Comparative Analysis of Production Efficiency of Hybrid Rice and Inbred Varieties in Bangladesh: A Case Study of Joypurhat District

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A B S T R A C T

This study discusses the pattern and sources of technical efficiency (TE) of rice farm in Bangladesh of Joypurhat district. For the measurement of technical efficiency, we have used Cobb-Douglas stochastic frontier model and estimated technical efficiency by specifying a Cobb-Douglas stochastic frontier production function. We have also tried to explain Maximum Likelihood Estimates (MLE) for some specific input variables for various rice productions ((Hybrid (HB), High Yielding Variety (HYV), and Aman)). We have obtained technical efficiency scores as of all 240 rice farms. The stochastic frontier presents that signs of the βi parameters of the Cobb-Douglas stochastic frontier are all positive, as expected. The estimated coefficients of land, labor, fertilizer, irrigation and pesticides on the production of HB, HYV and Aman are positive and significant. The value R^2, $\bar{R}$ and F for all rice variety indicates the well fitted for the model. The technical efficiency of

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hybrid rice, high yielding variety and Aman are estimated for four unions in Joypurhat district in Bangladesh and technical inefficiency models are also presented as a function various form specific socio-economic variables. We have identified how these factors affect the efficiency performance. The maximum likelihood estimates the parameters of the Cobb-Douglas frontier production model for hybrid rice, high yielding variety and Aman which are described.

INTRODUCTION

There are several approaches to estimate farmers' technical efficiency and among them, stochastic frontier approach is the most widely used method. Stochastic frontier approach was preferred by Fare et al. (1985), Kirkley et al (1995), and Coelli et al (1998) for assessing efficiency in agriculture because of its inherent stochastic in involvement. Ali et al .(1991) Bravo et al.(1993) and Coelli (1995) have applied the stochastic frontier approach in agriculture .Very recently, Dey et al (2000) used the stochastic frontier approach in estimating the efficiency of fish production in the Philippines**.**
The stochastic frontier estimation was done to determine technical efficiency both hybrid rice and inbred rice (HYV and Aman) production. Stochastic frontier approach, including ordinary least squares and maximum likelihood function were used for data analysis. We estimated the yield response function for hybrid rice, high yielding variety, and Aman production using the standard Cobb-Douglas production function in our study; because the Cobb-Douglas functional form is usually preferred on account of its well-known advantages and this model suggests that variables land, labor, fertilizer, irrigation and pesticides are positive and significant for HB, HYV and Aman . For Maximum Likelihood (ML) estimation, the input variables are same as Cobb-Douglas functional form but here we have also tried to analyze inefficiency variables. The estimated ML coefficient of HB, HYV and Aman production for land, labor, fertilizer, irrigation and pesticides are positive values and statistically significant for the production. In spite of these, we consider some explanatory variables such as age, education, occupation, training, Integrated Pest Management (IPM), use of electronic tools, lack of seeds, ,increasing input price, and source of information in the model for all rice varieties production for worthy of deeper analysis. For measuring the

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farmers' technical efficiency, well-organized data sets were used .Thedata was collected from the participatory farmers involved in the rice cultivation in JaypurhatSadar and Panchbibiupazilla in Bangladesh. The data included information of rice production as well as socio-economic variables.

LITERATURE REVIEW

A study (Janaiah and Hossain, 2000) indicated that although farmers got about 16% yield advantage in the cultivation of hybrids compared to the popularly grown inbred varieties. Husain et al (2001), considered six agro-ecological regions of hybrid rice for household survey in 1998-99 Boro season. Total sample number was 173 and of 108 produced Alok-6201 and of 65 Sonar Bangla hybrid variety. All of 173 sample farmers produced hybrid rice along with inbred rice variety. The survey traced study farmers who cultivated both of hybrid (ALOK-6201 and Sonar Bangla) and HYV the average yield gain of Alok-6201 over HYV was only 5% while for farmers who grew both Sonar Bangla and HYV the average yield gain of Sonar Bangla over HYV was as high as 29%.Accumulated two hybrids, the yield gain of hybrid over HYV was 14%.

Awal et al (2007), experimented a farmers in Sherpur district to evaluate the comparative performance of two hybrid rice varieties, Sonarbangla-2 and Sonarbangla-3 with three conventional modern commercial varieties BRRIdhan32, BRRIdhan33 and BR 11 in transplanted Aman season of 2003.The study presented that BRRIdhan-32 obtained higher yield compared to the Sonarbangla-2.Thus the hybrid Sonarbangla-3 was found superior to conventional varieties for transplanting in the Aman season in Bangladesh.

