 years was 32.5% in Mymensingh, 26% in Sherpur, and 35% in Jamalpur, respectively.

Education, in addition to skills and experience, has a significant influence on the modernisation of agricultural industry. It assists farmers in making the best decisions for their farm businesses by providing updated knowledge on new agricultural innovations. The majority of farmers in the study regions are illiterate. Mymensingh has the greatest illiteracy rate (57.5%), whereas Jamalpur has the lowest (47.3%). Some farmers have completed basic and secondary school, but just a handful have completed post-secondary education. As a result, it may be claimed that farmers find it difficult to absorb new technology and information, while technology suppliers find it difficult to inspire them.

The survey results show that some farmers in the research region work in a variety of vocations, despite the fact that agriculture (88.3%) is the primary source of income for the inhabitants in the study area. Aside from agriculture, some farmers work in trading, some in services, and just a few farmers work as housewives or students (Table 1).

Table 1. Socio-demographic factors of the selected respondents

Particulars	Region			All
	Mymensingh	Sherpur	Jamalpur	
Age of the respondents (years)				
20-30 (%)	33.8	35	27.5	32.1
31-40 (%)	7.5	25	23.75	18.8
41-50 (%)	26.3	13.75	13.75	17.9
More than 50 (%)	32.5	26.25	35	31.25
Education level of selected respondents (Years of schooling)				
Illiterate (%)	57.5	56.1	47.4	53.8
Up to primary (%)	20.0	29.3	20.5	23.3
Up to secondary (%)	17.5	7.3	20.5	15.0
Above secondary (%)	5.0	7.3	11.5	7.9
Occupation of the respondents				
Farming (%)	80.0	90.2	94.9	88.3
Labor (%)	3.8	1.2	1.3	2.1
Business (%)	13.8	0.0	1.3	5.0
Job (%)	0.0	1.2	1.3	0.4
Housewife (%)	1.3	0.0	0.0	0.8
Student (%)	1.3	7.3	1.3	3.3
Agricultural cultivable land (Average decimal)				
Own (decimal)	118.92	185.76	199.27	168.27
Leased in (decimal)	81.58	90.93	207.10	140.82
Leased out (decimal)	64.40	133.50	88.62	98.54
Total (decimal)	153.93	182.95	239.94	192.70
Land distribution in different sectors (Average decimal)				
Homestead area	24.96	35.25	27.75	29.17
Pond size	17.44	14.88	6.80	12.15
Forest	29.30	39.69	24.28	29.85
Others	30.00	5.00	2.85	5.27
Mean (Years)	24.55	20.33	23.54	22.78
Range (Years)	1-60	3-70	3-60	1-70
St. Dev. (Years)	12.85	13.791	16.382	14.45
Categories of farming experience (% of respondents)				
Up to 10	21.30	34.10	26.90	27.50
11-15	10.00	18.30	19.30	15.80
16-20	13.70	9.80	14.10	12.50
More than 20	55.00	37.80	39.70	54.20

Farm size refers to how much land a farmer owns and uses to grow a variety of crops and run profitable enterprises, as well as how it influences resource allocation. Sample families can be classified into three farm groups based on land ownership status: small (0.05-2.49 acres), medium (2.50-7.49 acres), and big (more than 2.50 acres) (7.50 acres and above). Small farmers found to dominate ranges of 78 to 88 percent of total samples across all areas. Farmers' land

holdings averaged 192.70 decimal, with the farmers of Mymensingh having the smallest (154 decimals) and the farmers of Jamalpur having the most (240 decimals).

Average land distribution for forest was found 29.85 decimal, while it was 29.30 decimal in Mymensingh, 39.69 decimal in Sherpur and 24.28 decimal in Jamalpur. The respondents' average agricultural experience was 22.78 years. A total of 54.20 % of farmers had more than 20 years of experience on the field. Mymensingh district has the most experienced farmers, while Sherpur had the least. Farm experience refers to knowledge or abilities in agricultural activities that a farmer has acquired through time by exercising or using their senses. Farming expertise is beneficial during the early phases of farmers' acceptance of new technology.

Financial analysis plays a vital role for the relatively realistic estimation of whether farmers are or will be profitable from exercising such practices (Duguma, 2013) as agroforestry is a long-term investment (Jara-Rojas et al., 2020) and financial capital consists of both stocks (e.g. bank deposits, jwellery or livestock) and flows (e.g. regular earned income or remittances). It is seen that access to bank, the percentage of farmers received credits, average amount of loan and the ranges of loans have some impact on farmer’s knowledge and attitude towards agroforestry. Usually, NGO disburses loan lower amount then that of bank and getting loan from bank still challenging for the farming community. The study reveals that the percentage of farmers received credits in Mymensingh, Sherpur, and Jamalpur region was 36.3%, 34.1% and 33.3% respectively in last five years. Aggregate annual earning is one of the important components for measuring the strength of financial capital. A farmer’s income can influence his knowledge, attitude and information towards anything related to agriculture. That is why, income status of our study regions farmers is necessary. Table 2 shows the average income of sample farmers from nine different sources. Most of the farmers in the study areas earn money from their crop selling as agriculture is their main occupation. The average income from crop selling was estimated at Tk. 95733, Tk. 111851, and Tk. 65421 for Mymensingh, Jamalpur, and Sherpur districts, respectively. As agroforestry is an important part of agriculture sector, income from tree and tree product source is important here to increase the knowledge, attitude and information sources of agroforestry.

3.1. Major pattern and plan distribution under agroforestry practices

Farmers, who practice agroforestry in their land, use on an average 30, 33, and 39 decimals of land in Mymensingh, Jamalpur, and Sherpur districts, respectively.

The average plants were 111 in average 39 decimals of land (Table 3). In Mymensingh, the plant species that are adopted by farmers include Akashi, Mahogoni, Lombu, Koroi, Mango, Jackfruit, Guava, Lemon, Litchi, and Coconut. In Sherpur, the tree species they adopted agroforestry practices include Eucalyptus, Mahogoni, Mango, Jackfruit, and Lemon. In Jamalpur, the tree species they adopted for agroforestry practices include Akashi, Eucalyptus, Mahogoni, Mango, Jackfruit, Guava, Lemon, and Coconut.

Table 2. Annual earning of respondent households

Yearly family income (Tk.)	Region			Total
	Mymensingh	Sherpur	Jamalpur	
Income from crop selling	95733.33	111851.85	65421.05	91431.03
Income from tree and tree product	22075.12	29797.30	24303.03	25529.37
Income from Livestock poultry	41346.15	44484.62	43651.67	43280.23
Income from fisheries ponds	69000.00	70555.50	21333.33	59452.36
Income wages and salaries	87388.89	128625.00	135272.73	110540.54
Income small business	63812.50	131428.57	164571.43	114729.73
Income from Remittances	0.00	0.00	440000.00	440000.00
Govt support or grants	10000.00	0.00	0.00	10000.00
Others	0.00	0.00	63000.00	63000.00
All average	389356	516743	957553	957963

Table 3. Average area and plant under agroforestry practices

Criteria	Mymensingh	Sherpur	Jamalpur	All
Area (decimal)	30.22	33.36	47.93	38.77
Average plant	44.70	162.79	141.24	110.57

Table 4. Number of plants produced per decimal and per hectare

District	Per decimal	Per hectare	Type of plant	Per decimal	Per hectare
Jamalpur	3.02	744.12	Wood	3.30	812.95
Mymensingh	2.03	500.02	Fruits	2.51	623.34
Sherpur	3.87	979.71	Medicinal	2.40	592.33
Total	2.84	702.36	Others	1.20	296.00
			Total	2.84	702.36

Distribution by plant name

Plant name	Per decimal	Per hectare	Plant name	Per decimal	Per hectare
Akashi	4.46	1097.38	Jackfruit	1.58	386.56
Amloki	3.60	889.00	Koroi	1.68	413.00
Boyra	1.50	370.00	Lemon	6.19	1522.93
Coconut	1.24	333.00	Litchi	1.03	253.60
Drum stick	1.20	296.00	Mahogany	1.91	471.56
Guava	2.77	680.67	Malta	3.00	740.00
Haritaki	2.40	592.00	Mango	1.79	442.85

Natural capital holdings have a very close relationship with knowledge, attitude and information sources of agroforestry. Those who have more forest and

cultivable land they have positive attitude about learning new techniques that can be agroforestry. Land, forest, pond are the main natural resources belong to rural households. On their own land they cultivated different crops and vegetables seasonally which is the basic income source of the farmers. It was found that the sample households own 193 decimals of land for cultivation. They also possess 30 decimals of forest and 12 decimals of pond. The households of char land own on average 30-50 trees as natural and Akashi seems to require less land and can be produced more per unit of land according to Table 4.

The agroforestry system of vegetable farming is well-known in the Old Brahmaputra floodplain scheme. This system includes Mymensingh, Jamalpur, and Sherpur, which are all part of our research region. In this region, a wide range of vegetables are cultivated under various cropping patterns, with variations from one location to the next. Rice, jute, brinjal, potato, tomato, chili, and red amaranth are the most prevalent crops and vegetables planted by the sample farmers. Table 5 shows the details of major crops and vegetables produced in Mymensingh, Jamalpur and Sherpur District.

Table 5. Types of crops and vegetables grown by the sample farmers

District	Name of crops and vegetables
Mymensingh	Rice, Wheat, Jute, Sweat gourd, Potato, Brinjal, Bottle gourd, Raddish, Cabbage, Chili, Mustard, Carrot, Cucumber, Amaranth, Red amaranth, Okra, Grass pea, Sweet potato.
Jamalpur	Rice, Wheat, Jute, Cotton, Sweat gourd, Sweet potato, Brinjal, Amaranth, Red amaranth, Onion, Tomato, Okra, Ginger, Cauliflower, Mashkalai, Bean, Chili.
Sherpur	Rice, Jute, Maize, Sweat gourd, Potato, Brinjal, Tomato, Chili, Red amaranth, Peanut, Grass pea, Chili, Cauliflower, Cucumber, Bean, Bottle gourd, Raddish.

3.2. Knowledge about agroforestry practices

The important benefits of agro-forestry which perceived were that it helps in becoming 'self-reliant' in terms of fuel, fodder, timber and other minor forest produce (MFPs), 'helps in increasing soil fertility, checking soil erosion and retention of soil moisture', 'capable of improving socio-economic conditions of the farmers', 'meeting the raw material demands of forest based industries', 'overall increase is more than pure forestry and agriculture land use', 'solving un-employment problem', etc. According to the survey, 70% of farmers in Mymensingh said they'd heard of agroforestry, but that doesn't indicate they're using it (Table 6). Agroforestry was used by 30% of these farmers. Despite the fact that the majority of farmers have never practiced agroforestry, they are eager to do so. On Sherpur, 46% of farmers said they'd heard of agroforestry, and 30% of them said they'd tried it in their fields. Approximately 67 percent of farmers said they had market access for the items they produce, which is lower than in Mymensingh

and Jamalpur districts, suggesting that market facilities in this area should be enhanced. In Jamalpur, 77% farmers mentioned that they have heard about agroforestry within which 39% practiced this. About 96% farmers mentioned that they have market access for the products they produce.

Table 6. Information about agroforestry practices

Particulars	% of farmers response yes			Total
	Mymensingh	Sherpur	Jamalpur	
Familiar with agroforestry	70.0	46.3	76.9	64.2
Experience in agroforestry	30.0	30.5	38.5	32.9
Received support	12.5	7.3	26.9	15.4
Access to market	90.0	66.7	96.4	89.7

3.3. Source of information

Information is a very important element before doing a task. When one has proper information about a task or a thing, one can easily gain knowledge about it. Depending in the degree of access to information, knowledge can vary from person to person. Types of information source and the interest to take information from those sources affect a person's attitude too. Agricultural information to farmers has been highlighted as critical agent needed to transform subsistence farming into a modern and commercial agriculture. The present study investigated the information sources of agroforestry practices available to the farmers. Figure 1 portrays the information sources related to agroforestry practices in the selected districts and in total. In Mymensingh, farmers got information mainly from the Bangladesh Agricultural University followed by Agriculture offices, relatives, and neighbours. In Sherpur, 32% farmers got information from Agriculture office, mainly BARI followed by neighbours, NGOs, relatives, and university. In Jamalpur, most of the farmers got information from Agriculture office, i.e. BARI.

Extension services play a vital role in providing different information and guidance that is needed for the development of knowledge, skills, practices and improvement of livelihood as well**.** But from the survey, extension staff in char areas are not the most effective to visit communities. About one-third to one-fifth of farmers reported that they have not seen any extension staff visited to their locality (Table 7). In contrast, about 50 % of the farmers never visit to the extension office. Again, a good portion of the respondents (17 to 25 %) reported that they rarely visit to the extension office as well as extension staff also visit rarely (33 to 38 %) to them. A few percentages of the farmers often visit to the extension office for advisory services. It can be said that delivery of extension services to the door steps and farmers interest to gather information from extension office were found at lower level. This is not unexpected as the study samples were drown from char areas.

