ISSN 0258-7122
Bangladesh J. Agril. Res. 35(1) : 101-112, March 2010

TECHNICAL INEFFICIENCY OF WHEAT PRODUCTION IN SOME SELECTED AREAS OF BANGLADESH

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Abstract

The main objective of the study was to identify and analyze the inefficiency and yield gaps of wheat production in Bangladesh. The study employed farm level cross sectional data from three major wheat growing areas of Bangladesh. Yield of wheat was found to vary across locations and farm categories. The average technical inefficiency of wheat production in Bangladesh is 16. This indicates a good potential for increasing wheat output by 16 percent with the existing technology and levels of inputs. Education and training on wheat of the farm operators was found to have significant effect on yield and technical efficiency of wheat production.

Keywords : Technical inefficiency, wheat production, yield gaps.

Introduction

Wheat is one of the main cereal crops in Bangladesh. Starting with an area of 0.126 million hectares, and production of 0.103 million metric tons in 1971, the area and production increased to 0.83 million hectares and 1.84 million metric tons, respectively, in 2000 (Hasan, 2006). The yield also increased from 0.86 t/ha to 2.21 t/ha during the period. This increased area, production, and yield of wheat spurred mainly because of the introduction of modern seed-water-fertilizer technologies. After reaching its highest area (0.88 million hectares) and production (1.91 million tons) in 1999; the area and production was found to be decreasing during next seven years. In 2006, the area decreased to 0.48 million hectares and production to 0.74 million metric tons. The yield was also reduced to 1.6 t/ha (BBS, 2007). On the contrary, farm level expected yield of high yielding wheat varieties was found to be 3.5-5.1 t/ha (Hasan, 2006). Performances of varieties vary significantly from research station to farmers' field, even wide variation in yields is observed among the farmers. Variation in different factors of production package is mainly responsible for such kind of yield gap. Amount and quality of different inputs used and other management vary from one farmer to another. Thus the potential yield level at farmers' field is not achieved in many cases. Farmers cultivating HYVs of different crops also do not follow the recommended packages. As a result, the differences between potential yield and yield under farmers' practice are widened. The management

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practices and input use are likely to be influenced by various socio-agro-economic factors, such as farmers' age, education, occupation, experience in farming, resource base, family size, access to information, physical infrastructure, demand of the family, market, etc. These factors influence farmers to adopt any technology fully or partially. It is possible to attain a higher yield of different crops by adopting modern practices and thus the yield gaps can be minimized in this way.

The socioeconomic constraints to higher production of wheat are of vital importance. The socioeconomic constraints may explain why farmers are not utilizing the practices and inputs identified as capable of raising yields. Therefore, planners and policy makers need information on the relative importance of various yield constraints so that they can allocate and redistribute the available resources for various researchable issues in order to augment productivity. There is a scope to increase the yield level by minimizing the yield gap. The technology that gives high yields on experiment stations may not give high yield in the less favourable environment that exists in a large part of the crop growing areas. There may also be components of experiment station technology that are not transferable to a farmer's field, named yield gap-I by Dc Datta *et al.*(1978). Yield gap-2 is the difference between the potential and actual yields in farmer's environments. By definition, this gap exists because farmers use inputs or practices that result in lower yields than those possible on their farms. The study will focus on the yield gap-2 of wheat production in the selected areas.

The study was, therefore, designed to identify and analyze the possibilities for improving productivity of wheat by increasing the productive efficiency of wheat farmers of Bangladesh. However, the specific objective of the study was to identify and measure various factors associated with yield gaps and technical inefficiency of wheat farmers.

Materials and Method

Source of data

A multistage sampling procedure was followed to select wheat growing areas. In the first stage, three wheat growing districts i.e., Dinajpur, Rajshahi, and Jamalpur were chosen purposively considering the intensity of wheat area coverage among different regions. In the second stage, one upazila from each district and one union from each upazila were selected randomly. Finally, three mouzas (one from each union), namely Char Palisha Madhyapara from Char Banipakuri union of Melandah Upazila under Jamalpur district, Bhatgaon from Sundarpur union of Kaharol Upazila under Dinajpur district and Bhograil under Noahata union of Paba Upazila under Rajshahi district were selected randomly for this study.