India is the second country after china to develop and release the first rice hybrid in 1994, while in other country such as Vietnam and Bangladesh, the first released rice hybrids were imported from china (Janaiah and Hossain 2003). It was reported based on early experiences that many farmers who grew hybrid rice initially for one or two seasons started dropping out from hybrid rice cultivation in India (Janaiah 1995, 2000, 2002, Janaiah et al 1993, 2002).

According to Aldas et al 2010, the contribution of hybrid rice to total rice production in India as a whole is computed at 5.6%, although its share of total rice area is only 3.2%. Hybrid rice thus covered about 7% of the rice area in eastern India, accounting for nearly 13% of the rice output in the region. This shows that there is a potential opportunity for India to increase rice production in the future, especially in the low income areas of eastern India, without additional rice area, or even by releasing some of the existing rice area to other crops by the large-scale adoption of hybrid rice, as has been done in China. The large-scale adoption of hybrid rice, however, depends on the sustainability of the technology in farmers' fields.

Chengappa et al, (2003), expressed the result of the study that the average yield of hybrid rice was more than that of inbred varieties. It also emerges that the yield realized by hybrid rice growers was higher by 13.34 percent compared with inbred rice growers in Karnataka. Here also stated that in china hybrid rice has shown a yield advantage of 15-20 percent over conventional inbred varieties in farmer's fields (Lin and Pingali 1994, Lin 1994). So it is clear to us that the yield performance of hybrid rice cultivation is higher than that in inbred varieties.

RESEARCH METHODOLOGY

Methodology of information collection was focused on rice farmers in Bangladesh of Joypurhat. Both primary and secondary data will be used in this research. Primary data will be collected through random sample survey. A random sample survey was carried out during the year 2017 in the district of Joypurhat in Bangladesh and we have tried to collect ins and outs information of a household. Here three seasons were considered that include Kharip-1, Kharip-2, and Boro. We emphasized getting information of hybrid rice cultivation along with HYV and Aman. But not to any other hybrid seeds such as vegetables, fruits etc.

Sample farmers were interviewed from the selected villages using random sample survey. Eight villages have taken to be counted under the random sample survey in Joypurhat district. A sample of 30 firm households following random survey from each of the villages totally 240 sample households. The respondents were interviewed using a set of structured questionnaire. The details collected from respondents included age, education status, occupation, land use pattern, farm size, cropping pattern, about crops and its disease, knowledge of new agro-technology and so on related issues. The collected data were coded, edited, validated and analyzed using the Statistical Packages for the Social Science (SPSS) program and econometric analysis will be used. Such as, measurement of production efficiency Stochastic Frontier Approach is used.

EFFICIENCY ANALYSIS USING EXPERIMENTAL DATA

Some empirical application of stochastic frontier applied a two stage approach to investigate the sources of efficiency. The first stage estimates a stochastic frontier by maximum likelihood technique and calculates the technical efficiency for each producer under the assumption that these inefficiency effects are identically distributed. Once technical inefficiency is estimated, it is further regressed in the second stage on a set of producer-specific factors that may explain differences in technical efficiency and inefficiency among producers using ordinary least square. The result in the second step contradicts the assumption of identical distributed inefficiency effects in the stochastic frontier model since the technical inefficiency, the depended variable is one side (Kumbhakar et .al.,1991).Thus in the second stage, the estimated technical inefficiency effects are modeled as function of some producer-specific characteristics

that implies that inefficiency effects are, not identically distributed unless the coefficient of the producer specific factors are simultaneously equal to zero (Coelli et. al.,1998).Stochastic frontier approach including Ordinary Least Square (OLS) and Maximum Likelihood function (MLE) estimation methods for data analysis has been used to measure the efficiency level. In the analysis, technical efficiency is measured as the function of various socio-economic factors. This study uses the MLE approaches to estimate the parameters of stochastic production frontier, SPSS Frontier version 4.1(Collie, 1995) and MS Excel are used for editing and analyzed the data.
The important factors of production are land, labor, fertilizer, irrigation and pesticides. If all the factors are utilized properly and efficiently, then the production would be at a maximum level. Otherwise, there will be a gap between the maximum level of production and the actual level of production and this gap will represent inefficiency. Using variables are presenting of rice farm from the survey data collection in Joypurhat district.

