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The Role of Training, Extension and Education Facilities on Production Efficiency of Rice Growers in Dinajpur District of Bangladesh

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Abstract

To meet the growing food demand of Bangladesh requires efficiently use of inputs and effectively manage of production practices at the farm level. Thus, the present study aims to measure the technical efficiency and establish core factors affecting Boro and Aman rice production in Bangladesh. The study employed mainly farm level data collected from 80 farm households selected randomly in Dinajpur district. Translog Stochastic Frontier Production function approach used to estimate arm specific technical efficiency of the farmers. Evidence revealed that, overall production efficiency of Boro and Aman rice production were 83.25, and 85.15 percent, respectively which implies that there is still room to further improve technical efficiency given the same level of inputs and technology. Furthermore, the level of output of Boro and Aman rice production varied according to area cultivated, employed human labor, irrigation management, fertilizer and manure application. On the other hand, farmer's education, access to microcredit, training and extension facilities were the important factors influencing the level of inefficiency according to technical inefficiency effect model. In conclusion, the sustainability of the high efficiency will dependent on the continuous support of supply and proper use of inputs in the study areas.

1. Introduction

The world's largest delta, Bangladesh is a densely populated agriculture based country. Agriculture has been the mainstay of Bangladesh economy, contributed about 14.75 % to the gross domestic product (GDP) and provided employment for about 47% of the total labor force in 2016-2017 (BBS, 2016). Rice is the main crop that supplies about 92% of total food grain and covers about 76% of the total cropped area in Bangladesh (BBS, 2016). Rice alone contributed about 7.58% of the national GDP (Khan et al., 2013).

The country has made a remarkable progress in agriculture in terms of adoption of modern technologies and rice production since 1990's. Rice yield has increased more than three-folds from1.57 tons/ha during the early 1970's to 4.44tons/ha in 2016-17 (BBS, 2016). According to BBS (2016), Aman and Boro rice production were 13.66 and 18.41 million tons, respectively. The country needs to increase further growth in rice productivity (at least 20% greater than the current rice yield) for meeting the demand of food-grain for growing population (estimated to be 173 million by 2020) (Husain et al., 2001), (Magor et al., 2007). Bangladesh agriculture already operates at its land frontier and there is little or no scope to expand the cultivable land to meet the increasing demand for food requirements for its ever-increasing population (Rahman, 2003).To feed the growing amount of population, farmers need to be more efficient in rice production. Moreover, average farm size is relatively smaller compared to other countries due to existing ownership and inheritance system in our country and in many cases it becomes very difficult to adopt modern agricultural technologies (Hossain and Rahman, 2012). By analyzing these situations, measurement of technical efficiency of Boro and Aman rice production is an important issue from the stand point of agricultural productivity. The present study aims to estimate the determinants of both technical efficiency and inefficiency of the farmers. It will give useful information for making sound management decisions, resource allocations, and for formulating agricultural policies and institutional improvement (Nargis and Lee, 2013). So, the specific objectives of this study were to determine the level of technical efficiency of Boro and Aman rice production in Dinajpur district of Bangladesh and to assess the effects of the key inputs on inefficiencies.

Review of Literature

An inclusive review of literature regarding different aspects of technical efficiency of agricultural production in the context of Bangladesh has been done. Khan et al. (2010) found that the mean technical efficiency of Boro and Aman rice production were 95% and 91%, respectively. Moreover, in the study area education and experience of the farmers substantially reduce farm inefficiencies. Bala et al., (2010) reported that the average technical efficiencies of aus HYV (76.10%), Aman LYV & HYV (83.30% & 75.80%) and Boro HYV & hybrid rice (80.20%& 84.5%) in the 4 regions of Bangladesh. They found microcredit, training status, extension contact, farm size, age and education were influenced on inefficiencies drastically. Technical efficiency of rice farming in Naogaon district of Bangladesh is 79.58% (Hossain and Rahman, 2012).The study also observed that proper use of seed, labor, fertilizer, insecticide and irrigation might help to increase the level of rice production in the study area. Hasnain et al. (2015) found that mean technical efficiency of boro rice farms in Meherpur district was 89.5%. It was also found that labor, fertilizer, pesticide, seed and irrigation were the significant factors that affect the level of technical efficiency while farm size and land preparation cost found insignificant. The empirical result of Cobb-Douglas stochastic production frontier approach showed that the technical efficiency of Boro rice production is on average 0.92 in Jhenaidah district (Hasan et al., 2016). Authors also revealed that cost of labor, irrigation, seed and ploughing are the important factors that affect increasing efficiency where farm size, age, education, training and credit facility are negatively related to technical inefficiency of boro rice production.