To collect primary data, a sampling frame of wheat growing holdings in the selected mouzas were constructed with the help of village leaders and record book of union council. These farm holdings were stratified into small (0.2 ha to < 1.0 ha), medium (1.0 ha to <2.0 ha), and large (2.0 ha and above) as per classification of farm category followed in different studies (Karim, 1996; Hasan *et al.*, 2002). For determining the sample size Fisher's measure of skewness formula (Fisher, 1958) was applied and an optimum number (Cochran, 1999) of 293 samples (Dinajpur-10l, Jamalpur-89, and Rajshahi-103) were chosen. A pre-designed and pre-tested schedule was applied to collect data during November 2003 to June 2004.

Analytical techniques

Technical inefficiency effect model

The empirical Cobb-Douglas frontier production function for technical inefficiency effect can be expressed as follows:

$$u_i = \delta_0 + \delta_1 z_{1i} + \delta_2 z_{2i} + \delta_3 z_{3i} + \delta_4 z_{4i} + \delta_5 z_{5i} + \delta_6 z_{6i} + \delta_7 z_{7i} + W_i \qquad (1)$$

where,

The u_i's are non-negative random variables, assumed to be independently distributed such that the technical inefficiency effect for the i[th] farmer, u_i, were obtained by truncation of normal distribution with mean zero and variance, σ_u^2, such that

z_{1i} = Ln operated land of the i-th farm operator (ha)

z_{2i} Age of the i-th farm operator (years)

z_{3i} = Education level of the i-th farm operator (year of schooling)

z_{4i} = Experience in wheat farming of the i-th farm operator (years)

z_{5i} = Household size of the i-th farm operator (persons/household)

z_{6i} = Dummy for extension linkage of the i-th farm operator (1= yes, 0 = otherwise)

z_{7i} = Dummy for wheat training of the i-th farm operator (1 yes, 0 = otherwise)

δ's are unknown parameters to be estimated

W_1s were unobservable random variables or classical disturbance term, which are assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance, σ^2, such that u_i is non-negative.

The β, η and δ coefficients are unknown parameters to be estimated, together with the variance parameters which are expressed in terms of

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \qquad (2)$$

and $\gamma = \sigma_u^2 / \sigma^2$ (3)

γ is the ratio of variance of farm specific technical efficiency to the total variance of output and has a value between zero and one.

The estimates for all parameters of the inefficiency model (1) were estimated by using the Maximum Likelihood (ML) method. The econometric computer software package FRONTIER 4.1 (Coelli, 1996) was applied to estimate the parameters of stochastic frontier models using the ML method.

Estimation of yield gap

Yield gap may be defined as the difference between technically full efficient yield and observed yield. Therefore, yield gap was estimated by deducting observed yield from technically full efficient yield. In other words, yield gap is the amount which represents less yield due to technical inefficiency [(for detail see Hasan (2006)1.

Results and Discussion

Yield gap due to technical inefficiency

The yield gap that occurred due to technical inefficiency is presented in Table 1. It was observed that mean technical inefficiency was 16 percent which caused 454 kg/ha yield gap of wheat. The highest yield gap of wheat due to technical inefficiency was recorded with the farmers at Dinajpur (497 kg/ha) followed by that at Rajshahi (493 kg/ha) and Jamalpur (361 kg/ha) implying that Dinajpur farmers had more potential to increase yield than Jamalpur farmers with existing technology. According to farm categories, large and medium farmers had more potential to increase yield than small farmers with the existing technology.

Table 1. Yield gap of wheat due to technical inefficiency.

Location/Farm category	Mean technical inefficiency (%)	Observed yield (kg/ha)	Yield gap (kg/ha)
Locations:			
Dinajpur	0.17	2493	497
Jamalpur	0.16	2189	361
Rajshahi	0.17	2477	493
Farm categories:			
Large	0.15	2532	463
Medium	0.16	2381	463
Small	0.16	2347	446
All farms	**0.16**	**2395**	**454**

Source: Hasan (2006, p. 201)

To test whether there were significant differences in yield gaps among the locations and farm categories, an analysis of variance was carried out. Table 2 shows that there were significant differences in the yield gaps of the farmers between the locations, but within each location there was no significant difference in yield gaps between the farm categories.

Table 2. Analysis of variance of yield gap due to technical inefficiency among different locations and farm categories in wheat cultivation.