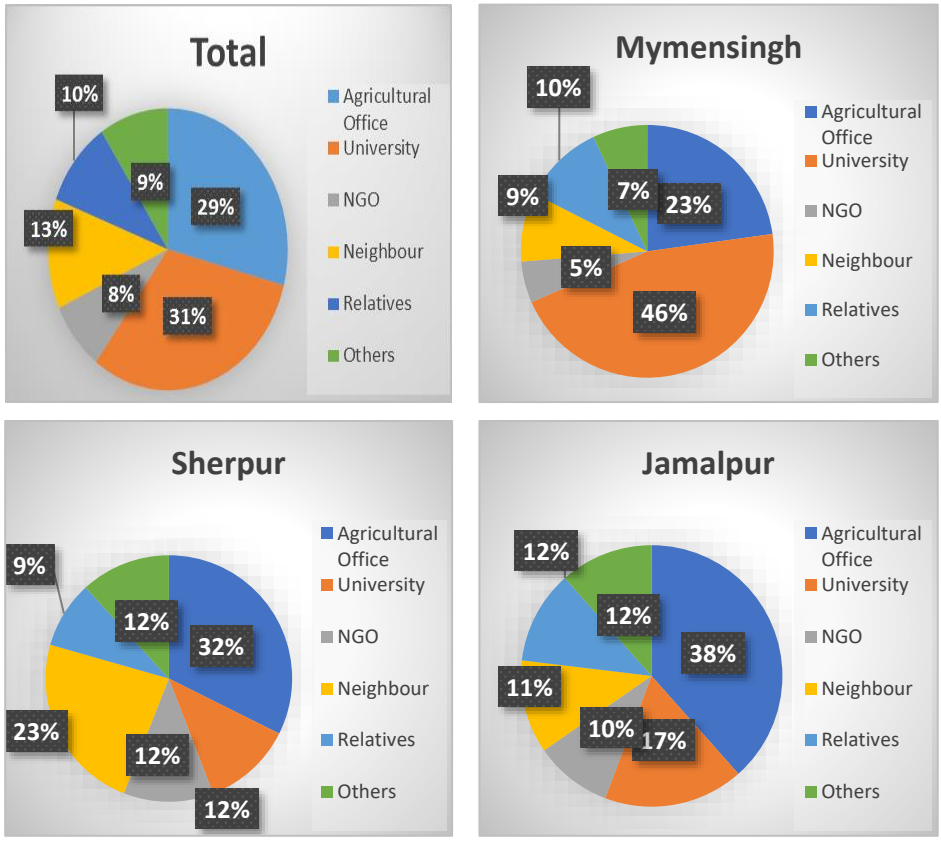

Figure 1. Agroforestry information sources to the farmers

Table 7. Mode of extension services received by the respondents

Particulars	Region			Total
	Mymensingh	Sherpur	Jamalpur	
Visit of extension staff (percentage)				
Not at all	21.6	17.6	30.3	23.2
Rarely	32.4	37.8	32.9	34.4
Yearly	14.9	10.8	3.9	9.8
Once in a month	25.7	20.3	11.8	19.2
Quite often	5.4	13.5	21.1	13.4
Respondents visit to extension office (percentage)				
Not at all	46.5	51.5	61.8	53.5
Rarely	25.4	17.6	17.1	20.0
Yearly	5.6	8.8	1.3	5.1
Once in a month	16.9	16.2	10.5	14.4
Quite often	5.6	5.9	9.2	7.0

3.3.2. Access to support of agroforestry

Bangladeshi farmers are gradually embracing agroforestry using indigenous knowledge on a small scale rather than commercialization using advanced scientific knowledge (Hanif et al., 2018). In Bangladesh, the majority of farmers still lack appropriate understanding regarding agroforestry operation and management. As a result, they are less concerned with combining different trees to maximize returns (Jahan et al., 2022) That is why support of agroforestry is needed in input sector as well as in case of trainings also.

Farmers were found to receive the majority of their help in the form of seed/seedlings and training. In Mymensingh, around 4% of sample farmers received seed, 10% received seedlings, 2.5% received labor, and 5% received instruction to help them conduct agroforestry. A few farmers received help with fertilizer, irrigation, and herbicides (Table 8). Only 2.4% of the farmers in Sherpur received assistance, and it was limited to seed or seedlings. In Jamalpur, 6% of farmers received seed, 22% received seedlings, 5% received labor, 10% received fertilizer, and 22% received instruction to help them implement agroforestry. They received an average of 1 kg of seed and 17 seedlings per area. They received 6 labor, 60 kg fertilizer, 850 Tk for irrigation, 300 Tk for pesticides, and 694 Tk for training on average in Mymensingh and Jamalpur. Farmers are unable to sell their produce at the market due to a lack of assistance. Table 6 provides more information on market support.

Table 8. Information about support services to practice agroforestry

Type of support	Yes (%)	All average	Mymensingh		Sherpur		Jamalpur	
			Yes (%)	Amount	Yes (%)	Amount	Yes (%)	Amount
Seed (Kg)	4.2	1	3.8	2.33	2.4	0.57	6.4	5.0
Seedling (No.)	11.3	17	10.0	50.63	2.4	35	21.8	42.57
Labor (No.)	2.5	5.75*	2.5	3.0	0.0	0.0	5.1	8.5
Fertilizer (Kg)	3.8	60*	1.3	100	0.0	0.0	10.3	19.57
Irrigation (Tk.)	0.8	850*	1.3	500	0.0	0.0	1.3	1200
Pesticide (Tk.)	0.8	300*	1.3	300	0.0	0.0	1.3	300
Insecticide (Tk.)	0.4	200**	1.3	200	0.0	0.0	0.0	0.0
Market support	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Training (Tk.)	8.8	694*	5.0	733.33	0.0	0.0	21.8	655.55
Fencing net	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* Average of Mymensingh and Jamalpur; ** Mymensingh only.

3.4. Farmers' willingness and perception towards practice agroforestry

There are variations in sample farmers in terms of knowledge, attitude and adoption level regarding agroforestry practices. There are some farmers who never heard about agroforestry. Some were practicing agroforestry while some were interested to do agroforestry. They study therefore interested to know the percentage of the

farmers who are currently doing agroforestry and will continue this practice in future. In addition, it was also investigated who are interested to start this practice. Table 9 shows that in Mymensingh, 72% farmers who are familiar with agroforestry practices are doing this and among them 93% will continue this practice. Farmers who are practicing agroforestry, 50% are doing this practice with support and 50% are doing without support. Farmers who wish to continue in future, mentioned that they will continue this practice if they get support (86%). However, 14% replied that they will continue this practice even they will not get any support. In Sherpur, 67% farmers who are familiar with agroforestry practices are doing this and among them 93% will continue this practice. Farmers who are practicing agroforestry, 75% are doing this practice with support and 25% are doing without support. Farmers, who wish to continue in future, mentioned that they will continue this practice if they get support (100%). Nobody replied that they will continue this practice without support. In Jamalpur, 32% farmers who are familiar with agroforestry practices are doing this and among them 96% will continue this practice. Farmers who are practicing agroforestry, 72% are doing this practice with support and 28% are doing without support. Farmers, who wish to continue in future, mentioned that they will continue this practice if they get support (53%) and 47%mentioned that they will continue this practice even they will not get any support. Among the farmers, who are not currently practicing agroforestry, 51% in Mymensingh are interested to start agroforestry in future and half of them expressed interest for support while half of them said that they are interested even without support. The similar situation was found in Jamalpur district. However, in Sherpur the percentage of interested farmers is very low (5%). This may be the lack of knowledge and information they got about agroforestry.

Table 9. Farmers' willingness to practice agroforestry

	Mymensingh (%)			Sherpur (%)			Jamalpur (%)		
	Yes	WS	WOS	Yes	WS	WOS	Yes	WS	WOS
Continuing	72.0	50.0	50.0	66.7	75.0	25.0	32.1	72.0	28.0
Future continue	92.9	86.4	13.6	92.9	100.0	0.0	96.4	83.3	16.7
Interested in agroforestry	51.2	51.2	48.8	4.9	45.1	54.9	46.2	52.6	47.4

WS=With support; WOS= Without support.

Farmers, who are practicing agroforestry in their field, received or bought seed or plant from different sources (Figure 2). The main sources for seed or plant are market, agricultural offices, project, NGO, Seed Company, and others. In Mymensingh, 56% farmers bought seed/plant from market. In addition, 15% got seed or plant from the project (i.e. NATP phase-1 project), 15% from agriculture offices, and some 12% from relatives or neighbors. In Sherpur, most of the farmers (84%) purchased seed or plant from market followed by others (relatives, neighbors, etc.). In Jamalpur, 39% farmers used the market source for their seed or plant. They also got these from others (37%), and from agriculture office (i.e. BARI).

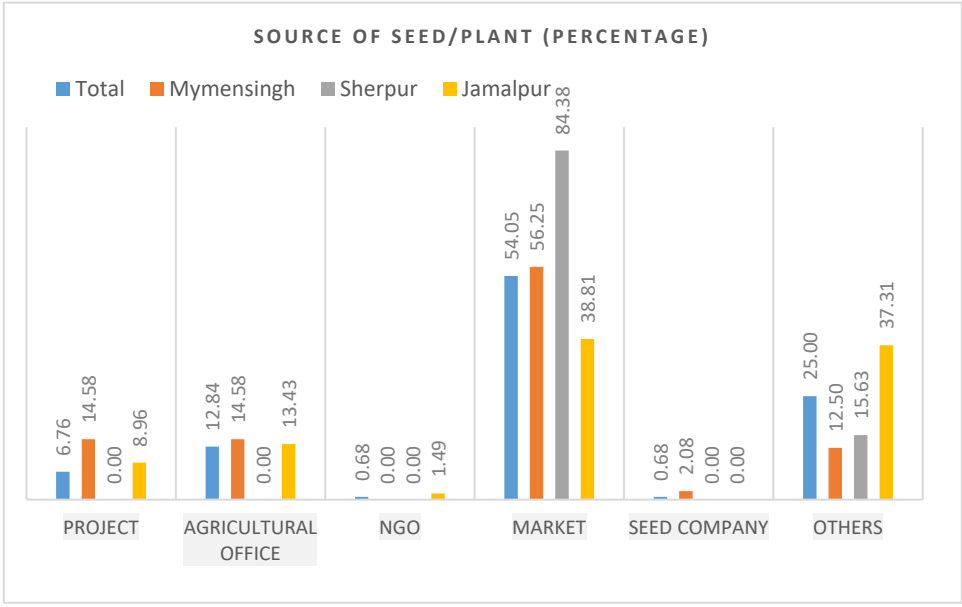

Figure 2. Source of Seed/plant for agroforestry practices

3.5. Economic Benefits of adoption of Agroforestry Practices

The profitable and income generation way is the combination of cultivating vegetables and trees as well. Mahogany is an excellent choice for a rice field boundary plantation and growing this economic tree zonally or sequentially with crops on the same piece of land that offers a good production strategy (Noman et al., 2018). Here, the study provides the financial analysis of mahogany tree combined with chili. In this combination, first year cost was estimated as the highest as most of the investment was done in first year including land preparation and plantation. Later, the cost was reduced slightly over the years. In the subsequent years the costs include operation and maintenance cost, thinning, pruning, etc. Encouragingly, from the beginning of the investment agroforestry system generated revenue because of vegetables production although net cash flow was a bit negative. It is observed that in the first three years, revenue was generated through vegetables production (chili in this case) which could not be possible without adopting agroforestry practices. The highest amount of revenue obtained in the 10^{th} year of tree plantation when first sale from the tree occurred. Accordingly, the net cash flow was also appeared as the highest at that year. Finally, NPV, BCR, and IRR were estimated based on the discounted value method. Table 10 present the details of cost and return of Mahogany Tree with Chili cultivation in the study areas.

Table 10. Investment Analysis for Mahogany Tree with Chili

(BDT '000'/ha)

Year	Activity	Direct cost (A)	Opportunity cost (B)	Total Cost (A+B)	Revenue from trees (C)	Revenue from Chili	Total Revenue (C+D)	Net Cash flow (A-B)	Net cash Position (Cumulative)
0	Establishment cost	327	76	402	0	395	395	-7	-7
1	Operation & Maintenance (O&M) cost	273	71	345	0	395	395	50	44
2	1st pruning + O&M	279	72	350	7	216	224	-127	-127
3	1st thinning + O&M	45	53	98	12	0	12	-86	-212
4	2nd Pruning + O&M	20	51	71	12	0	12	-58	-58
5	O&M cost	10	50	60	0	0	0	-60	-119
6	O&M cost	10	50	60	0	0	0	-60	-60
7	O&M cost	5	50	55	0	0	0	-55	-115
8	O&M cost	5	50	55	0	0	0	-55	-55
9	Harvest 50% @2500/tree	10	50	60	1853	0	1853	1792	1738
10	O&M cost	5	50	55	0	0	0	-55	-55
11	Harvest 25% @3000/tree	10	50	60	1081	0	1081	1020	966
12	O&M cost	5	50	55	0	0	0	-55	-55
13	O&M cost	5	50	55	0	0	0	-55	-110
14	Final harvest saw long @3500/tree	15	51	66	1235	0	1235	1169	1169

The estimated NPV, BCR, and IRR were found as below:

NPV=Tk.1076,000/ha; BCR=1.21; IRR=42%

Likewise, mahogany, investment analysis of akashmany with other vegetables practices were done. The study of Alam et al. (2012) support this finding that summer vegetables cultivation with the combination of different fruit, timber and soil conserving tree species can be a profitable agroforestry practice in charland areas. Here, in case of akashmoni with combination of brinjal, the most cost was incurred in the first year. Since, it is an agroforestry system, revenue can be earned from the first year by selling vegetables (brinjal in this case). The revenue from tree started from the 10^{th} year and continued until 15^{th} year.

In general, for any investment, no return is expected for first couple of years as initial investment cost is higher for first few consecutive years which is true for sole plantation also. But for agroforestry practices revenue is generated from the beginning of the investment as revenue is obtained from vegetables production hence the net cash flow for agroforestry combination shows relatively lower negative value. Table 12 presents the details cost and benefit analysis of Lambu Tree with Bitter gourd cultivation.