2. Materials and methods

Study area and data collection: The present study is mainly based on primary data of Dinajpur district. A multistage sampling procedure was followed to select rice-growing farmers. The study was carried out purposively in eight villages namely; Purbasherpur, Dangapara, Hamidpur, Dhulaudal, Hiramani, Sonachaluni, Barakala and Nandagaon under two Upazilas namely; Parbatipur and Birganj due to higher concentrated rice growing area. Ten rice-growing farmers from each village were nominated by using simple random sampling technique. Therefore, a total of 80rice-producing farmers were interviewed for fulfilling the objective of the study. The data were collected in the period of 2016-17 for Aman and Boro season in the study area.

Concept of technical efficiency: Technical efficiency is the synonym of production efficiency. Farrell (1957) in his seminal paper illustrated the concept of technical efficiency. He says that it reflects the farm's ability to obtain maximum output from a given set of inputs. Thus, it is likely to show the high-performance of a farm than another farm that does not do the same, given a similar bundle of resources and technology. The technical efficiency of the individual farm can be defined as:

$$\text{Tecnical efficiency} = \frac{\text{Observed output by a given set of inputs}}{\text{Maximum attaiable output at the same level of output}}$$

By definition, production frontier represents the maximum attainable output at each input level. Hence, it reflects the current state of technology in the industry (Coelli et al., 2005). Therefore, we may rewrite symbolically, the technical efficiency of the i^{th} farm can be written as

$$TE_i = Q_i / Q_i^*$$

Where, Q_i denotes realized or observed output of the i^{th} farm for a given input level and technology, Q_i^* denotes the maximal attainable or production frontier output of i^{th}farm at the same input level and technology.

There are two general paths of estimating the production frontier: (a) deterministic frontiers – which force all observations to be on or below the production frontier so that all deviations from the frontier can be attributed to inefficiency and (b) stochastic frontier–where disturbance term consists of two components, one corresponding to technical inefficiency and other to the usual random noise. The advantage of stochastic frontier over the deterministic frontier is that farm-specific efficiency and random error effect can be separated (Banik, 1994).Villano and Fleming (2004) proposed the model of stochastic production frontier as:

$$Q_i = f(X_i,\beta)\exp(v_i - u_i)$$

Where, Q_i denotes the output of the i^{th} farm; $X_i = [1 \quad X1_i \quad X2_i \ \ldots \ Xp_i]'$ which is a (p+1)×1 vector of inputs of the i^{th} farm; $\beta_i = [\beta_0, \beta_1, \beta_2, \ldots \beta_p]'$ is a vector of unknown parameters; v_i's are the statistical noise which permit variation in output due to factors like weather, plant diseases, measurement error, inadvertent omission of relevant variables from the vector X_i and approximation errors associate with the choice of functional form. Note that, u_i's are one-sided components (i.e., $u_i \geq 0$) which reflects technical inefficiency relative to the stochastic frontier $Q_i = f(X_i, \beta)\exp(v_i)$. Thus, $u_i = 0$ indicates any farm lying on the frontier while $u_i > 0$ for any farm lying below the frontier. Hence, expression u_i denotes the amount by which the frontier exceeds realized output. For a clear understanding of the model, we may show the different components such as deterministic component, noise component and inefficiency component: $Q_i = f(X_i,\beta) \times \exp(v_{\ i)} \times \exp(v_i)$

When a farm is technically efficient, the inefficiency component of above equation will vanish and $Q_i^* = f(X_i, \beta)\exp(v_i)$ will represent the maximum attainable output for the i^{th}farm. Now technical efficiency i^{th}farm as a ratio of observed and maximum output can be written as: $TE_i = Q_i/Q_i^* = \{f(X_i,\beta) \quad \exp(v_i - \quad u_i)\}/\{f(X_i,\beta) \exp(v_i)\} = \exp(-u_i)$

This measure of technical efficiency takes a value between zero and one. It measures the output of i^{th}farm relative to the output that could be produced by a fully efficient farm using same input vector.