Source of variation	Sum of Squares	Degrees of freedom	Mean Square	F	Significance
Between locations	658445.363	2	329222.682	20.039	.000
Within locations	4764508.909	290	16429.34 1		
Total	5422954.272	292			
Between farm categories	17425.243	2	8712.621	0.467	.627
Within farm categories	5405 529.029	290	18639.755		
Total	5422954.272	292			

Factors affecting farm-specific technical inefficiency

The ML estimates of technical inefficiency effect models which show the best practice performance are presented in Table 3-5. The estimates of farm specific variables in those models which were responsible for technical inefficiency are discussed below:

Operated land: The coefficient of operated land is positive but not significant in the technical inefficiency model for wheat production (Table 3) which implied that technical inefficiency increases with the increase in operated land. That is, farmers with smaller farms are technically more efficient than farmers with larger operations. This corresponds to the argument which is made frequently for smaller farmers who tend to be more efficient in production than larger farmers in developing country. The coefficient of operated land is significantly negative for Dinajpur, insignificantly positive for Jamalpur and Rajshahi in the location-specific technical inefficiency model (Table 4) which indicated that technical inefficiency decreases with the increase in operated land at Dinajpur. This may be due to the advantage of applying mechanical devices for land preparation in the larger wheat plots at Dinajpur. On the other hand, the coefficient of operated land for large farms were negative and that for medium and small farms were positive in the farm size-specific technical inefficiency model for wheat production (Table 5) but all were insignificant.

Technical efficiency of farmers with respect to farm size was observed in many studies with various kinds of findings. It was observed from a number of studies (Rahman *et al.,* 1999; Ajibefun *et al.,* 2002) that there was a significant negative correlation with farm size and efficiency, others (Sharma *et al.,* 1999; Rahman *et al.,* 2000) observed significant positive correlation between farm size and efficiency. This difference of findings in different studies may be the outcome of farm sizes. Farm size itself was different for various studies.

Table 3. Maximum likelihood estimates of the technical inefficiency model for wheat.

Independent variables	Para-meters	Co-efficient	Standard error	t-ratio
Constant	δ_0	0.173	0.068	2.56
Ln Operated land	δ_1	0.0002	0.0 12	0.22
Farmer's age (years)	δ_2	-0.0005	0.0006	-1.18
Farmer's education (year of schooling)	δ_3	-0.005'	0.002	-2.81
Wheat farming experience (years)	δ_4	-0.002"	0.001	-1.98
Household size (person/hh)	δ_5	-0.003	0.004	-1.50
Dummy for Extension linkage (1=Yes, 0 = otherwise)	δ_6	0.007	0.008	1.04
Dummy for wheat training (1=Yes, 0=otherwise)	δ_7	-0.006	0.026	-0.45
Variance parameters				
Sigma-squared	σ^2	0.005**	0.001	8.746
Gamma	γ	1.000**	0.006	175.03
Log likelihood function			371.148	

** and * indicate significant at 1% and 5% level of probability, respectively.

Farmers' age: The coefficient of farmers' age was negative but not significant in the technical inefficiency model for wheat production (Table 3) which implied that technical inefficiency effect decreases with the increase in age of farmers. The coefficients of farmers' age was positive for Dinajpur and negative for Jamalpur and Rajshahi in the location-specific technical inefficiency model for wheat production (Table 4), but all were insignificant. On the other hand, the coefficients of farmers' age were positive for large and negative for medium and small farm categories in the farm size-specific technical inefficiency model for wheat production (Table 5) but also all were insignificant.

Farmers with older age were technically more efficient was reported by Coelli and Battese (1996) and Rahman (2002). Llewelyn and Williams (1996) observed that technical efficiency increases upto a certain age level and then eventually declines. Ajibefun *et al*. (2002) and Miah (2001) observed a negative association with age of farmers and technical efficiency of rice farmers in Dominican Republic and Bangladesh, respectively. This indicates that age has mixed impact on efficiency and may be depending on crop and study area.

Table 4. Maximum likelihood estimates for parameters of location-specific technical inefficiency model for wheat.