Table 11. Investment Analysis for Akashmoni Tree with Brinjal

(BDT '000'/ha)

Year	Activity	Direct cost (A)	Opportunity Cost (B)	Total Cost (A+B)	Revenue from trees	Revenue from	Total Revenue	Net Cash flow (A-B)	Net cash Position
0	Establishment cost including fence	414	83	496	0	494	494	-2	-50
1	Operation & Maintenance (O&M) cost	367	79	446	0	494	494	48	-49
2	1st pruning + O&M	372	79	451	7	395	403	-49	-96
3	1st thinning + O&M	45	53	98	12	0	12	-86	-182
4	2nd Pruning + O&M	20	51	71	12	0	12	-58	-58
5	O&M cost	10	50	60	0	0	0	-60	-119
6	O&M cost	10	50	60	0	0	0	-60	-60
7	O&M cost	5	50	55	0	0	0	-55	-115
8	O&M cost	5	50	55	0	0	0	-55	-55
9	Harvest 50% @3500/tree	10	50	60	2161	0	2161	2101	1738
10	O&M cost	2	50	52	0	0	0	-52	-52
11	Harvest 25% @4000/tree	10	50	60	1235	0	1235	1175	969
12	O&M cost	5	50	55	0	0	0	-55	-55
13	O&M cost	5	50	55	0	0	0	-55	-110
14	Final harvest saw long @4500/tree	15	51	66	1389	0	1389	1324	1169

The estimated NPV, BCR, and IRR were found as below:

NPV=Tk. 1,370,000/ha; BCR=1.21; IRR=65%

Table 12. Investment Analysis for Lambu Tree with Bitter gourd

(Per hectare in BDT '000')

Year	Activity	Direct cost (A)	Opportunity Cost (B)	Total Cost (A+B)	Revenue from trees (C)	Reve-nue from Bitter gourd (D)	Total Revenue (C+D)	Net Cash flow (A-B)	Net cash Position (Cumulative)
0	Establishment cost including fence	289	73	362	0	356	356	-6	-6
1	Operation & Maintenance (O&M) cost	242	69	311	0	320	320	9	3
2	1st pruning+ O&M	247	69	317	7	285	292	-25	-25
3	1st thinning +O&M	45	53	98	12	0	12	-86	-110
4	2nd Pruning+O&M	20	51	71	12	0	12	-58	-58
5	O&M cost	10	50	60	0	0	0	-60	-119

Year	Activity	Direct cost (A)	Opportunity Cost (B)	Total Cost (A+B)	Revenue from trees (C)	Reve-nue from Bitter gourd (D)	Total Revenue (C+D)	Net Cash flow (A-B)	Net cash Position (Cumulative)
6	O&M cost	10	50	60	0	0	0	-60	-60
7	O&M cost	5	50	55	0	0	0	-55	-115
8	O&M cost	5	50	55	0	0	0	-55	-55
9	Harvest 50% @2200/tree	10	50	60	1494	0	1494	1434	1379
10	O&M cost	2	50	52	0	0	0	-52	-52
11	Harvest 25% @2800/tree	10	50	60	951	0	951	891	839
12	O&M cost	5	50	55	0	0	0	-55	-55
13	O&M cost	5	50	55	0	0	0	-55	-110
14	Final harvest sawlong @3200/tree	15	51	66	1087	0	1087	1021	1021

The estimated NPV, BCR, and IRR were found as below:

NPV=Tk. 889,000/ha; BCR=1.12; IRR=43%

According to BCR, IRR, and NPV calculations, NPV is positive, BCR is more than 1, and IRR exceeds the opportunity cost of capital (10% here). As a result, mahogany with chili may be recommended as a profitable tree mix, and farmers will benefit from investing in this farm business. The estimated BCR, NPV, and IRR all come out positive, indicating that combining akashmoni with brinjal is a viable investment option for farmers. An examination of an agroforestry practice (lambu with bitter gourd) reveals that the NPV is positive. The NPV and IRR for agroforestry operations are likewise higher than for tree planted alone. As a result, we can observe that agroforestry is far superior to tree plantation.

4. Conclusion

This study attempted to identify the knowledge, and adoption behaviour of farmers regarding agroforestry. To satisfy the objectives of the study, this study employed descriptive and financial analysis. Results revealed that about 64% farmers replied that they have heard about agroforestry but this doesn't necessarily mean that they are practicing agroforestry. Among them 33% farmers practiced agroforestry. Although most of the farmers never practiced agroforestry but most of them are interested to adopt agroforestry practices. It was found that farmers received support mainly in terms of seed/seedlings and training. On average, 15% farmers got seed/seedlings support and 9% farmers got training support. The percentage is low as there are small numbers of farmers in the study area who practice

agroforestry. The main sources for seed or plant are market (54%), agricultural offices (13%), project (7%), NGO (1%), Seed Company (1%), and others (25%).

The findings also revealed that the NPV, BCR, and IRR of agroforestry practices meet the economic advantage of the activity, allowing farmers to embrace it. The Akashmoni Tree with Brinjal yielded the most economic advantage of every tree combination. Under the current framework, agro- forestry was identified as a viable alternative to conventional farming systems by farmers, at least in less productive areas. Furthermore, the role of modern agroforestry to improve biodiversity, soil, and water quality should be better recognized by existing policy measures providing payments for environmentally friendly farming.

The successful promotion and implementation of agroforestry among smallholders will require the adoption of a participatory approach in project planning and implementation. Smallholders' attitudes, needs, preferences and traditional knowledge are crucial factors to take into account in any project. Finally, it can be concluded that the successful adoption of agroforestry to raise farm productivity and overall income of the respondents in the study area depends on raising awareness on benefits of agroforestry, providing adequate technical supports as well as ensuring the efficient use available farmlands of all types of landholders.

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FINANCIAL ANALYSIS OF SESAME PRODUCTION IN SELECTED AREAS OF BANGLADESH

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Abstract

Sesame is very important in Bangladesh to ensure the self-sufficiency in oilseed production. The main purposes of this study were to explore the financial returns of sesame. The principal objectives of this study were to determine the level of input use, cost and return and major problems of sesame cultivation. In total 405 data were collected from three major sesame growing areas of Bangladesh through stratified random sampling technique. Descriptive statistics and profitability model were used to analyze the collected data. The study revealed that total variable cost of sesame cultivation was Tk. 33233 ha^{-1}. The total cost of production was Tk. 59621 ha^{-1} where 44% was fixed costs and 56% was variable cost. The average gross return and gross margin of sesame cultivation were found Tk. 90044 ha^{-1} and Tk. 56811 ha^{-1}, respectively. Per hectare average net return was Tk. 30423 which was found to be highest in Jashore (Tk. 36817) followed by Barishal (Tk. 28479) and Tangail (Tk. 25975). BCR was found 1.51, which was the highest in Jashore 1.57 and lowest was 1.47 in Tangail district. The first constraint to oilseed sesame variety in all areas was the lack of quality seeds at appropriate time. Other problems were insect infestation (37%) followed by water logging condition (22%), adulterated seed & fertilizer (13%), labour crisis at harvesting time (10%), lack of training facilities and low market price (9%). This study helps to formulate appropriate policy to stakeholders, researchers and policy makers for increasing oilseed production of the country due to its high yield potential and profitability.

Keywords: Financial profitability, sesame, constraints and Bangladesh.

1. Introduction

Sesame is one of the important oilseeds in Bangladesh. A lot of foreign exchange is spent every year for importing edible oils and oilseeds to meet domestic demand (Myint, 2020; Eleuch *et* al., 2021). We are producing only 20% oilseed and 80% are imported to meet the demand. The crop is now grown in a wide range of environments, extending from semi-arid tropics and sub-tropics to temperate regions (Islam *et* al., 2018; Raikwar and Srivastva, 2013). The world produces about 3 million metric tons of sesame seeds every year on average. The global

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sesame exports are estimated to be about 0.5 to 0.6 million m tons (Agro, 2016). World production of sesame was estimated to be 5,531,948 tonnes produced on 9,983,165 hectares of land in 2017. Asia is the major producers (56.4%) of sesame in the world, followed by Africa (39.3%) and America (4.4%). The largest producers of sesame is India (665,566.67 tonnes) followed by China (616,004.96 tonnes) while Nigeria (192,295.96 tonnes) ranks 8th out of the ten major producing countries in the world. As a result of its high demand, any quantity of the product offered to the market is easily sold. This increasing demand for sesame seed provides Bangladesh an opportunity to increase its production to meet the international demand for the commodity. The realization of the potential of sesame production in the acquisition of foreign currency for the country made production of the crop a prominent priority in the agricultural sector of Bangladesh.

Profitability measures the capability of farmers to cover their costs. It is defined as the total value of production less the total cost of production. Bangladesh government has given due importance for research and development (R&D) of oilseed crops and invests a lot for attaining self-sufficiency in edible oils. Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA) have released a good number of improved varieties of oilseeds. The area, production and productivity of sesame at 2019-20 were 33656.89 hectare, 31786 m tons, and 944 kg per hectare, respectively (BBS, 2021). A study on financial analysis of sesame cultivation aimed at determining the input use and cost return to aid farmers improve/increase their profitability. Some relevant study were conducted to find out the profitability of sesame cultivation, but this study was conducted to estimate the cost and return data for major sesame varieties of Bangladesh specially for updating the database. The objectives of the study were **(**i**)** to determine the level of input use of sesame cultivation at farm level; **(**ii**)** to estimate the cost and return of sesame production; and **(**iii**)** to identify the major problems of sesame cultivation. An in-depth analysis is needed to explore the causes of low adoption and find out the ways for the expansion of oilseed cultivation. This study explores the challenges and opportunities in the oilseeds sector of Bangladesh.

2. Materials and Methods

The study was conducted in three intensively sesame growing areas of Bangladesh, namely Tangail, Barishal and Jashore district. In this study, stratified random sampling was used. From each district three upazila were selected randomly to conduct the study. The selected upazila were Sadar, Nagarpur and Bhuapur from Tangail, Mehendiganj, Muladi and Bakerganj from Barishal and Sadar, Bagharpara and Sharsha from Jashore district in sesame intensive growing areas. Total sample size was 405, 135 from each district and 45 from each upazila.

Sampling design and data collection method: In this survey, both multi-stages and random sampling techniques adopted to select sample farm households for collecting primary data and information. Priority in selection of study areas was specified to the intensity of area coverage by respective crops and regional differences in Agro-ecological zones. In each selected location (district), 3 upazilas will be chosen randomly for the survey. The upazilas and villages were selected by respective scientists of BINA and consultation with local DAE officials. Sample size has designated for the survey and year wise distribution of samples.

Measurement of financial costs and returns

In this study, costs and returns an analysis was done on total cost basis. The following equation (Π) was used to assess the financial profitability of sesame cultivation (Burja, 2009).

$$\Pi = \sum_{i=1}^{n} P_i Q_i - TC = \sum_{i=1}^{n} P_i Q_i - (VC + FC) \text{ ----------(1)}$$

Where,

Π = Profit or value addition from sesame production

Q_i = Quantity of sesame of i^{th} farmers (kg ha^{-1})

P_i = Average price of sesame of i^{th} farmers (Tk. kg^{-1})

TC = Total cost (Tk. ha^{-1})

VC = Variable cost (Tk. ha^{-1})

FC = Fixed cost (Tk. ha^{-1})

i = 1, 2, 3, ……., n

Per hectare profitability of growing sesame from the viewpoints of individual farmers was measured in terms of gross return, gross margin and net return. Gross return was calculated by simply multiplying the total volume of output with it's per unit of price in the harvesting period. Gross margin calculation was done to have an estimate of the difference between total return and variable costs. The argument for using the gross margin analysis was that the farmers of Bangladesh are more interested to know their return over variable costs. The analysis considered fixed cost which included land rent and family supplied labour. Net margin was calculated by deducting total costs from gross return. According to Debertin (2012), the greatest or maximum profit will be attained when the difference between TR and TC is greatest.

3. Results and Discussion

Pattern of input use for sesame cultivation

Farmers in the study areas used various inputs for sesame cultivation. Farmers used on an average 75 man-days per hectare of total human labour for sesame

cultivation where family labour was 34 man-days and hired labour was 42 man-days. On an average, they sowed 11 kg seed per hectare of land. They applied Urea at the rate of 99 kg ha^{-1}, TSP 140 kg ha^{-1}, and MoP 65 kg ha^{-1}. It was observed that among the chemical fertilizer, farmers used highest amount of TSP for the studied districts (Table 1). In the study areas, farmers also applied Gypsum (35 kg ha^{-1}) and Boron (8 kg ha^{-1}) for sesame cultivation.

Table 1. Level of input use per hectare of sesame cultivation

Particulars	Districts			
	Tangail	Jashore	Barisal	All
Human labour (man-days)	69	82	75	75
Hired	38	46	42	42
Family	31	37	33	34
Seed (kg ha^{-1})	11	11	10	11
Urea (kg ha^{-1})	92	119	87	99
TSP (kg ha^{-1})	129	145	146	140
MoP (kg ha^{-1})	52	79	66	65
Gypsum (kg ha^{-1})	32	41	31	35
Boron (kg ha^{-1})	7	8	8	8

Source: Field survey, 2019-20

Cost of Cultivation

Total cost of Sesame production

The cost of production included all kinds of variable costs such as hired labour, land preparation, seed, manure, fertilizers, irrigation, pesticides, etc. used for the production of sesame. Both cash expenses and imputed value of family supplied inputs were included in the variable cost. The study revealed that total variable cost of sesame cultivation was Tk. 33233 per hectare which was 54% of total cost of production. The highest variable cost item was hired labour which accounted for about 25% of the total cost. Land preparation cost accounted for about 12% of total cost and ranked second variable cost item. Family labour and rental value of land was considered as fixed cost of production. The family labour and land use cost were Tk. 11732 and Tk. 14656 per hectare which was accounted for about 20% and 25 % of total cost respectively. Total cost of production included variable costs and fixed costs incurred for sesame cultivation. On an average, the total cost of production was Tk. 59,621 per hectare where 44% was fixed costs and 56% was variable cost (Table 2). Similarly it was found that the total cost of sesame production was Tk. 42,918 per hectare (Monayem *et* al., 2015).

Table 2. Per hectare cost (Tk. ha^{-1}) of Sesame cultivation

Particulars	District				
	Tangail	Jashore	Barisal	All	
	(Tk/ha)	(Tk/ha)	(Tk/ha)	(Tk/ha)	%
Variable Cost					
Cost of land preparation	6835	7315	6739	6963	12
Hired labor	13397	15977	14626	14667	25
Seed	781	783	679	747	1
Cowdung	-	500	700	600	1
Urea	1559	2028	1485	1691	3
TSP	2845	3191	3215	3084	5
MoP	1142	1732	1442	1439	2
Gypsum	509	660	488	552	1
Boron	1253	1476	1379	1369	2
Cost of insecticide pesticide	980	1140	1010	1043	2
Sub-total	29301	34801	31764	31955	54
Interest on operating capital	1172	1392	1271	1278	2
Total variable cost	30473	36193	33034	33233	56
Fixed Cost					
Family labor	10828	12882	11485	11732	20
Land use cost	14159	15883	13925	14656	25
Total fixed cost	24987	28765	25410	26387	44
Total cost	**55460**	**64958**	**58444**	**59621**	**100**

Source: Field survey, 2019-20

Financial Profitability of Sesame

Financial profitability (FP) is based on calculation of market prices of inputs and outputs that farmers actually pay or receive for producing a crop, along with the quantities used of each. Farmers allocate land and other resources in the production of different crops on the basis of relative financial profitability.