The economic literature provides numerous functional forms for the specification of stochastic frontier model such as Cobb-Douglas, Trans-log, Leontief, CES, and Linear function. But, we will choose Cobb-Douglas and Trans-log (transcendental logarithm) functions for their popularity. These functions, however, place a-prior restrictions on either the substitution possibilities among the factors of production or on scale of economics. Trans-log functional form is a flexible functional form that can be used to approximate any twice-differentiable function without placing a-prior restriction on the production technology. Furthermore, the function allows testing for the restrictions imposed by the other functions. The general functional form of Trans-log can be presented as below:

$$\ln Q = \beta_0 + \sum_{j=1}^{p} \beta_j \ln X_j + \frac{1}{2}\sum_{j=1}^{p} \sum_{k=1}^{p} \beta_{jk} \ln X_j \ln X_k$$

Where**,** ln denotes the natural logarithm, Q denotes the output, X_j's are explanatory variables, p is the number of explanatory variables,β_0, βj's and β_{jk}'s are unknown parameters and$\beta_{jk} = \beta_{kj}$ for all j and k.

The Cobb-Douglas function is a special case of Trans-log function. When the effect of interaction terms including square terms are equal to zero, i.e., $\beta_{jk} = 0$, for all j,k=1,2,... p then Trans-log function becomes identical to the Cobb-Douglas function. It is possible to estimate these functions with maximum likelihood method under the assumptions made on u_i and v_i. According to Coelli et al., (2005), it is common to assume that each v_i is distributed independently of each u_i and that both errors are uncorrelated with the explanatory variables in X_i. In addition, the following assumptions are as:

$E(v_i) = 0$	(Zero mean)
$E(v_i^2) = \sigma_v^2$	(Homoscedastic)
$E(v_i v_j) = 0$ for all $i \neq j$	(Uncorrelated)
$E(u_i) = a > 0$	(Non-zero mean)
$E(u_i^2) = \sigma_u^2$	(Homoscedastic)
$E(u_i u_j) = 0$ for all $i \neq j$	(Uncorrelated)

Thus, the no is e component v_i is assumed to have properties that are identical to those of the no is component in the classical linear regression model. The inefficiency component has similar properties except it has anon-zero mean (because$u_i \geq 0$).

Under the above assumptions, Battese and Corra (1977) suggested that the maximum likelihood estimates (MLE) of the parameters of the model could be obtained in terms of parameterization.

$$\hat{\sigma}^2 = \hat{\sigma}_v^2 + \hat{\sigma}_u^2 \text{ and } \gamma = \hat{\sigma}_v^2/\hat{\sigma}^2$$

However, the estimate of farm-specific technical efficiency (TE) as presented by Battese and Coelli (1995) will be used for its optimal property in the sense that it minimizes the mean square prediction is

$$\widehat{TE}_i \equiv E\{\exp(-u_i) \mid Q_i\} = [\emptyset(\frac{u_i^*}{\sigma_*} - \sigma_*)/\emptyset(\frac{u_i^*}{\sigma_*})]\exp\{\frac{\sigma_*^2}{2} - u_i^*\}$$

Where, $u_i^* = -\{\ln Q_i - f(X,\beta)\}\sigma_u^2/\sigma^2$ and $\sigma_*^2 = \sigma_v^2 \sigma_u^2/\sigma^2$ and $\emptyset(x)$is the cumulative distribution function of the standard normal random variable evaluated at X.