Independent variables	Parameters	Location		
		Dinajpur	Jamalpur	Rajshahi
Constant	δ_0	0.134**(0.046)	0.262* (0.125)	0.214* (0.110)
Ln Operated land	δ_1	-0.013* (0.007)	0.006 (0.115)	0.010 (0.012)
Farmers age (years)	δ_2	0.0004 (0.0007)	-0.0003 (0.002)	-0.00 1 (0.00 1)
Farmers education (year of schooling)	δ_3	0.004** (0.0014)	-0.004* (0.002)	0.007** (0.002)
Wheat farming experience (years)	δ_4	-0.0008 (0.0013)	0.002* (0.001)	-0.002 (0.002)
Household size (person/hh)	δ_5	-0.002 (0.003)	-0.003 (0.043)	-0.004 (0.004)
Dummy for Extension linkage (1=Yes, 0=otherwise)	δ_6	0.0 13 (0.009)	0.0 19 (0.049)	-0.012 (0.022)
Dummy for wheat training (1=Yes, Ootherwise)	δ_7	-0.001 (0.016)	-0.223 (0.143)	0.030* (0.012)
Variance parameters				
Sigma-squared	σ^2	0001**(0.0004)	0.005**(0.002)	0.004**(0.001)
Gamma	γ	1.000**(0.0378)	0.996**(0.085)	1.000*(0.455)
Log likelihood function		192.646	137.667	146.161

** and * indicate significant at 1% and 5% level of probability, respectively. Figures in the parenthesis indicate standard error.

Farmers' education: The coefficient of farmers' education was negative and significant in the technical inefficiency model for wheat production (Table 3) which implied that technical inefficiency decreases with the increase in farmers' education. It may also be concluded that farmers with higher education tend to have lower inefficiency effects than farmers with lower education. That is, farmers with higher education were technically more efficient than farmers with lower education. It may be mentioned here that the average year of schooling of the sampled farmers was only 4.9 years.

The coefficient of farmers' education was negative and significant for all the three locations in the location-specific technical inefficiency model for wheat production (Table 4) which implied that technical inefficiency decreases with the increase in farmers' education in all the three locations. The coefficient of farmers' education was negative and significant for all the three farm categories in the farm size-specific technical inefficiency model for wheat production (Table 5), which also implied that technical inefficiency decreases with the increase in farmers' education for the large, medium, and small farms.

The results of some other studies revealed that the association between farmers' education and individual farm technical efficiency was quite mixed. Islam (2002) found significant positive relationship of farmers' education and technical efficiency for aromatic and fine rice growers in Bangladesh, but for coarse rice, he observed negative but non-significant relationship. Ajibefun ***et al.*** (2002) and Khan and Alam (2003) observed significant positive correlation with education and efficiency. On the contrary, Miah (2001) and Rahman (2002) found significant negative relationship with education and efficiency.

Wheat farming experience: The coefficient of wheat farming experience was negative and significant at 5% level in the technical inefficiency model for wheat production (Table 3) which implied that technical inefficiency decreases with the increase in wheat farming experience. It may also be concluded that farmers with higher wheat farming experience tend to have lower inefficiency effects than farmers with lower wheat farming experience. This implied that performance of farmers with higher experience in wheat farming in adopting new technology was far better than less experienced farmers. The coefficient of wheat farming experience was negative for all the three locations but was found significant for only Jamalpur in the location-specific technical inefficiency model for wheat production (Table 4) which implied that technical inefficiency decreases with the increase in wheat farming experience. This may be due to the less wheat farming experience of the farmers in Jamalpur district compared to Dinajpur and Rajshahi. The coefficient of wheat farming experience was negative for all the three farm categories but was found significant for medium and small farms in the farm size-specific technical inefficiency model for wheat production (Table 5). This implied that technical inefficiency decreases with the increase in wheat farming experience for the medium and small farms significantly.

Table 5. Maximum likelihood estimates for parameters of farm size-specific technical inefficiency model for wheat.

Independent variables	Parameters	Farm category		
		Large	Medium	Small
Constant	δ_0	0.220 (1.026)	-0.259 (0.602)	0.0001 (0.092)
Ln Operated land	δ_1	-0.041 (0.156)	0.072 (0.103)	0.007 (0.032)
Farmers age (years)	δ_2	0.0001 (0.002)	-0.0003 (0.00!)	-0.0002 (0.001)
Farmers education (year of schooling)	δ_3	-0.003* (0.002)	0.002* (0.001)	-0.0l2** (0.004)
Wheat farming exp. (years)	δ_4	-0.002 (0.008)	-0.001 * 0.0005)	-0.007* (0.004)
Household size (person/hh)	δ_5	0.018 (0.012)	-0.0 19 (0.010)	-0.004 (0.012)
Dummy for Extension linkage (l=Yes, 0=otherwise)	δ_6	0.042 (0.092)	0.034 (0.034)	0.013 (0.031)
Dummy for wheat training (l=Yes, 0=otherwise)	δ_7	-0.025* (0.012)	-0.006 (0.044)	-0.015(0.055)
Variance parameters:				
Sigma-squared	σ^2	0.007** (0.001)	0.008** (0.001)	0.008** (0.001)
Gamma	γ	1.000 (0.004)	1.000** (0.001)	0.985** (0.060)
Log likelihood function		101.549	123.427	199.425