Table 3. Per hectare return (Tk. ha^{-1}) of Sesame

Particulars	Districts			
	Tangail	Jashore	Barisal	All
Yield (Ton)	1.25	1.44	1.33	1.34
Price (Tk./kg)	60	65	61	62
Return from Sesame	74600	93917	80625	83047
Return from by-product	6834	7858	6298	6997
Gross Return	81434	101775	86923	90044
Total variable cost (TVC)	30473	36193	33034	33233
Total fixed cost (TFC)	24987	28765	25410	26387
Total cost (TC)	55460	64958	58444	59621
Gross Margin	50961	65582	53888	56811
Net Return	25975	36817	28479	30423
BCR over total cost	**1.47**	**1.57**	**1.49**	**1.51**

Source: Field survey, 2019-20

Financial profitability for sesame

Per hectare average yield of sesame was 1.34 ton. The average gross return and gross margin of sesame cultivation were found Tk. 90044 ha^{-1} and Tk. 56811 ha^{-1} respectively. Per hectare average net return was Tk. 30423 which was found to be highest in Jashore (Tk. 36817) followed by Barishal (Tk. 28479) and Tangail (Tk. 25975). BCR on total cost basis was found 1.51 which was the highest in Jashore 1.57 and lowest in Tangail districts 1.47 (Table 3). On the other hand, it was found that the BCR of sesame production was 1.32 (Monayem *et* al., 2015).

Problems faced by the farmers in sesame cultivation

Sesame is a profitable crop in all of the studied areas. But Farmers faced various problems to sesame cultivation (Islam *et* al., 2018; Islam *et* al., 2021). In table 4, the first constraints to oilseed sesame variety in all areas were the lack of quality seeds at appropriate time. Other problems were insect infestation (37%) followed by water logging condition (22%), adulterated seed & fertilizer (13%), labour crisis and high price at harvesting time (10%). They also mentioned about lack of training facilities and low market price at harvesting time (9%).

Table 4. Problems faced by the farmers in sesame cultivation (%)

Particulars	Tangail	Barishal	Jashore	All
Lack of quality seeds at appropriate time	53	35	25	37
Insect infestation (Cutter piller)	45	34	33	37
Water logging condition	10	30	25	22
Distance of Market is high	10	25	6	14
Adulterated seed	15	11	12	13
Adulterated fertilizer	19	6	16	13
Labour crisis & high price in harvesting time	21	6	4	10
Lack of training facilities	14	6	8	9
Low market price at harvesting time	12	9	5	9

Source: Field survey, 2019-20

The government should ensure the supply of quality seed at the proper time with a reasonable price, and should control the supply and availability of adulterated fertilizer from the market. More emphasis should be given on developing new varieties with short-duration, stress-tolerance and other characteristics. Frequent interaction was needed among farmers, extension personnel and sesame growers. Hand-on training on improved sesame cultivation and crop management practices for the sesame growing farmers is also important. Ensuring timely supply of labour to sesame growers during cultivation and harvest time is suggested to reduce yield loss.

4. Conclusion

It can be concluded that sesame production in the study areas are profitable which has positive implications for investment for farmers, NGOs and corporate organizations. Also adjustment in the production inputs such as seed, labour and efficient use of fertilizers and their cost of acquisition could lead to increased sesame production as well as profit. Noticeable gaps in profit could be improved upon if problems such as inadequate supply of quality seed at the proper time, problem of insect infestation, high cost of labour, thereby contributing to the wellbeing of sesame farmers as well as their standard of living. Increasing yield as well as productivity of sesame cultivation is urgent as a part for ensuring the self-sufficiency in oilseed production in Bangladesh.

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PROFITABILITY AND RESOURCE USE EFFICIENCY OF ELEPHANT FOOT YAM PRODUCTION IN SELECTED AREAS OF SOUTH WESTERN BANGLADESH

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Abstract

The study was conducted in Jashore, Kushtia and Satkhira areas during 2017-18 to determine profitability and resource use efficiency of elephant foot yam as well as to identify the constraints to elephant foot yam production. A total of 150 samples taking 50 samples from each district were randomly selected for data collection. Tabular and statistical analyses were done. Findings revealed that majority farmers were used *Madrazi* variety of elephant foot yam and inputs use were differed from area to area. Cobb-Douglas production function model reveals that labour, ploughing, zinc and irrigation had positive effect on yield. The average yield of elephant foot yam was 26.87 t/ha. The average cost of production was estimated at Tk.444508/ha on the basis of full cost. The average gross return, gross margin and net return were found to be Tk.740486/ha, Tk.331269/ha and Tk.295978/ha, respectively. Benefit cost ratio (BCR) was found to be 1.64 on total cost basis. According to returns and BCR, elephant foot yam production was found to be profitable in the study areas. Farmers faced some constraints which hampered yield. The major constraints were lack of improved production technology and attack of viral and fungal diseases. So, research thrust should be given to develop improved variety and to control pest and diseases for higher production of this important medicinal and high value crop.

Keywords: Elephant foot yam, profitability, resource use efficiency, Bangladesh.

1. Introduction

Vegetable is important for nutrition, food security and economic development. Bangladesh is suffering from the problems of poverty, unemployment and malnutrition. Vegetable sub-sector can play an important role to solve these problems in the shortest possible time. The Elephant foot yam belongs to the family of "Araceae" and genus of "Amorphophallus". Many indigenous *Ayurvedic* and *Unani* medicinal preparations are made using its tubers. It is a good source of protein, carbohydrates and omega 3 fatty acids, antioxidants. It helps in reducing LDL (bad cholesterol), lowering blood sugar levels, preventing muscle spasms, reducing the risk of cancer, weight loss, women for estrogen and hormonal

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balance, lowering blood pressure, liver cleansing. It has low glycemic index, hence helps in diabatic patients. The tubers are believed to have blood purifying characteristics and are used in medicines for the treatment of piles, asthma, dysentery and other abdominal disorders.

Elephant foot yam is extensively cultivated in the south western part of Bangladesh. Farmers in the areas face many problems in field level condition. But their agronomic practices and profitability are unknown to the researchers. A limited research work was found in India (Tavva and Ramanathan, 2005; Singh *et al.*, 2014; Ghosh *et al.*, 2008; Venkatram *et al.*, 2007). But, no study on economic or financial analysis of this crop in Bangladesh has been found in the literature. Therefore, this study is expected to provide valuable information and may be useful to the researchers as well as GO and NGO policy makers for formulating appropriate policy for widespread cultivation of the crop in Bangladesh. With this view, the study was undertaken to determine profitability and resource use efficiency of elephant foot yam as well as to identify the constraints to its production and to suggest some policy implications for further improvement.

2. Methodology

Sampling design: A multi-stages sampling procedure was followed to select the study areas and sample households. At first, three elephant foot yam (EFY) growing Upazillas namely Chaugachha upazila (belong 130 ha of EFY) of Jashore district (561 ha of EFY), Kushtia sadar upazila (90 ha of EFY) of Kushtia (150 ha of EFY) district and Tala upazila (100 ha of EFY) of Satkhira (538 ha of EFY) district were purposively selected for the study due to extensively cultivated in the areas. Secondly, three villages namely Chandpara, Jhaudia and Putiakhali were purposively selected from Chaugachha, Kushtia sadar and Tala upazilla respectively for household survey according to easy commucation and concentration of EFY production. Finally, three lists of elephant foot yam growers were constructed from Chandpara, Jhaudia and Putiakhali villages where the numbers of elephant foot yam growers were 100, 243 and 80 for Chandpara, Jhaudia and Putiakhali villages, respectively. Then a total of 150 samples taking 50 samples from each village were randomly selected for data collection.

Data collection procedure: Data for the present study were collected by interviewing sample elephant foot yam growers using a pre-tested interview schedule during the period from March to September, 2017. Secondary data were also collected from Department of Agricultural Extension (DAE) to supplement the study.

Analytical techniques: The collected data were analyzed by tabular and statistical methods. The profitability of elephant foot yam cultivation was examined on the basis of gross margin, net return and rate of return over cost.

Per hectare gross return (GR), total cost (TC), total variable cost (TVC), gross margin (GM), net return (NR) and benefit cost ratio (BCR) were calculated on the basis of prevailing market price of the input and output.

GR = Return of main product= Yield × price (Tk.)

TC = All input cost including rental value of land and interest on operating capital.

TVC = All input cost except rental value of land.

NR = GR - TC

GM = GR – TVC

Benefit Cost Ratio = $\frac{Gross\ return}{Total\ cost}$

Model specification

The Cobb-Douglas production function was used to estimate the productivity of resource use efficiency of elephant foot yam cultivation. The appropriateness of this model is that the input coefficients indicate the respective elasticities (Gujarati, 2003; Suresh and Reddy, 2006 and Venkatram *et al.,* 2007). Besides, the major constraints to production were identified and they were ranked using Garret Ranking Technique.

The production function had the form as given by following equation:

$$Y = AX_1^{b1} X_2^{b2} .....X_n^{bn} e^{ui} \quad .....(1)$$

Where, Y is output and X_1 to X_n are inputs.

This function was fitted in the log-term with yield (Y) as dependent variable and inputs as explanatory or independent variables.

The production function was converted to logarithmic form so that it could be solved by least square method i.e,

$$\text{Log } Y = \text{Log } a + b_1 \log X_1 + ... + b_n \log_n + U_i \quad .....(2)$$

The empirical production function was as follows:

$$\ln Y = a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + b_{11} \ln X_{11} + U_i \quad .....(3)$$

where,

Y = Yield of elephant foot yam cultivation (t ha^{-1})

a = Constant or intercept

X_1 = Labour (No. ha^{-1})

X_2 = Cost of ploughing (Tk. ha^{-1})

X_3 = Seed (Kg. ha^{-1})

X_4 = Cowdung (Kg. ha^{-1})

X_5 = Urea (Kg. ha^{-1})

X_6 = TSP (Kg. ha^{-1})

X_7 = MoP (Kg. ha^{-1})

X_8 = Zinc (Kg. ha^{-1})

X_9 = Boron (Kg. ha^{-1})

X_{10} = Cost of irrigation (TK. ha^{-1})

X_{11} = Cost of pesticides (TK. ha^{-1})

Ui = Error term

Resource use efficiency

In order to maximize profit through the efficient allocation of resources, the producer should use more of the variable resource so long as the value of the added production is greater than the cost of the added amount of resource used in the production. The straight forward way of examining such efficiency is to compare the marginal value product (MVP) with marginal factor cost (MFC) of each variable input. The efficiency of inputs used in elephant foot yam production was measured by the following equation (4). This approach was used in many past studies (Miah *et al.*, 2021; Khatun *et al.*, 2019; Ali *et al.*, 2017; Umar and Abdulkadir, 2015; Dhakal *et al.*, 2015; Abid *et al.*, 2011) for measuring the resource use efficiency.

$$MVPx/MFCx = 1 \quad \text{..... (4)}$$

The value of MVP can be estimated using the following equations (5 and 6).

$$MVPx = MPPx \times Py \quad \text{..... (5)}$$

$$MPPx = bi \times APPx = bi \times \bar{Y}\bar{X}i \quad \text{..... (6)}$$

Where,

$MVPx$= Marginal value product of ‘X’ input

MPPx = Marginal physical product of ‘X’ input

APPx = Average physical product of ‘X’ input

$MFCx$= PXi = Marginal factor cost of ‘X’ input (unit price of factor input resource)

Py = Unit price of output

bi = Elasticities or regression coefficients of the various inputs

$\bar{Y}$ = Mean of output

$\bar{X}$i = Mean of ‘X’ input factor

The resource is considered to be efficiently used and profit will be maximized when the ratio of MVP to MFC is equal to unity or MVP and MFC for each input are equal. When the ratio is greater than unity, it implies that the resource is underutilized. In that case, there is an ample opportunity to increase total production by increasing the use of specific input in the production process keeping other resources constant. When the ratio is less than unity implying the resource is overused. In that case, it is possible to reduce production cost remains total production unchanged by decreasing the use of specific input.

The relative percentage change in MVP of each resource required to obtain optimal resource allocation, which is MVP = MFC, was estimated using equation 7 below. This formula was also used in different past studies (Miah *et al.*, 2021; Khatun *et al.*, 2019; Chandra *et al.*, 2017; Gani and Omonona 2009) in home and abroad.

$$D = [1 - 1/(MVP/\ MFC)\ ] \times 100 \quad \ldots\ldots (7)$$

Where, D = Value of percentage change in MVP of each resource. The significance of each explanatory variable was determined using the t-test.

3. Results and Discussion

3.1 Agronomic practices of elephant foot yam production

Appropriate inputs use and time of operations are essential for achieving higher yield and economic benefit. Therefore, it is important to know the existing level of technology in terms of agronomic practices, time of operation and input use. The existing level of technology employed in the production of elephant foot yam has been presented in Table 1.

Farmers in the study areas ploughed their elephant foot yam lands with the help of power tiller and tractor. The number of plowing varied from farm to farm and location to location. On an average, 79% farmers ploughed their land 4-6 times and 21 farmers ploughed their land 2-3 times for elephant foot yam production. Farmers in the study areas followed line sowing method for elephant foot yam corm planting. On an average, 67% farmers followed spacing 114 cm corm to corm and 114 cm line to line while 33% farmers followed 92 cm corm to corm and 92 cm line to line. According to areas, 100% farmers followed 114 cm corm to corm and 114 cm line to line in Kushtia and Satkhira areas while 100% farmers followed 92 cm corm to corm and 92 cm line to line in Jashore. Corm planting was started from 16 February and it continued up to the 30 April in all study areas. It is observed that early cormplanting was found in Jashore and Satkhira areas whereas late planting was found in Kushtia area. On an average, 30% farmer's planted corms on February 16-28, 28% farmers planted on March 16-31 and 16% farmers planted on April 1-15. In Jashore, 58% farmers planted corm on February 16-28 and 42% farmers planted on March 1-31. About 88% Kushtia farmers planted

corms on April 1-30 and 64% farmers planted corms on March 1-31 in Satkhira area. Elephant foot yam was not harvested in a day. It ranged from July 16 to September 30. Majority farmers (60%) harvested it in the month of August. Weeding was done by human labour. The average weeding was found 3 times and irrigation was also 3 times by STW in all study areas.