When the predicted farm-specific technical efficiency values, i.e., $\widehat{TE}_i$'s are available, we can compute the industry's technical efficiency which is nothing but the arithmetic mean of the farm-specific technical efficiencies. Hence, the average technical efficiency of n sample farms can be computed by,

$$\overline{TE_i} = \left(\frac{1}{n}\right)\sum_{i=1}^{n}\widehat{TE_i}$$

One of the interests of this study is to identify the characteristics/factors, which influence the farms ability to convert the inputs into output. These are the exogenous variables that characterize the environment in which production takes place. Battese and Coelli (1995) and Kulekci (2010), considering the frontier model and proposed the following inefficiency effect model: $u_i = \delta_0 + Z_i\delta + w_i$

Where, Z_i is a vector of the farm-specific variables that are assumed to influence u_i; δ is a vector of unknown parameters except δ_0; the random variable, w_i's are defined by the truncation of the normal distribution and variance, σ_w^2, such that the point of truncation is $-Z_i\,\delta$, i.e., $wi > -Z_i\,\delta$. These assumptions are consistent with u_i being a non-negative truncation of the N ($Z_i\,\delta$, σ_u^2)-distribution.

Empirical models: Empirically, Translog stochastic production frontier model is used to estimate the level of technical efficiency of rice producing farms. For his purpose, total amount of paddy production of farmers are taken as dependent variable and inputs of rice production usedby farmers are incorporated as independent variables. Thus, following Villano and Fleming (2004),the empirical model for the present study is specified as:

i. The Trans-log stochastic production frontier model for Boro paddy, which is given by

$$\ln Q1_i = \beta_0 + \sum_{j=1}^{7}\beta_j \ln X_{ji} + \frac{1}{2}\sum_{j=1}^{7}\sum_{k=1}^{7}\beta_{jk}\ln X_{ji}\ln X_{ki} + v_i - u_i$$

Where, $\beta_{jk} = \beta_{kj}$ for all j and k;Q represents the quantity of freshly threshed Paddy (in kg); X_1 is the total area planted to rice (decimals);X_2 is the total labor input (man-days);X_3 is the amount of seed used (kg);X_4 is the total amount of fertilizer applied (kilograms); $X_5$is the manure (kg);X_6 is the irrigation cost (taka);X_7 is the land preparation cost (taka); B_0, β_j's, and β_{jk}'s are the unknown parameters to be estimated; v_i's are the symmetric error terms; and u_i's are one sided components (i.e., $u_i \geq 0$) and reflect technical inefficiencies relative to the stochastic frontier.

ii. The Trans-log stochastic production frontier model for Aman paddy, which is given by

$$\ln Q2_i = \beta_0 + \sum_{j=1}^{6}\beta_j \ln X_{ji} + \frac{1}{2}\sum_{j=1}^{6}\sum_{k=1}^{6}\beta_{jk}\ln X_{ji}\ln X_{ki} + v_i - u_i$$

Where, $\beta_{jk} = \beta_{kj}$ for all j and k;Q represents the quantity of freshly threshed Paddy (in kg); X_1 is the total area planted to paddy (decimals);X_2 is the total labor input (man-days);X_3 is the amount of seed used (kg);X_4 is the total amount of fertilizer applied (kilograms); X_5 is the manure (kg);X_6 is the land preparation cost (taka); B_0, β_j's, and β_{jk}'s are the unknown parameters to be estimated; v_i's are the symmetric error terms; and u_i's are one sided components (i.e., $u_i \geq 0$) and reflect technical inefficiencies relative to the stochastic frontier.

Inefficiency effect model

It is assumed that the technical inefficiency effects are linearly related to the farmers' characteristics as follows:

$u_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + w_i$

Where, Z_1 = Age (in years); Z_2 = Education (years of schooling); Z_3 = Experience on farming (in years); Z_4 = Farm size (in decimal); Z_5 = Dummy variable for extension service received (1 = yes and 0 = otherwise); Z_6 = Dummy variable for training on farming participated by the paddy growing famer (1 = yes and 0 = otherwise); Z_7 = Dummy variable for micro finance taken from any source (1 = yes and 0 = otherwise); Z_8 = Dummy variable for watching and/or listening agriculture related programs on TV and/or radio (1 = yes and 0 = otherwise); δ_0, ….., δ_8 are unknown parameters to be estimated; and w_i's are random error.

3. Results and discussion

Profitability of Aman and Boro paddy cultivation:

Profitability of paddy cultivation was estimated and showed in Table 1. In the study area, gross margin of Boro and Aman production were estimated at Tk. 37,184 and Tk. 34,961 per hectare, respectively. BCR (undiscounted) of Boro and Aman farmers were 1.07 and 1.05, respectively which indicated that production of Boro and Aman paddy were profitable from the viewpoints of individual farmer's investment. The result showed that Boro paddy production was more profitable than Aman paddy production. But per hectare input cost of Boro was higher than Aman cultivation because of irrigation cost does not require in Aman season.