** and * indicate significant at 1% and 5% level of probability, respectively. Figures in the parenthesis indicate standard error

This negative coefficient of wheat farming experience also corresponds with the negative coefficient of farmers' age in the technical inefficiency model i.e., technical inefficiency tends to decline with years of experience. This finding was in conformity with the findings of Islam (2003) and Khan and Alam (2003). Wilson *et al.* (1998) found producers with fewer years of experience to have achieved higher levels of technical efficiency.

Household size: The coefficient of household size was negative but not significant in the technical inefficiency model for wheat production (Table 3) which implied that technical inefficiency decreases with the increase in household size. That is, farmers with smaller family size were technically less efficient than farmers with larger family size. The coefficients of household size were positive for large farms and negative for medium and small farms, but all were insignificant in the farm size-specific technical inefficiency model for wheat production (Table 5) which implied that technical inefficiency increases with the increase in household size for the large farms, but technical inefficiency decreases with increase of household size for medium and small farms. Parikh and Shah (1994) observed that greater family size increased technical efficiency.

Extension linkage: The coefficient of dummy for extension linkage was positive but not significant in the technical inefficiency model for wheat production (Table 3). This implied that technical inefficiency was higher with the farmers who had link with extension agents than that of the farmers without extension linkage.

Though it is assumed that extension linkage should have a positive effect on technical efficiency by providing up-to-date information regarding modern technology than that of non- linkage farmers, in this particular case, no significant role was found due to very poor extension linkage with the farmers in the study areas. It was observed that 49.1 percent of the farmers had no linkage or contact with the extension agents, while only 21.2 percent had weekly contact with the extension agents. Regarding sources of agricultural information, most of the farmers depended on neighbours and relatives (79.9%), while 45.1 percent on electronic media like radio and television and only 44 percent on extension agents like BS and others which also indicated the poor influence of government extension service.

Islam (2003) found that the visits of agricultural extension agents on the farm or farmers' visits to extension office played positive and statistically significant role in achieving frontier output.

Training on wheat: Training of farmers on any particular crop is important because it can improve farmers' skill regarding production practices and related aspects. A number of farmers in the study areas received training on wheat for I to 2 days mainly on production practices and seed storage in the household level. The coefficient of wheat training dummy was negative and significant in the technical inefficiency model for wheat production (Table 3) which implied that technical inefficiency effect decreases with farmers having training on wheat. It may also be concluded that farmers with training on wheat tended to have lower inefficiency effects than farmers without training. That is, farmers with training were technically more efficient than farmers without training.

The coefficients of wheat training dummy were negative for all the three locations but was found significant for Rajshahi in the location-specific technical inefficiency model for wheat production (Table 4) which implied that technical inefficiency effect decreases with the farmers who had training on wheat than the farmers without training at Rajshahi. The coefficient of wheat training dummy were negative for all the three farm categories but was found significant for only large farms in the farm-size specific technical inefficiency model for wheat production (Table *5)* which implied that technical inefficiency decreases with the training on wheat for the large farms.

The finding of this study is in conformity with the findings of Rajasekharan and Krishnamoorthy (1999) who found significant positive role of training on the technical efficiency for rubber farming.

Conclusions

The findings of the study indicated that the yield gap of wheat between best practice and average farmers can be reduced and efficiency of wheat production can be increased significantly by adopting a number of measures:

Average yield gap in wheat production is 454 kg/ha which is derived from technical inefficiency. This amount of less yield can be recovered with existing technology and yield gap can be minimized by giving attention to the formal education, training on wheat technologies and wheat farming experience of the growers. The average technical inefficiency of wheat production in Bangladesh is 16 percent. This indicates a good potential for increasing wheat output by 16 percent with the existing technology and levels of inputs. Education and training on wheat of the farm operators was found to have significant effect on yield and technical efficiency of wheat production in the farm specific, location specific and farm size specific stochastic frontier production function models. Technical inefficiency decreases (i.e., efficiency increases) with the increase in education and training on wheat of farm operators. Thus, it is a priority issue to invest in public education to explore and develop human resources of farms. Formal training on wheat technology will also be an effective technique to improve farmers' efficiency.

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