Table 1. Agronomic practices of elephant foot yam production at farm level

Technology	Jashore	Kushtia	Satkhira	All
1. No of plowing (% of respondent)				
2-3	36	20	06	21
4-6	64	80	94	79
2. Spacing (% of respondent)				
Corm to corm: 92 cm	100	-	-	33
Corm to corm: 114 cm		100	100	67
Line to line : 92 cm	100	-	-	33
Line to line: 114 cm	-	100	100	67
3. Sowing time (% of respondent)				
February 16-28	58	-	30	30
March 1-15	16	-	18	11
March 16-31	26	12	46	28
April 1-15	-	42	06	16
April 16-30	-	46	-	15
4. Harvesting time (% of respondent)				
July 16-31	08	-	20	09
August 1-15	06	18	50	25
August 16-31	58	28	18	35
September 1-15	38	38	12	24
September 16-30	04	16	-	07
5. No. of weeding	3	3	3	3
6. No. of irrigation	3	3	3	3

3.2 Input use pattern

Human labour was employed for land preparation, corm sowing, fertilizing, weeding, pesticiding, harvesting, cleaning and washing of elephant foot yam. The average total number of human labour used for elephant foot yam cultivation was 255 man-days/ha (Table 2). The highest human labour (299 mandays/ha) were used in Satkhira area due to more use in cleaning and washing of elephant foot yam and the lowest was in Jashore (224 mandays/ha). The average elephant foot yam corm was required 10584 no./ha in all study areas, while the corms were 11719, 8480 and 11554 no./ha for Jashore, Kushtia and Satkhira, respectively. The quantity of corm was lower in Kushtia due to use higher spacing. Elephant foot yam corm was used at the rate of 6657 kg/ha in all areas. Kushtia farmers used more quantity of corm (8483 kg/ha) compared to Satkhira (6289 kg/ha) and Jashore farmers (5200 kg/ha) due to higher weight of single corm. The average

single corm weight of sample farmers of Jashore, Kushtia and Satkhira areas were 444 g, 998 g and 544 g, respectively. The single corm weight of Jashore and Satkhira is lower than the recommendation of Indian Elephant foot yam cultivation guide (750-1000 g).

The average application of cowdung, urea, TSP, MoP, gypsum, zinc sulphate and boric acid were 14.41tonnes, 387 kg, 426 kg, 289 kg, 120 kg, 14 kg and 5 kg per hectare, respectively in all study areas. The applied cowdung amount is lower and NPK are higher than recommendation of Indian Elephant foot yam cultivation guide (FYM: 25-30 tonnes, NPK: 80:60:100 kg/ha) and Azad et all., 2020, edited: TCRC, BARI, Krishi Projukti hatboi (Cowdung: 20 t/ha, Urea, TSP and MoP: 325:210:175 kg/ha). The reason of higher NPK application in study areas might be lower application of FYM. Tavva and Ramanathan (2005) found that NPK ratio was observed to be 401:189:446, 451:214:207 and 131:246:91 in Kerala, Andhra Pradesh and Tamil Nadu, respectively. According to areas, cowdung and chemical fertilizer use was varied. The highest cowdug use was found in Jashore (18.55 t/ha) and it followed by Satkhira (16.30 t/ha) and Kushtia (9.52 t/ha). The reason behind less use of cowdung in Kushtia was that only 58 percent farmers used it. But cowdung users of Jashore and Satkhira were 96% and 98%, respectively. The application of all chemical fertilizer except urea was the highest in Satkhira area compared to Jashore and Kushtia areas. Kushtia farmers used maximum urea due to less use of cowdung. The gypsum users in Jashore, Kushtia and Satkhira were 62%, 22% and 72%, respectively. The highest zinc sulphate users were found in Satkhira (80%) and it followed by Kushtia (58%) and Jashore (48%). The percentage of boric acid user in Jashore, Kushtia and Satkhira were 46%, 14% and 60%, respectively.

Table 2. Input use pattern of elephant foot yam production at farm level

Inputs	Jashore	Kushtia	Satkhira	All
Human labour (man days/ha)	224	243	299	255
Corm (no./ha)	11719	8480	11554	10585
Corm (kg/ha)	5200	8483	6289	6657
Cowdung (t/ha)	17.42	9.52	16.30	14.41
Urea (kg/ha)	269	453	438	387
TSP (kg/ha)	435	356	488	426
MoP (kg/ha)	262	219	385	289
Gypsum (kg/ha)	120	53	188	120
Zinc sulphate (kg/ha)	9	12	20	14
Boric acid (kg/ha)	5	2	8	5

3.3 Productivity and profitability

Productivity: The average yield of elephant foot yam was 26.873 t/ha in all areas (Table 3). The highest yield (28.26 t/ha) was found in Jashore due to higher use of

cowdung, TSP and bigger size of corm as well as lower attack of virus and foot and root rot disease. The lowest yield was in Satkhira (25.73 t/ha) due to higher attack of virus and foot and root rot disease. Tavva and Ramanathan (2005) found that the farmers got a yield of 33.50, 27.29 and 34.66 t/ha in Kerala, Andhra Pradesh and Tamil Nadu, respectively.

Cost: The cost of cultivation was calculated on the basis of total variable cost and total cost. The average cost of elephant foot yam production was estimated at Tk.444508/ha and Tk.409217/ha, respectively on the basis of total cost and total variable cost (Table 3). Corm cost was the lion share (55%) of total cost and it was followed by human labour (21%). Tavva and Ramanathan (2005) found that planting material (corm) cost was observed to be 40.36, 26.59 and 47.62 per cent of total cost in Kerala, Andhra Pradesh and Tamil Nadu, respectively and labour costs were 20.85, 22.78 and 19.22 per cent of total cost in Kerala, Andhra Pradesh and Tamil Nadu, respectively.

The total cost of elephant foot yam production in Satkhira area was the highest (Tk.511972/ha) among all the areas due to higher cost involved of human labour, ploughing, corm, manure, chemical fertilizer, irrigation and pesticides and the lowest total cost was in Kushtia (Tk.371030/ha) due to lower cost of human labour, corm, manure and chemical fertilizer. Corm cost was also the lion share in all the areas and it was supplied by own source. Corm is sold as a piece in the study areas and the prices of single piece of corm were Tk.23, Tk.24 and Tk.23 for Jashore, Kushtia and Satkhira, respectively. The price of Kushtia area was slightly higher compared to Jashore and Satkhira areas due to use bigger corm size. The labour wage rates of Jashore, Kushtia and Satkhira were Tk.400, Tk.300 and Tk.400, respectively. Ploughing cost was higher in Jahsore and Kushtia due to more number of plough. Farmers in the study areas ploughed the elephant foot yam land by tractor and harrow. The cost of farm yard manure of Satkhira was the highest (Tk.16303/ha) and it followed by Jashore (Tk.13154/ha) and Kushtia (Tk.9519/ha). The per kg price of cowdung was Tk.0.76, Tk.1.00 and Tk.1.00 for Jashore, Kushtia and Satkhira, respectively. Pesticides cost was higher (Tk.6632/ha) in Satkhira due to severe attack of virus and foot and root rot disease compared to Kushtia (Tk.3882/ha) and Jashore (Tk.2363/ha).

Returns: Gross return was found to be Tk.740486/ha in all study areas (Table 3). The highest gross return was calculated in Satkhira (Tk.1009318/ha) due to higher output price of local variety of elephant foot yam which is very tasty to the consumers. The lowest gross return was found in Kushtia (Tk.494833/ha) due to lower output price of madrazi variety. The reason of comparatively lower price in Kushtia is that it is far from secondary market.

Profitability: The average gross margin of elephant foot yam was estimated at Tk.331269/ha in all areas (Table 3). Gross margin was the highest in Satkhira (Tk.534846/ha) and it was followed by Jashore (Tk.272017/ha) and Kushtia (Tk.186944/ha). The average net return of elephant foot yam was calculated at Tk.295978/ha in all areas. The net return was also the highest in Satkhira (Tk.497346/ha) and it was followed by Jashore (Tk.234517/ha) and Kushtia (Tk.156069/ha). Benefit cost ratio (BCR) was found to be 1.64 on total cost basis in all areas. BCR of Jashore, Kushtia and Satkhira was 1.53, 1.42 and 1.98, respectively. Tavva and Ramanathan (2005) found that BCR was worked out to be 1.38, 1.38 and 1.50 in Kerala, Andhra Pradesh and Tamil Nadu, respectively.

Table 3. Productivity, cost, return and profitability of elephant foot yam production at farm level

Items	Jashore	Kushtia	Satkhira	All
Yield (t/ha)	28.259	26.493	25.867	26.873
Price (Tk./kg)	24.24	20.02	39.21	27.82
Cost (Tk./ha):				
Labour	89484	72988	119426	93966
Ploughing	7208	11855	12963	10676
Corm	263910	203561	267931	245134
Manure	13154	9519	16303	12992
Fertilizer	21797	21420	31670	24962
Irrigation	7974	11080	11386	10147
Pesticides	2393	3882	6632	4302
Int. on operating capital	7104	5850	8160	7038
Rental value of land	37500	30875	37500	35292
Total cost (Tk./ha)	**450524**	**371030**	**511972**	**444508**
Total variable cost	413024	340155	474472	409217
Gross return (Tk./ha)	**685041**	**527099**	**1009318**	**740486**
Gross margin (Tk./ha)	272017	186944	534846	331269
Net return (Tk./ha)	234517	156069	497346	295978
BCR (undiscounted)	1.53	1.42	1.98	1.64

3.4 Resource-use efficiency

Input output relationship: In order to determine the contribution of independent variables in elephant foot yam production, Cobb-Douglas production function was used. Before going to analyze data, multi-collinearity among the variables was checked and found no multi-collinearity in the data. The coefficients of labour, ploughing, zinc sulphate and irrigation were positive and significant at 1-5% levels, which indicated that 1% increases in those inputs keeping other factors remaining constant would increase the yield by 0.049%, 0.073%, 0.018% and 0.198%, respectively (Table 4). It implied that labour, ploughing, zinc and irrigation had positive effect on the yield of elephant foot yam production. The

coefficient of cowdung, urea, MoP, boric acid and pesticide were negative and significant at 1-10% levels, which indicated that 1% increases of those inputs, keeping other factors remaining constant would decrease the yield by 0.005%, 0.037%, 0.050%, 0.003% and 0.088%, respectively. It indicated that these inputs were used very lower dose of cowdung and boron as well as higher dose of urea, MoP and pesticides in the farmers of study areas. The returns to scale of elephant foot yam production was 0.162. This implied that production function exhibited decreasing return to scale and lied on the second stage of production. This also implied that if all inputs specified in the production function were increased simultaneously by 100%, the yield would increase by 16%. The value of the coefficient of determination (R^2) is 0.725 which indicated that around 73% of the variation in output is explained by the independent variables included in the model. The value of F is 33.659 which is significant at 1% level indicates the good fit of the model. Production function is a functional relationship between outputs and inputs (Jhingan, 2007).

Table 4. Estimated coefficients and related statistics of Cobb-Douglas production function for elephant foot yam production

Explanatory variables	Coefficients	Standard error	t-values
Constant	12.078***	0.792	12.242
LnLabour	0.049**	0.02	2.498
LnCost of ploughing	0.073**	0.029	2.506
LnSeed	0.027	0.073	0.364
LnCowdung	- 0.005***	0.002	- 2.684
LnUrea	- 0.037**	0.016	- 2.259
LnTSP	- 0.02	0.016	- 1.209
LnMoP	- 0.05***	0.016	- 3.176
LnZinc sulphate	0.018***	0.001	13.731
LnBoric acid	- 0.003**	0.002	- 2.169
LnInnrigation cost	0.198***	0.024	8.323
LnPesticide cost	- 0.088***	0.014	- 6.219
Returns to scale (RTS)	0.162		
R^2	0.73		
F-value	33.659***		
N	150		

Note: ***, ** and * indicate significant at 1%, 5% and 10% level, respectively

Resource use efficiency: The ratios of MVP and MFC for cowdung, urea, TSP, MoP, zinc sulphate and boric acid are greater than unity and positive indicating that there are ample opportunities for elephant foot yam producers to increase yield by using more of these inputs in all areas (Table 5). For labour and seed, the ratios are less than unity and negative which imply the inefficient use of these inputs. This suggests that farmers can reduce the number of labour and seed to make its use efficient. Overall, the study revealed that all the inputs used in elephant foot yam production were not optimally utilized.

It further reveals that the adjustment in the MVPs indicated that the level of input use should be increased or decreased for optimal allocation of resources. The level of use of cowdung, urea, TSP, MoP, zinc sulphate and boric acid should be increased by 100%, 78%, 34%, 89%, 85% and 70% respectively to obtain the optimum profit. On the other hand, human labour and seed were needed to decrease by 65% and 1138% for getting the highest profit.

Table 5. Estimated resource use efficiency indicators in elephant foot yam production

Variables	Coefficients	MPP	Py	MVP	MFC	MVP/MFC	Adjustment required (%)
Labour	0.049	5.16	28.6	147.69	243.7	0.61	- 65
Seed	0.027	0.11	28.6	3.12	38.6	0.08	- 1138
Cowdung	- 0.005	9.32	28.6	266.68	0.92	289.87	100
Urea	- 0.037	2.57	28.6	73.48	16.33	4.50	78
TSP	- 0.02	1.26	28.6	36.08	23.71	1.52	34
MoP	- 0.05	4.65	28.6	132.97	15	8.86	89
Zinc sulphate	0.018	34.55	28.6	988.16	150.3	6.57	85
Boric acid	- 0.003	16.12	28.6	461.14	138	3.34	70

3.5 Constraints to elephant foot yam production

The farmers in the study areas encountered some constraints to elephant foot yam production. The first ranked constraints were attack of virus disease (leaf become yellow) and foot and root rot of elephant foot yam in all study areas. It was followed by lack of technical know-how, and lack of training, as well as high price of pesticides (Table 6).

Table 6. Constraints to elephant foot yam production at farm level

Constraints	Rank value			
	Jashore	Kushtia	Satkhira	All
1. Attack of virus disease	1	1	1	1
2. Attack of foot and root rot	1	1	1	1
3. Lack of improved production technology	2	2	2	2
4. Lack of training	4	3	3	3
5. High price of pesticides	3	4	4	4

4. Conclusion

Based on the findings of the study, it may be concluded that majority farmers used Madrazi variety of elephant foot yam. Agronomic practices and input use of elephant foot yam was differed from area to area. Cobb-Douglas production function model reveals that labour, ploughing, zinc and irrigation had positive effect on yield. But resource use efficency model indicates that all inputs use were seemed to be inefficiently used in all study areas which affect net profit of the

farmers. Elephant foot yam production was found to be profitable in all study areas. Yield was hampered due to lack of improved production technology and attack of viral and fungal diseases of elephant foot yam. So, research thrust is required for varietal development, disease management and improved production technology for improvement of this important medicinal and high value crop. The gross margin and net return of elephant foot yam cultivation were positive and encouraging to the farmers. This message should be circulated among the growers through various media.