Estimates of stochastic production frontier function:

The maximum likelihood estimates of the parameters of the Trans-logs to stochastic production frontier for Aman and Boro paddy were presented in Table 2.The estimated value of Gama (γ)for Boro rice production was found as 0.97, which means that 97% of the total variation in Boro rice output is due to technical inefficiency.

Table 1. Profitability of Aman and Boro paddy production

Items	Boro growers	Aman growers
Gross returns (Tk./ha)	94,305.00	80,010.00
Variable costs (Tk./ha)	57,121.00	45,049.00
Gross margin (A-B) (Tk./ha)	37,184.00	34,961.00
Fixed costs (Tk./ha)	31,138.00	30,828.00
Total costs (B+D) (Tk./ha)	88,259.00	75,877.00
Net returns (A-E) (Tk./ha)	6,046.00	4,133.00
BCR (Undiscounted)	1.07	1.05

Source: Field survey (2017).

Table 2. Maximum likelihood estimates of Boro and Aman paddy farmers

Variables	Parameters	Coefficients		Standard Error	
		Boro	Aman	Boro	Aman
Intercept	β_0	13.61*	12.75*	0.90	0.96
Area	β_1	1.11**	0.49	0.48	0.31
Human labor	β_2	-0.86	1.57***	0.97	0.81
Seed	β_3	0.60	1.01	0.75	0.81
Fertilizer	β_4	1.27	1.13**	0.87	0.51
Manure	β_5	2.35**	0.05***	0.96	0.03
Irrigation cost	β_6	1.77*	-	0.66	-
Land preparation cost	β_7	-3.48*	-0.11***	0.87	0.06
$(\text{Area})^2$	$\beta 8$	-4.24*	-1.70**	0.83	0.83
$(\text{Human labor})^2$	$\beta 9$	0.13	0.77	0.77	0.72
$(\text{Seed})^2$	β_{10}	-1.09	0.12	0.86	0.12
$(\text{Fertilizer})^2$	β_{11}	0.03	-1.40*	0.81	0.23
$(\text{Manure})^2$	β_{12}	-1.06	0.17	0.58	0.18
$(\text{Irrigation})^2$	β_{13}	-0.16	-	0.67	-
$(\text{Land preparation cost})^2$	β_{14}	-4.52*	0.15	0.64	0.52
Area * Human labor	β_{15}	1.88**	-0.58	0.90	0.85
Area * Seed	β_{16}	3.46*	-0.93*	0.92	0.11
Area * Fertilizer	β_{17}	-1.15	1.21	0.91	0.94
Area * Manure	β_{18}	-3.14*	1.15	0.81	0.66
Area *Irrigation	β_{19}	0.58	-	0.87	-
Area * Land preparation cost	β_{20}	1.55	0.65*	0.86	0.11
Human labor * Seed	β_{21}	-1.35	1.27	0.90	0.82
Human labor * Fertilizer	β_{22}	0.04	0.54	0.90	0.73
Human labor * Manure	β_{23}	0.68	-0.01	0.78	0.58
Human labor * Irrigation	β_{24}	-0.57	-	0.79	-
Human labor * Land preparation cost	β_{25}	1.47	-1.91**	0.83	0.82
Seed *Fertilizer	β_{26}	-0.10	-1.38*	0.92	0.40
Seed * Manure	β_{27}	2.22*	0.54	0.83	0.44
Seed * Irrigation	β_{28}	-1.00	-	0.85	-
Seed * Land preparation cost	β_{29}	-2.40*	0.50	0.86	0.57
Fertilizer * Manure	β_{30}	1.02	0.45	0.86	0.26
Fertilizer * Irrigation	β_{31}	-1.63	-	0.86	-
Fertilizer * Land preparation cost	β_{32}	1.33	-0.60	0.87	0.90
Manure * Irrigation	β_{33}	0.07	-	0.85	-
Manure * Land preparation cost	β_{34}	1.44	-1.38*	0.85	0.43
Irrigation * Land preparation cost	β_{35}	2.72*	-	0.86	-
Sigma-squared	σ^2	0.02*	0.02**	0.03	0.01
Gama	γ	0.97*	0.75*	0.11	0.25
Log-likelihood value	-	58.61	70.63	-	-

*, ** and *** indicate significance at 1%, 5% and 10% respectively. Source: Field survey (2017).

It also indicates that about 97% of the discrepancies between observed output and the frontier output are due to technical inefficiency. In Boro production the estimated coefficients of area, manure, and irrigation were statistically significant at 5% and 10% level, which specifies that these factors of production are the key elements that affect production in the study areas. Coefficient of area, irrigation and manure used are found 1.11, 1.77 and 2.35, respectively indicating that 1% increase in area, manure used and irrigation cost may increase output by 1.11, 1.77 and 2.35 percent, respectively. Coefficient of land preparation cost (3.48) was negatively significant at 10%, meaning that a 1% increase in land preparation cost may decrease output by 3.48%.

This indicated that the amount of land preparation cost should be dwindled in order to enhance the production of rice farming. However, the coefficients of human labor, seed and fertilizer cost found statistically insignificant. Among seven square parameters only the coefficient of area and land preparation cost square was statistically significant but negative sign. It means that an increase in area and land preparation cost will decrease Boro rice production at a decreasing rate.

From Table 2 it is also found that, among the interactive variables 'area*human labor' was significant at 5% level and also have positive sign. Besides, 'area*seed', 'area*manure', 'seed*manure', 'seed*land preparation cost' and 'irrigation*land preparation cost' were significant at 10% significance level with negative and positive sign. Moreover, coefficients of other interactive variables are statistically insignificant indicating no significant meaning in explaining Boro rice production.

For Aman paddy production, coefficients of human labor (1.57), manure (0.05) and fertilizer (1.13) use were positively significant at 1% and 5% level, respectively. These empirical results appeared that a 1% increase in human labor, manure and fertilizer used may increase output by 1.57, 0.05 and 1.13 percent, respectively. On the other hand, land preparation showed negatively significant at 1% level indicating there is no opportunity of increasing the production of Aman paddy by increasing land preparation cost. Area and fertilizer square were statistically significant with negative sign while other square parameters were statistically insignificant. Among the interactive variables 'area*seed', 'seed*fertilizer' 'manure*land preparation cost' were significant at 10% significance level and have negative sign. But 'area*land preparation cost' was positively significant at 10% level where 'human labor*land preparation cost' negatively significant at 10% level.

In Table 3 the farm-specific technical efficiency of the individual Boro and Aman paddy-growing farmers has also been estimated and presented. The result of Boro paddy revealed a wide variation in the levels of technical efficiencies across the sample farms, ranging from 67.5 to 96.45 percent. The mean technical efficiency for Boro paddy is 83.25%, which means that famers in this region produce rice 83.25% efficiently with best practices at the current level of production inputs and technology. This also suggests that, Boro rice output has the potential of being increased by a further 16.75% at the same level of inputs if farmers had been technically efficient. For Aman production the results also showed, a variation in the levels of technical efficiencies, ranging from 69.6% to 98.55%.The present study found that, the average level of technical efficiency of Aman rice farms was85.15 %. This result means that, the Aman rice farms in the study area have been operating below the maximum level of production frontier. Given the available technology, farmers can increases their production by 14.85%.However,the technical efficiency for Boro season of individual farmers was less than Aman season (83<85) but there is a chance to increase technical efficiency in both seasons.

Table 4 represents the parameters of the rice production's technical inefficiency effect model. In the Boro model specification, it is obvious that education, experience and training had negative coefficient signs at5% level of significance, while microfinance also had negative coefficient sign but was significant at 10%, indicating positive relationships of these four factors to TE of Boro rice production. These results revealed that development of higher years of farmers schooling and more farming experience, received rice production training and well access to agricultural microfinance are the core factors to cause to increase technical efficiency of Boro rice production.

Besides extension contact was significant at 10% with positive sign. That means the farmers who have access to extension services perform significantly better in terms of earning actual profit, incurring less loss and operating at higher level of technical efficiency and also move the inefficient farmers to closer to the frontier.