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COMPARING THE PROFITABILITY OF TWO NEW VARIETIES OF POTATO: EVIDENCE FROM MUNSHIGANJ DISTRICT

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Abstract

The overarching goal of the study was to examine the profitability of two new varieties of potato production using evidence from the Munshiganj district. The sample size for this study was purposefully set at 60 from various income categories. In March and April of 2019, data were collected through a farm survey utilizing a pre-tested questionnaire. According to the study, the gross and net returns from Diamant variety of potato were higher than those from Algure potato. The benefit-cost ratio of Diamant potato was higher than that of Algure potato. On the basis of total cost, average per ha cost was estimated at Tk.137317 and Tk.102289 for Diamant and Algure potato respectively. Net return from Diamant potato was Tk.43164 per ha and from Algure potato was Tk.26479 per ha. In case of producing Diamant, BCR was 1.31 and for the Algure potato production it was 1.25 on full cost basis. Farmers age, education level, farm size played a positive role in increasing net return for both Diamant and Algure potato. Family size had negative influence on both variety and year of farming experience had positive influence on Diamant potato and negative effect on Algure potato. The study estimated several technical, economic, marketing, and social issues that impede the expansion of potato production due to its high demand, such as a lack of good quality seed and fertilizers, insufficient funds, high input costs, a lack of adequate cold storage facilities, loss of production due to theft, and so on. Finally, well-planned management training tailored to their challenges, requirements, goals, and resources can lead to the development of successful production techniques and long-term income from potato farming in the study area.

Keywords: Farm, Economics, Production, Quality, Diamant, Algure.

1. Introduction

Agriculture is the main stay of the economy of Bangladesh. It is enjoying a sub-tropical monsoon climate. Bangladesh has been famous for growing large variety of tropical crops particularly rice, wheat, potato, jute, pulses, oilseeds, sugarcane, etc. Potato is one of the important crops and very common vegetable in Bangladesh. It is both a vegetable crop and cash crop. It is an important food crop from the very beginning of human civilization and occupying its position just after wheat and rice in respect of production and consumption (Thompson and Kelly,

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1957). In Bangladesh, potato occupied the first position among all the vegetables in respect of area coverage and production. It contributed 65.65 percent of the total production of vegetables in Bangladesh in 2015 (BBS, 2015). In Indian sub-continent, the cultivation of potato was probably started during the 17th century (Ahmed, 1977). But in Bangladesh the cultivation of potato was started in the late 19th century (Siddique and Hussain, 1988). Potato cultivation was started as a cash crop after 1920 (Hoque, 2004) in Bangladesh. At least in 100 countries, potato is the most important vegetable crop for human consumption.

Potato varieties that are cultivated in Bangladesh are broadly categorized into two groups, local and high yielding. The so-called local cultivars are in fact, not strictly native. There are about 27 local cultivars of potatoes cultivated in different parts of the country. They have familiar local names. The familiar local varieties are: *Sheel bilatee, Lal sheel, Lal pakri, Du hajari, Jhau bilatee and Suryamukhi* are notable. Bangladesh Agricultural Research Institute (BARI) has also established a farm at Debiganj in Panchgarah district for the production of HYV seed potatoes. Among the high yielding popular varieties followings are notable: Cardinal, Diamant, Algure, Kufri shindhury, Patronis, Alpha, Archa, Multa, Ukama, Hira, Maurin, Origo, Alisa etc. Though Bangladesh has become a major potato producer in the SAARC countries, the status of this crop has remained vegetable in the country. The time has come to understand and appreciate the role of potato that can play an important role in the present food situation of Bangladesh, potato is one of the main commercial crops grown all over the country. Various other food items are also made from potato. Adequate supply of potato stabilizes the vegetable market round the year (Moazzem and Fujita, 2004). Recently, the government has been trying to diversifying food habits and encourage potato consumption to reduce pressure on rice. So, potato is becoming an important food item for the food security in Bangladesh.

Elias *et al.* (1980) carried out an economic analysis on potato production in a few locations in Bangladesh. They calculated the average per hectare potato production cost to be Tk.7376 and the average gross return to be Tk. 9931. Elias *et al.* (1982) investigated improved potato technology in two districts of Bangladesh, Bogra and Munshigonj. They estimated that the average net return per hectare was Tk.7211, which was greater in Munshigonj (Tk.8751) than in Bogra (Tk.7211). Islam (1987) conducted a research on potato preservation in cold storage in Bangladesh, including marketing considerations. Sabur (1988) did a study on marketed excess of potatoes in two districts of Bangladesh and discovered that production and marketed surplus of potatoes were moving in the right direction. Das (1992) investigated the economics of potato growing. He calculated the net return above full costs per hectare to be Tk. 11085.89. In the Bogra district, Hakim (1993) did a comparative economic study on Cardinal and various kinds of potatoes. He found that net returns per hectare on a full costs basis were Tk. 45196.65 and Tk. 451.65.

Rashid (1994) examined the profitability of various planting patterns with and without potatoes in two villages in the Dinajpur district. Huq (1998) conducted a study in Dinapjur to evaluate the comparative profitability of potatoes and the factors influencing yield and profit variance. Arif (1998) conducted a potato product research in selected districts of the Comilla district. He demonstrated that the net returns per hectare for small, medium, and large farmers were Tk.37607, Tk.37179, and Tk.366617, respectively. Akhter et al. (2001) carried out a survey on potato production in a few districts in Bangladesh. According to this study, potato growing is highly profitable and might provide farmers with cash. Ahamed (2009) conducted research to compare the economics of Boro rice and potato production. The study's main finding was that rice and potato farming was profitable from the perspective of farmers.

The specific objectives of this study were:

i. to analyze the profitability and influencing aspects of the two potato varieties production; and
ii. to find out the constraints of new variety of potato.

2. Methodology

The present study was conducted in some selected villages under three upazillas namely Gozaria, Sreenagar and Tongibari of Munshiganj district. A total number of 60 households were selected in the proposed research by following purposive random sampling technique with a view to fulfilling the objectives of the study. The period of the investigation covered by the study was potato growing season of 2018-2019. In the study area, potatoes are generally sown in September to October and harvested in January to February.

The following equation was used to estimate the gross return (GR): $GR_i = \Sigma Q_{mi} P_{mi}$

Here, GR_i= Gross return from i^{th} product (Tk./hectare;

Q_{mi}= Quantity of the i^{th} product (kg/hectare;

P_{mi}= Average price of the i^{th} product (Tk./kg);

i= 1,2,3…n

Gross margin (GM) has given an estimate of the difference between total return and variable costs,

GM= TR-VC

Here, GM= Gross margin;

TR= Total return;

VC= Variable cost

Net return (NR) was calculated by deducting all costs (variable and fixed) from total return.

Net return= TR-TC

Here, TC= Total fixed cost + Total variable cost

Multiple linear regression model (log-linear model) model was used to identify the effects of key variables and to determine the contributions of the most important variables in the production process of potato. The following specification of the function was made:

$$Y_i=aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}e^{ui}$$

The Multiple linear regression model (log-linear model) was converted to the following logarithmic form so that it could be solved by the ordinary least squares method:

$$\log Y_i= \log a+b_1\log X_1+b_2\log X_2+b_3\log X_3+b_4\log X_4+b_5\log X_5+u_i$$

Here,

Y_i= Gross return from potato production (Tk.)

X_1= Farmer's age (year)

X_2= Education level (year)

X_3= Family size (No.)

X_4= Farm size (hectare)

X_5= Year of farming experience (year)

b_1- b_6= Production co-efficient to be estimated

a= Intercept

u_i= Random error term

3. Results and Discussion

Total labor cost for Diamant potato cultivation was Tk.24073 per ha which is 17.53 percent on total cost basis (Table 1). On the other hand, total labor cost of Algure potato cultivation is Tk.21099 per ha which is 20.63 percent of total cost on total cost basis. Land preparation cost for Diamant potato was Tk.12031 per ha which shared 12.87 percent of total cost on total cost basis. For Algure potato land preparation cost was Tk.13161 per ha and it shared 12.87 percent of total cost on total cost basis. Cost of seed was Tk. 20059 per ha for Diamant potato which bears 14.60 percent of total cost on total cost basis and Tk.14893/ha for Algure potato which bears 14.56 percent of total cost on total cost basis (Table 1). Fertilizer cost was determined by the actual market prices paid by the farmers. Average requirement of urea, TSP, MP and boric acid for Diamant potato cultivation were 347.51 kg, 323.21kg, 183.97 kg, 5.34 kg per ha. Cost of urea, TSP, MP, boric acid were Tk.5727, Tk.7807, Tk.2694, Tk.108.77 per ha in the study area which

required 4.17 percent, 5.68 percent, 1.96 percent, 0.41 percent of the total cost respectively on total cost basis.

Table 1. Per hectare average costs and returns of Diamant and Algure potato production on total cost basis

Items		Unit	Diamant Potato				Algure Potato			
			Average				Average			
			Quantity	Price per unit (Tk.)	Cost/ Returns (Tk./ha)	Percentage of total cost	Quantity	Price per unit (Tk.)	Cost/ Returns (Tk./ha)	Percentage of total cost
Labor cost										
Human labor		Tk.	-	-	24073	17.53	-	-	21099	20.63
Material cost										
Land preparation		Tk.	-	-	12031	8.76	-	-	13161	12.87
Seed		Kg	1203.71	17.07	20059	14.60	966.62	15.78	14893	14.56
Chemical fertilizers	Urea	Kg	347.51	16.88	5727	4.17	331.96	17.00	5511	5.39
	TSP	Kg	323.21	24.74	7807	5.68	331.96	24.79	8036	7.86
	MP	Kg	183.97	15.00	2694	1.96	189.30	15.00	2772	2.70
	Boric acid	Kg	5.34	108.77	566	0.41	7.15	108.78	777	0.75
	Others	Tk.	-	-	1073	0.720	-		923.64	0.88
Insecticides		Tk.	-	-	1705	1.24	-	-	1515	1.48
Irrigation		Tk.	-	-	2877	2.10	-	-	1946	1.90
Sorting and packaging		Tk.	-	-	5183	3.77	-	-	4000	3.91
Transportation		Tk.	-	-	2680	1.95	-	-	1500	1.47
Storage		Tk.	-	-	38765	28.23	-	-	14550	14.22
Interest on operating capital		Tk.	-	-	1565	1.14	-	-	1133	1.11
Land use cost		Tk.	-	-	10505	7.65	-	-	10505	10.27
A. Gross cost		Tk.	-	-	137317	100	-	-	102289	100
B. Total Production		Kg	13316	-	-	-	9533	-	-	-
C. Gross return		Tk.	-	13.87	180482	-	-	13.83	128768	-
D. Net return (C-A)		Tk.	-	-	43164	-	-	-	26479	-
E. BCR (C/A)			-	-	1.31	-	-	-	1.25	-

Source: Field survey, 2019

For Allgure potato cultivation average requirement of urea, TSP, MP and boric acid were 331.96 kg, 331.96 kg, 189.30 kg, 7.15 kg per ha cost of urea, TSP, MP and boric acid were Tk.5511, Tk.8036, Tk.2772, Tk.777 per ha in the study area which required 5.39 percent, 7.86 percent, 2.70 percent, 0.75 percent of the total cost respectively on total cost basis. The total average cost for insecticides was Tk.1705/ha for Diamant potato cultivation and it shared 1.24 percent of total cost on total cost basis. For Algure potato cultivation total average cost of insecticides was Tk. 1515 per ha and it shared 1.48 percent of total cost on total cost basis. For Diamant potato cultivation total cost of irrigation was Tk.2877 per ha which bears 2.10 percent of total cost on total cost basis. For Algure potato cultivation total cost of irrigation was Tk.1946 per ha which bears 1.90 percent of total cost on total cost basis. Total average cost of sorting and packaging for Diamant potato is Tk. 5183 per ha and it required 3.77 percent of total cost on total cost basis. For Algure potato total average cost of sorting and packaging is Tk.4000 per ha and it required 3.91 percent of total cost on total cost basis. For Diamant potato the average total transportation cost is Tk. 2680 per ha which shared 1.95 percent of total cost on total cost basis. For Algure potato average transportation cost is Tk.1500 per ha which shared 1.47 percent of total cost on total cost basis.

Average storage cost of Diamant potato is Tk.38765 per ha which required 28.23 percent of total cost on total cost basis (Table 1). Average storage cost of Algure potato is Tk.14550 per ha which required 14.22 percent of total cost on total cost basis. Interest on operating capital of Diamant and Algure potato were estimated at TK.1565 and Tk.1133 per ha respectively. The operating cost of capital was multiplied by 10 per cent interest for both varieties for three months the cost item was included in total cost analysis and it constituted 1.14 percent and 1.11 percent of gross cost of Diamant and Algure potato cultivation respectively. The average perha land use cost was Tk.10758 which representing 7.65 percent and 10.27 of total cost of Diamant and Algure potato cultivation respectively. On the basis of total cost, average per ha cost was estimated at Tk.137317 and Tk.102289 for Diamant and Algure potato respectively. It appears from Table 1 that the storage cost was the highest item in producing Diamant potato, which shared 28.23 percent of total cost. Table 1 reveals that human labor cost is the major cost item for producing Algure potato, which consumed 20.63 percent of total cost. Return from Diamant potato was Tk.180482/ha and from Algure potato was Tk.128768/ha. Per hectare net return of Diamant potato was Tk.43164 and per ha return of Algure potato was Tk.26479 in the study area. In case of producing Diamant potato, BCR was 1.31 and for the Algure potato production, the BCR was 1.25 on full cost basis. Table 1 reveals that per ha cost of Diamant potato production is higher than that of Algure potato production. Per hectare yield of Diamant potato was 13316 kg which was higher than per ha yield of Algure potato 9533 kg. As a result, gross return from Diamant potato was higher than that of Allgure potato. Net return from Diamant potato was also higher than the net return from Algure potato. Benefit cost ratio was higher in Diamant potato than that of Allgure potato.