For Aman production coefficients of education and microfinance had negative sign but were significant at 10%. It implies that these factors have an effect on inefficiency of the farmers' field. The coefficient of education indicates that with more years of schooling farmers become more efficient. Similarly farmers who have more excess of agricultural micro-finance will also lead to less inefficiency in growing Aman paddy.

Table 3. Farm-specific technical efficiencies of Boro and Aman farmers

Technical efficiency (percent)	Boro		Aman	
	No. of farms	Percentage	No. of farms	Percentage
60-70	1	1.25	2	2.5
70-80	18	22.5	15	18.75
80-90	29	36.25	27	33.75
90-100	32	40.00	36	45.00
Total	80	100.00	80	100.00
Mean	83.25		85.15	
Maximum	96		99	
Minimum	68		70	

Source: Field survey (2016-17).

Table 4. Estimates of the technical inefficiency of Boro and Aman paddy growers

Variables	Parameters	Boro		Aman	
		Coefficients	Standard Error	Coefficients	Standard Error
Intercept	δ_0	0.25	0.99	0.11	0.13
Age (years)	δ_1	0.004	0.004	0.001	0.05
Education (years of schooling)	δ_2	-0.34**	0.16	-0.03*	0.009
Experience (years)	δ_3	-0.04**	0.02	0.04	0.03
Farm size (decimal)	δ_4	0.22	0.94	-0.002	0.002
Extension contact (yes = 1; no = 0)	δ_5	0.42*	0.09	-0.04**	0.01
Training (yes = 1; no = 0)	δ_6	-0.50**	0.21	0.04	0.07
Micro finance (yes = 1; no = 0)	δ_7	-0.88*	0.30	-0.02*	0.006
Watching/listening agricultural program on TV and/or Radio (yes = 1; no = 0)	δ_8	-0.13	0.14	0.03	0.05

*, ** and *** indicate significance at 1%, 5% and 10% respectively.Source: Field survey (2016-17).

Extension contact was significant at 5%with negative sign meaning land security reduce technical inefficiency of Aman farmers in the Dinajpur district.

The coefficient, of age, farm size and watching/listening agricultural program on TV and/or Radio in both inefficiency model were estimated to be statistically insignificant with positive sign indicating have no remarkable impact on enhancing technical efficiency of Boro and Aman rice farmers in Dinajpur district.

4. Conclusion and recommendations

Estimation of technical efficiency is very important to increase the rice productivity of agriculture sector. The studies aimed at finding out the technical efficiency levels of Boro and Aman rice farmers and determine its main influencing factors by using the stochastic production frontier. The results indicated that both paddy productions are profitable. But Boro paddy yielded more and achieved higher net returns than Aman crops. Thus there is an ample scope to increase Aman paddy production in the area by introducing some new modern varieties and increasing technical efficiency. The present study found that, mean technical efficiency for Boro and Aman paddy were 83.25 and 85.15 percent, respectively indicating rice farmers in the study areas have been operating below the maximum level of production frontier. Yield can significantly be increased without increasing the level of inputs. At full technical efficiency, on an average, the farmers could reduce their inputs in Boro and Aman by around 20% ([(100 – 83.25)/ 83.25] × 100) and 18%([(100 – 85.15)/ 85.15] × 100), respectively without reducing paddy production, simply by improving technical efficiency. The estimated results of Translog production function shows that the main factors affecting the output level of Boro rice production appear to be area cultivated, manure applied and irrigation management. On the other hands employed human labor, fertilizer and manure applications main factors affecting TE of Aman rice production in the study areas. For both season lands preparation cost is appear as negative contributor to the level of production efficiency. This result might indicate that, the farmers in the study areas invest extra amount on land preparation cost and therefore, they should spent appropriately to enhance the technical efficiency. Inefficiency in farming can be reduced significantly by providing education and training facility, increasing access to microfinance, strengthening extension services and improve irrigation facilitates. The sustainability of the high efficiency will be dependent on the continuous support of input supply to the farmers receive in the areas. In conclusion, it can be suggested that the organizations operating in the study areas should promote about proper use of inputs forBoro and Aman rice cultivation to increase the level of technical efficiency.

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