Table 2. Estimated values of co-efficient and related statistics of multiple linear regression model (log-linear model)

Explanatory variables	Coefficient for Diamant potato	Coefficient for Algure potato
Intercept	3.618	9.072
Farmer's Age	0.956** (0.009)	1.427*** (0.058)
Education level	0.064 (0.119)	0.338** (0.040)
Family size	-0.257** (0.01)	-1.027 (0.188)
Farm size	0.363** (0.0047)	0.751* (0.0006)
Year of farming experience	0.021 (0.403)	-0.462 (0.145)
R^2	0.699	0.591
R^2 (adjusted)	0.637	0.506
F-value	11.164	14.615

Source: Author's calculation based on field survey, 2019

Note: Figures in the parentheses indicate P-values

***,** and * indicates significant at 10%, 5% and 1% level of significance, respectively

Table 3. Major problems faced by the farmers in producing potato

Name of the problem	Diamant	Algure
	Number	Number
Technical Problems		
i. Unavailability of good quality seed	13 (43.33)	15 (50)
ii. Unavailability of sufficient fertilizers in time	10 (33.33)	9 (30)
iii. Lack of farmers' knowledge on scientific method	17 (56.67)	20 (66.67)
iv. Disease infestation	5 (16.67)	6 (20)
v. Ineffective pesticides	6 (20)	7 (23.33)
Economic Problems		
i. Lack of adequate funds	16 (53.33)	18 (60)
ii. High cost of inputs	12 (40)	13 (43.33)
iii. High cost of fertilizers and insecticides	9 (63.33)	21 (70)
Marketing Problems		
i. Lack of adequate cold storage facilities	25 (83.33)	27 (90)
ii. High cold storage charge	17 (56.67)	15 (50)
iii. Low prices at peak harvest period	23 (76.67)	3 (10)
Social Problems		
i. Damage by rat, wild animals or domestic animals	10 (33.33)	9 (30)
ii. Wastage	6 (20)	5 (16.67)
iii. Loss of production due to theft	4 (13.33)	3 (10)

Figures in the parenthesis indicate percentage

Source: Field Survey, 2019

From the above discussion, income of the potato farmers is a complex variable, which is a function of the combined influences of a large number of interacting factors. In this study, multiple linear regression model (log-linear model) analysis

was used to determine the influence of some important factors. Farmer's age, education level, farm size played a positive role in increasing net return for both Diamant and Algure potato (Table 2). Family size had negative influence on both variety and year of farming experience had positive influence on Diamant potato and negative effect on Algure potato. The log linear regression model had the value of coefficient of multiple determinations (R^2) at 0.699 and 0.591 for Diamant and Algure potato respectively. The F-values were highly significant. Most of the variables included in the model were significant in explaining the production of potato. Three variables out of five variables were significant in explaining the net return.

Major Problems Associated with Production and Marketing of Potato:

There were tremendous problems associated with Diamant and Algure potato production in the study area. Problems based on the opinions of the respondents are reported here.

4. Conclusion and Recommendations

From the results of the present study, it can be concluded that considerable scope apparently exists in the study area to increase the productivity of potato and to increase income, employment and nutritional status of the farmers. It is easily realized that potato cultivation is not a highly profitable for the farmers. Farmers are used to grow potato every year and they hardly prefer to grow alternative crops due to their customized nature of growing this crop in that locality. The study revealed that Diamant potato growing was more profitable than Algure potato growing and farmers like to grow Diamant potato due to the little bit higher profit. Farmers generally sell Algure potato in the harvesting season, because the price of potato remains higher when Algure potato is harvested. But in case of Diamant potato, the price becomes very lower in the harvesting season. So the rich farmers store it and sell them later when the price rises. For this reason, storage cost is a major cost item for Diamant potato cultivation. The management practices of production in the study area were not found efficient enough. Effective education system and technological support may increase the income level of potato growing farmers. Farmers were not known about the application of inputs in right time with right doses. Consequently, they made over or under use of some inputs. Functional analysis proves that farmer's age, education level, farm size played a positive role in increasing net return for both Diamant and Algure potato farmers. Farmers should take care those issues. Thus, well planned management training in accordance with their problems, needs, goals and resource can lead to grow viable production practices and sustainable income from potato cultivation in the study areas.

The analysis found that seed, manure, fertilizer, irrigation, and insecticide all had a substantial impact on potato yield. However, the expenses of these inputs are extremely significant. As a result, the government's concerned department should do everything in its power to provide farmers with the necessary inputs and other assistance in order to greatly enhance potato production.

One of the significant issues that farmers in the research area experienced was a lack of suitable cold storage facilities and a high storage price. BADC should take steps to establish new cold storage facilities and provide enough amenities in the research area. The government's responsible body should also take the appropriate actions to limit the cold storage charge.

To boost potato productivity, the DAE training wing should offer farmers with training by extension service personnel to make farmers aware of the efficient use of inputs.

Quality seeds of improved kinds in sufficient quantity are acknowledged as one of the critical components for increasing agricultural production: Farmers also claimed becoming victims of seed adulteration. As a result, the DAE and other related organizations should make better seed available to farmers, and the DAE should take steps to control seed adulteration.

The potato is an important crop all across the world. Potato yield is considerably reduced due to the onslaught of many insect pests and illnesses, including viruses, which contribute to seed stock degeneration. Farmers must have access to high-quality seed materials in order to increase tuber crop productivity. As a result, focus should be placed on producing seed that is free of disease and insects.

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ROLE OF MICROFINANCE FOR WOMEN EMPOWERMENT: EMPIRICAL EVIDENCE FROM RURAL BANGLADESH

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Abstract

Microfinance programs are being considered as an important development strategy all over the world especially in developing countries like Bangladesh. Different studies focused on benefit of microfinance in rural development, but none explored the actual impact of microfinance in women empowerment. Thus, this study focused on the actual impact of microfinance on women empowerment in Bangladesh. Data were collected from 60 women beneficiaries from Grameen Bank, BRAC and ASA by face-to-face interview during June-July 2020. This study used average method and frequency distribution to construct women empowerment index in Bangladesh. The findings of the study reveal that the socio-economic condition and empowerment status of the respondents' female borrowers of microfinance was not satisfactory level. Only 18.3% respondents utilize the loan money herself and the other 81.7% respondents give the money to their husband. Additionally, in the study area microfinance services only help the rural women to improve their decision-making ability and it does not help to achieve other domains of empowerment.

Keywords: Decision making, Microfinance institution, and Women empowerment.

1. Introduction

Microfinance is a category of banking service provided to unemployed or lower income individual or group who otherwise would have no other access to financial services. It comprises microcredit, savings, checking accounts, insurance and other services. Microfinance enhances financial capacities of poorer segment of the population which help to mobilize small scale resources through investment especially women. Thus, microfinance is interlinked with women empowerment for creating employment opportunities and economic creditworthiness. Women empowerment is one of the most important indicators of the socio-economic development of a society (Mahmud, 2003; Singh, 2009). Sometimes women face discrimination at home, workplace and in society. Due to the lack of enough financial ability, they cannot start any income generating activities. In this situation, micro credit has given them some opportunity for starting their own business. The rising demand for credit may seem to indicate the popularity of the

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microcredit program (Chhay, 2011). In addition, microfinance program has the potential to make a large positive impact for women when applied well and where there is a good match between the program and the customers need (Parvin et al., 2005; Chalfin, 2002). For many women, microfinance is the only tool to empower as many microfinance institutions target only women for changing their social status toward improvement. They offer low interest rate and no collateral for easy taking loan. As poor people can't take loan from commercial bank because they are unable to provide high collateral or some deposit. This constraint is triggered out the poverty level. This is where the plan of microfinance plays a vital role to improve the status of women as well as the underprivileged. Thus, microfinance programs are playing important role for involving women in the economic activities which helps to improve the socio-economic vulnerability of women through empowerment.

This study has focused on the effect of microfinance service on achieving women empowerment through improving the decision-making ability of rural women. The specific objectives of the study include to understand the socio-economic profile of the beneficiary rural women, to examine the role of microfinance in improving decision making ability, to analyze women empowerment at domestic level in Bangladesh and to explore the problems faced by the respondents in accessing and utilizing microfinance services.

The aim of the study is to observe the status of women in various aspects of women empowerment and find out the relationship between microfinance and women empowerment.

2. Methodology

This study was conducted in rural areas of Manikganj district in Bangladesh from June to July 2020. In total 60 women beneficiaries from Grameen Bank, BRAC and ASA were selected as sample from three villages. The significant criteria for choosing these villages were the availability of microfinance institutions and a significant number of women involve with microfinance services. Samples were selected by using purposive sampling technique and a structured questionnaire was used to collect information. Women Empowerment Index (WEI) was computed by following average method and frequency distribution with the help of SPSS. Ten different issues were identified of women empowerment through microfinance. The microfinance receivers empowered different extent of empowerment strategies against different empowerment issues through microfinance. The selected issues were presented in rank order. WEI was computed for each issue of empowerment through microfinance by using the following formula:

$$WEI = E_N \times 0 + E_L \times 1 + E_M \times 2 + E_H \times 3$$

Where, E_N = No Empowerment; E_L = Low Empowerment; E_M = Medium Empowerment; E_H = High Empowerment

In WEI through microfinance each different empowerment issues could range from 0 to 180, where the scores towards 0 indicating lowest women empowerment and the scores towards 180 indicating highest women empowerment through microfinance. The construction of 'WEI' was based on this ranking procedure. Additionally, the assessment of decision-making power is determined by the ten-household decision making questions which was answered by the respondents. At first frequency and percentage of respondents under each question was computed then an empowerment index was made based on the decision-making related question. To find out respondent's empowerment condition through the decision-making questions answered by '1' standing for a 'Yes' and '0' standing for a 'No', and every 'Yes' indicate that the decision taken by women herself, while every 'No' indicates the women have no rights to take the decision. Using the method to measure empowerment index, the average empowerment index is 0.50. Women respondents who are more empowered and this empowerment level is greater than the average level of empowerment, which was 0.50, while the no empowerment level remain below the average level of empowerment (0.50).

3. Results and Discussion

Socio-demographic profile of the respondents: Socio-demographic status has facilitated to assess the situational level of the targeted women under the microfinance programs. The age of the female borrowers of microfinance have been varied from 25 to 60 years. From Table 1, it was revealed that the respondents' female borrowers of microfinance were classified into three age groups: up to 20-30 years, 31-45 years and above 45 years. It shows from the table that 47.7 % were belonged to the age group 30-45 years while only 10 percent were belonged to the age group above 45 years. The active age (31-45) respondents were generally more involved in different income generating activities (IGAs) and for that they communicate with microfinance providing organizations and received loan for different interventions. Table 1 explains that highest percentage (25%) of the respondents are illiterate and same percentage have Secondary School Certificate (SSC) while only 10% have Higher Secondary Certificate (HSC). It implies that the illiterate and lower educated group were more credit constraint as a result they were likely to receive microfinance services.

Additionally, 4-6 members size of family constitute the highest proportion (81.6 %) whereas only 1.7% respondents had above 6 members in the family. The average family size of female borrower is 4.28 (BBS, 2018). Considering earning members and occupation, it was revealed that most of the family (63.3%) of respondents contained only 1 earning member and 81.7 % respondents were housewife. This situation influenced them to take microfinance services so that they can contribute to their family income. Considering the source of family income, 23.3% respondents were involved in business while the lowest percentage of the respondents (1.7%) involved in agricultural labor, service, agriculture and allied activities, agriculture, business, employment; agriculture, rent and employment, fixed property, rent etc.

Table 1. Socio-demographic profile of the respondents

Items	Socio-demographic profile	Percentage (%)
Age category of the respondents	20-30 years	43.30
	31-45 years	47.70
	Above 45 years	10.00
	Average age distribution (Year)	38.20
Education levels of the respondents	Higher Secondary Certificate (HSC)	10.00
	Secondary School Certificate (SSC)	25.00
	Junior Secondary level (JSC)	16.70
	Primary level	23.30
	Illiterate	25.00
Family size	Up to 3 members	16.70
	4-6 members	81.60
	Above 6 members	1.70
	Average	4.28
Number of earning members	1 member	63.30
	2 members	30.0
	3 members	6.70
Types of occupation of the respondents	Housewife	81.70
	Service	18.30
Source of family income	Agricultural labor, Services	1.70
	Agriculture	15.00
	Agriculture and Allied activities	1.70
	Agriculture, Business, Employment	1.70
	Agriculture, Employment	20.00
	Agriculture, Rent	1.70
	Business	23.30
	Business, Agriculture	1.70
	Business, Employment	11.70
	Employment	20.00
	Employment, Fixed property, Rent	1.70

Source: Field survey (2020)

Monthly Income and Expenditure: Family income is dependent on the education level and employment status which is determinant livelihoods. Income and expenditure status of the fal\mily of the women respondents' has shown in the Table 2.

Table 2 shows the distribution of respondents according to their monthly household income and family expenditure. Data revealed that having Tk.12001-24000 monthly income of the respondents' spouse constitute the highest proportion (41.7%), while the lowest proportion (28.3%) earn above Tk.24000. The average monthly income of the respondents' spouse is Tk.19117. Considering the monthly income of the respondents, it was found that the highest proportion (81.7%) of the respondents' have no monthly income followed by 10% earn Tk.4001-8000, while the lowest proportion 1.7% respondents earn above Tk.8000. The average monthly income of the respondents' is Tk.966. In the context of

monthly family expenditure of the respondents' it was observed that the highest proportion (63.3%) were spent Tk.8001-16000/month while the lowest proportion (11.7%) of the respondents spent up to Tk.8000/month. The average monthly family expenditure of the respondents' is Tk.14033. The average monthly income of the respondents was not satisfactory in compared to average monthly expenditure. Nabahat (2014) stated that most of the women do not earn much money, thus they are financially and socially dependent on male members of their family in his study in women empowerment which is similar with the finding of this research. For extra earning and to boost family income microfinance could be a good option for the rural women.

Table 2. Distribution of respondents as per household income and expenditure

Selected characteristics	Categories	Percent (%)
Monthly income of the respondents' spouse	Up to Tk.12000	30.0
	Tk.12001 - 24000	41.7
	Above Tk.24000	28.3
Average monthly income of the respondents' spouse	Tk.19117	
Monthly income of the respondents'	No income	81.7
	Up to Tk.4000	6.6
	Tk.4001-8000	10.0
	Above 8000	1.7
Average monthly income of the respondents'	Tk.966	
Monthly family expenditure of respondents'	Up to Tk.8000	11.7
	Tk.8001-16000	63.3
	Above Tk.16000	25.0
Average monthly family expenditure of respondents'	Tk.14033	

Source: Field survey (2020)

Women Involvement in Agricultural Productivity: Agriculture is main source of the rural people for livelihood. Though women are engaged in agricultural activities at households, but they are mostly not engaged agricultural production process professionally. Table 3 represented that the highest percentage (58.3%) of respondents were not involved in agricultural productivity while the lowest percentage (10.0%) of respondents were involved to supplement income. However, 18.3% women were involved for producing food for consumption and 13.4% were involved for consumption with supplement income.

Table 3. Distribution of respondents as per involving in agricultural productivity

Reason of involving in agricultural productivity	Percent (%)
No involvement	58.3
For livelihood, to supplement income	10.0
To produce food for household consumption, for livelihood	18.3
To produce food for household consumption, to supplement income	13.4

Source: Field survey (2020)

Accessibility to Land Related Characteristics: For evaluate the role of microfinance on women empowerment of the respondents' female borrowers of microfinance various accessibility to land related characteristics were collected under the present study. The three selected salient features respondents' female borrowers of microfinance such as owner of the land and the way of acquiring land; size of cultivable land; and total cost of production respondent female borrowers of microfinance are presented Table 4.

Table 4. Distribution of respondents as per ownership and way of acquiring land

Selected characteristics	Categories	Percent (%)
Source of ownership of the land	Not responding	58.3
	Father	1.7
	Husband	40.0
The way of the acquiring land	Not responding	58.3
	Allocated	25.0
	Inheritance	11.7
	Purchase	5.0
Size of cultivated land	Not involved with agricultural activities	61.7
	Up to 85 decimals	13.3
	86-170 decimals	18.3
	Above 170 decimals	6.7
	Average land size	106 decimals
Information about the cost of production (Tk./Annually)	Not involved with agricultural activities	58.3
	Up to Tk.150000	16.7
	Tk.150001-Tk.300000	18.3
	Above Tk.300000	6.7
	Average cost of production	Tk.193040

Source: Field survey (2020)

Table 4 revealed that the highest 40.0% respondent's land were owned by her husband and only 1.7 percent land were owned by father. In considering the way of the acquiring land the highest (25%) referred that it was allocated, whereas 11.7% acquire it as inheritance and only 5% purchase the land. The size of cultivated land of the respondent female borrowers of microfinance ranged from 7 to 264 decimals. Based on the size of cultivable land, the respondents were classified into three categories. These categories were up to 85 decimals, 86-170 decimals and above 170 decimals. Table 4 indicates that 85-170 decimals of cultivated land holder constitute the highest proportion (18.3%) followed by up to 86 decimals of cultivated land holders were 13.3%, whereas the lowest 5% hold above 170 decimals of cultivated land. On the other hand, 61.7% respondent female borrowers of microfinance were not response for this question as they were not involved with agricultural activities. Considering the total cost of production, it was revealed that 58.3% respondent female borrowers of microfinance have not provide reply because they were not involved in agricultural activities. Among the respondent 18.3% replay that their total cost of production was within Tk.150001-

300000 and 16.7% seems that it was up to Tk. 150000, whereas 6.7% respondent female borrowers of microfinance reply that the cost of agricultural production was above Tk.300000. Table 5 shows that the average cost of production is Tk.193040. Microfinance is a good option which can help to arrange the necessary amount of money for agricultural production. This is one of the important reasons to take microfinance services.

Access to Credit Related Characteristics: To assess the role of microfinance on women empowerment of the respondents' female borrowers of microfinance different access to credit related characteristics were composed under the present study. As per the methodology all the respondents having experiences of credit obtaining.

Table 5. Characteristics of the respondents' female borrowers to access for credit

Selected Characteristics	Categories	Percent (%)	Selected Characteristics	Categories	Percent (%)
Last time credit obtained (Years)	1 year	86.7	Amount of loan money receive (BDT)	Up to 10000	70.0
	2 years ago	5.0		150001-300000	23.3
	3 years ago	5.0		Above 300000	6.7
	4 years ago	3.3			
Membership with MFI (Years	Last season	8.3	Number of loans repay (Times	1 time	18.3
	1 year	1.7		2 times	10.0
	2 years ago	8.3		3 times	13.3
	3 years ago	15.0		4 times	10.0
	4 years ago	10.0		5 times	10.0
	5 years ago	8.3		5 times more	38.3
	5 years more	48.3			
Amount of loan money receive (BDT)	Up to 10000	70.0	Who utilize the loan money (person)	By the wife	18.3
	150001-300000	23.3		By the husband	81.7
	Above 300000	6.7			

Source: Field survey (2020)

Table 5 shows that the highest 86.7% respondents were received credit within 1 year followed by (5%) 2 and 3 years ago and only 3.3% respondents received credit from MFI in 4 years ago. The highest proportion of respondents (48.3%) were the member of MFI for 5 years more followed by 3 years long (15%) and 4 years long (10%), and 8.3% in last season, 2 years long and 5 years long, respectively, whereas only 1.7% have been involved for 1 year. Considering amount of loan money received by the respondent female borrowers of microfinance ranged from Tk.10000 to 500000 with the mean and standard deviation of 134917 and 116264, respectively. Forty-two respondents receive the loan money up to Tk.150000 where 14 respondents receive the loan money ranged within Tk.150001-Tk.300000 and the other 4 respondents receive the loan money above Tk.300000. So, highest number of respondents (70%) received the loan money up to Tk.150000 and lowest number of respondents (6.5%) received the loan money above Tk.300000. It reveals that repaying lower amount of money is easier than repaying higher amount of money as most of the respondents repay the loan money more than 5 times. Considering the number of loans repay, the highest 38.3%

respondents repay the loan 5 times more followed by 1 time (18.3%) and 3 times (13.3%), while only 10% have been able to repay 2 times; 4 times; and 5 times, respectively (Table 5). Table 5 also shows that only 11 (18.3%) respondents' the female borrowers of microfinance use the loan money by herself and the other 49 (81.7%) respondents give the loan money to their husband and the money is used by the spouse of the respondents.

Access to Extension Services Related Characteristics: According to information in Table 6 indicates that the highest (63.3%) were aware to extension service in the area, whereas the rest (36.7%) of the respondents had no awareness to extension services. Considering the extension agents organize training programs for female entrepreneur responses 100% answered no such type of training program that eventually organized by extension agents. On the other hand, responses to the attended any entrepreneur training program the highest (86.7%) never attended any training program and only the lowest (13.3%) received entrepreneur training program. Among the respondents who never received any training on entrepreneur, 55% want to receive training, whereas 31.7% have no interest for receiving any training. Considering benefits from training of the respondents' female borrowers of microfinance 13.3% want to know about technology and get input.

Table 6. Salient features of the selected access to extension services related characteristics of the respondents' female borrowers of microfinance (In Percent)

Selected characteristics	Yes	No
Awareness to extension service in the area	63.3	36.7
Organizing training programs for female entrepreneurs	0	100
Attending any entrepreneur training program	13.3	86.7
Want to receive training program	55	45
Benefits receive from training	13.3	86.7

Source: Field survey (2020)

Decision-Making Related Characteristics: To assess the role of microfinance on women empowerment of the female borrowers different decision-making related characteristics were considered under the present study and presented in Table 7. Considering the empowerment to take decision about different issues within the household, the highest 98.3% replied yes, whereas the lowest 1.7% answered no. In the issue of taking decision to work for earning income, the highest (76.7%) answered no, while the lowest (23.3%) answered yes. Considering the issue to take decisions on saving, borrowing and investment the highest (80%) replied yes and the lowest (20%) answered no. In response to take decision about the construction of house, the highest (73.3%) answered yes, whereas the lowest (26.7%) replied no. In the context of empowered to take decision about children's education, the highest (88.3%) answered yes but 11.7% answered no. Considering empowered to take decision about buying necessary good from market for family without husband's permission the highest (51.7%) replied yes and the lowest (48.3%) answered no. In response to empowered to take decision about family planning,

the highest (90%) answered yes but the lowest (10%) replay no. In the context of empowered to take decision about the treatment of family members, the highest (70%) answered yes and the lowest (30%) replied no. Considering the issue to take decision about visiting relatives and father's house without husband's permission, the highest (83.3%) answered no but the lowest (16.7%) answered yes. In response of empowered to take decision about family affairs, the highest (83.3%) replied yes, on the other hand 16.3% answered no.

Table 7. Salient features of the selected decision-making characteristics of the female respondents' borrowers of microfinance

Selected characteristics	Percent (%)	
	Yes	No
Take decisions about different issues within the household	98.3	1.7
Takes decision to work for earning income	23.3	76.7
Take decisions on saving, borrowing and investment	80.0	20.0
Take decisions about the construction of house	73.3	26.7
Takes decision about children's education	88.3	11.7
Take decisions about buying necessary good from market without husband's permission	51.7	48.3
Take decisions about family planning	90.0	10.0
Take decisions about the treatment of family members	70.0	30.0
Takes decision to visit relatives and father's house without husband's permission	16.7	83.3
Take decisions about family affairs	83.3	16.7

Source: Field Survey (2020)

To find out respondent's empowerment condition through the decision-making questions answered by '1' standing for a 'Yes" answer and '0' standing for a 'No' answer, and every 'Yes' answer indicate that the decision taken by women herself, while every 'No' answer indicates the women have no rights to take the decision by whom herself but was taken by husband or male counterpart. Using the method to measure empowerment index, the average empowerment index is 0.50. The empowerment index of empowered women is found to be 0.68 in other hand the not empowered women's empowerment index is measured by 0.32.

Table 8. Women empowerment index through decision making

Group	Average Empowerment
Empowered	0.68
Not Empowered	0.32
Average	0.50

Source: Field Survey (2020)

Table 8 revealed the result by following weighted average method, here women respondents who are more empowered and this empowerment level (0.68) is greater than the average level of empowerment which was 0.50, while the not empowerment level (0.32) of remain below the average level of empowerment (0.50).

Women Empowerment Related Characteristics: Table 9 shows that to take part in the family income 3.3% respondents were highly empowered, 15% respondents were moderately empowered, 43% were low empowered, and 19% said they were not empowered. In case of purchasing capacity of necessary good for family 13.3% respondents were highly empowered, 45% respondents were moderately empowered, 40% were low empowered, and 1.7% said they were not empowered. In case of enterprise running capacity, no respondents were highly empowered, 23% respondents were moderately empowered, 16% were low empowered, and 60% said they were not empowered. In case of freedom of mobility 5% respondents were highly empowered, 33.3% respondents were moderately empowered, and 61.7% were low empowered. In case of freedom in expenditure 15% respondents were highly empowered, 40% respondents were moderately empowered, 43.3% were low empowered, and 1.7% said they were not empowered. In case of ability of get respect by the family members 16.7% respondents were highly empowered, 53.3% respondents were moderately empowered, 30% were low empowered. In case of ability of social value achievement 31.7% respondents were highly empowered, 41.7% respondents were moderately empowered, 26.7% were low empowered. In case of ownership of wealth, no respondents were highly empowered, 21% respondents were moderately empowered, 25% were low empowered, and 53% said they were not empowered.

Table 9. Salient features of women empowerment through microfinance

Selected characteristics	Empowerment level (%)			
	High	Medium	Low	No
Take part to the family income (monthly)	3.3	15.0	71.7	19.0
Purchasing capacity of necessary good for family	13.3	45.0	40.0	1.7
Enterprise running capacity	00	23.3	16.7	60.0
Freedom of mobility	5.0	33.3	61.7	00
Freedom in expenditure	15.0	40.0	43.3	1.7
Ability of participating in socio-cultural activities	6.7	48.3	45.0	00
Understanding with husband	40.0	45.0	15.0	00
Get respect by the family members	16.7	53.3	30.0	00
Social value achievement	31.7	41.7	26.7	00
Ownership of wealth	00	21.7	25.0	53.3

Source: Field Survey (2020)

Table 10. Extent of women empowerment

Group	Empowerment
High Empowerment	79 (13.16%)
Medium Empowerment	220 (36.66%)
Low Empowerment	225 (37.50%)
No Empowerment	76 (12.66%)

Source: Field Survey (2020)

Table 10 indicates that the highest 37.50 percent respondents mentioned that they have low empowerment whereas only 13.16 percent respondents said they are highly empowered. On the other hand, 36.66 percent respondents were empowered at medium level and 12.66 percent were totally not empowered.

Women Empowerment Index through Microfinance: To ascertain the best empowerment issues, Women Empowerment Index (WEI) was computed by using average and frequency distribution method. Ten different issues were identified of women empowerment through microfinance. The microfinance receivers empowered different extent of empowerment strategies against different empowerment issues through microfinance. The selected issues are presented below in rank order. A Women Empowerment Index (WEI) was computed for each issues of empowerment through microfinance by using the following formula:

Women Empowerment Index (WEI) = $E_N \times 0 + E_L \times 1 + E_M \times 2 + E_H \times 3$

Where, E_N = No Empowerment; E_L = Low Empowerment; E_M = Medium Empowerment; E_H = High Empowerment

In Women Empowerment Index (WEI) through microfinance each different empowerment issues could range from 0 to 180, where 0 indicating lowest women empowerment and 180 indicating highest women empowerment through microfinance. However, observed Women Empowerment Index (WEI) ranged from 38 to 135.

Table 11. Rank order as per score of women empowerment issues through microfinance

Issues of women empowerment through Microfinance	WEI	Rank
Understanding with husband	135	1st
Social value achievement	123	2nd
Get respect by the family members	112	3rd
Purchasing capacity of necessary good for family	102	4th
Freedom in expenditure	101	5th
Ability of participating in social and cultural activities	97	6th
Freedom of mobility	86	7th
Ownership of wealth	67	8th
Take part to the family income (monthly)	41	9th
Enterprise running capacity	38	10th

WEI=Women Empowerment Index; Source: Field Survey (2020)

Table 11 represents rank order of the adoption of ten issues of women empowerment through microfinance. As per Women Empowerment Index (WEI) understanding with husband positioned the 1st, social value achievement in 2nd, get respect by the family members in 3rd, purchasing capacity of necessary good for family in 4th, freedom in expenditure in 5th, ability of participating in social and cultural activities in 6th, freedom of mobility in 7th, ownership of wealth in 8th, take part to the family income (monthly) in 9th and enterprise running capacity positioned in 10th.

4. Conclusion

It can be concluded that microfinance services help to bring decision-making ability of the women in household level as it enables the female borrowers to help their husband and family economically. However, other women empowerment issues including time, wellbeing and leadership are not improved for involving in microfinance services. The main purpose of this study was to identify the empirical association between microfinance and women empowerment. For the proper execution of the microfinance program policy recommendation is important for both the government and non-government organization of microfinance. In the study area 100 percent respondents said that the MFIs do not offer them any kind of training program. It is one of the main reasons that the women can't develop their skill to run a business or doing something productive. Thus, both the GOs and NGOs should give emphasize to take a policy for conducting training programs and monitoring the borrowers.

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