Input Variables for MLE:
Land: Measured as hectare
Labor: Labor used per hectare (days)
Fertilizer: Fertilizer used per hectare (kg)
Irrigation: Per hectare irrigation cost (taka)
Pesticides: Pesticides used per hectare (taka)

Inefficiency Variables for MLE:
Age: Measured in Years
Education: Considered different stages in education system.
Occupation: Considered as agriculture and non-agriculture.
Training: Training related to cultivation and others.
IPM: Farmers used IPM, Considered as percentage.
Use of Electronic Tools: Dummy
Lack of Seeds: Dummy
Increasing Input Price: Dummy
Source of Information: Government, Non-Government and Papers for 1 and farmers relatives, Radio, Television for 0.

COBB-DOUGLAS STOCHASTIC FRONTIER RESULTS

The stochastic frontier production model is specified by the Cobb-Douglas production model. We estimated the yield response function for hybrid rice, high yielding variety and Aman rice production using the standard Cobb-Douglas production function in our study; because the Cobb-Douglas functional form is usually preferred on account of its well-known advantages. The results of Cobb-Douglas production are presented in table 1.1, 1.2 and 1.3 separately for high yielding variety (HYV), Hybrid (HB) and Aman production of sample farms respectively.
The following stochastic frontier model is used to estimate the technical efficiency of the rice farmers in the study areas.The stochastic frontier

production function of Cobb-Douglas specification in natural logarithm is given as:

$LnY_i = \beta_0 + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + \beta_5 LnX_{5i} + \varepsilon_1$……..

And the technical inefficiency model is expressed as;

$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + ... + W_1$

Table 1.1 focuses, for the production by HYV of the sample farms. Here we have obtained all the input variables which are positively associated with the production of HYV. It means increasing in one unit input variable such as land, labor, fertilizer, irrigation and pesticides which cause production increase 0.1902, 0.1059, 0.3433, 0.2359 and 0.1603 respectively.

From the table 1.1, we can construct the stochastic production function for HYV as:

lnYi=3.2848+0.1902lnXi1+0.1059lnXi2+0.3433lnXi3+0.2359lnXi4+0.1603lnXi5

Table 1.2 shows Cobb-Douglas production function for hybrid rice. We obtain positive coefficients for all five parameters. All the parameters are also showing significant effect on the yield. In the field survey, we have observed that all the input variables are more used for hybrid rice compare to HYV and Aman.

The estimated stochastic production function for HB rice is as follows:

lnYi= 2.7943+0.2070lnXil+0.2385lnXi2+0.3461lnXi3+0.1717lnXi4+0.0864 lnXi5.

In the table 1.3 all input variables for the production of Aman is positive and significant. It indicates increasing in one unit input variable increases for the production of Aman.

The estimated stochastic production function from table 3 for Aman is as follows;

lnYi = 3.5811+0.2943lnXi1+0.2081lnXi2+0.1830lnXi3+0.1708lnXi4+0.1554lnXi5

From the above discussion, we see that all the input variables for HB, HYV and Aman production are significant and the value of R^2, R and F for all rice variety indicates it’s well-fitting for the model. That means there is a positive impact on our production with our independent variables such as land, labor, fertilizer and irrigation.

MAXIMUM LIKELIHOOD ESTIMATES OF THE COBB-DOUGLAS STOCHASTIC FRONTIER MODEL

Stochastic Frontier Approach is an important and appropriate tool for measuring technical efficiency. The estimated result of ordinary least square and maximum likelihood are same because of using large sample size (240) in the study. Table 2.1.1, 2.2.1, 2.2.2, and 2.2.3 represent summary statistics of the variable of interest in the analysis for HB, HYV and Aman production respectively.

Estimates of technical efficiency of HB, HYV, and Aman Production

The summary statistics of the Cobb-Douglas stochastic frontier for technical efficiency (TE) results are presented in table (2.1.1). Here, the estimated technical efficiency for rice variety of hybrid, HYV and Aman production in Puranapoil, Jamalpur, Atapur and Aymarasulpur are described; each union included 60 farm observations. This table shows the average technical efficiency of each rice variety for each union. Average efficiency of hybrid rice is higher in Aymarasulpur (0.8633) than others union. Atapur union is carrying the highest technical efficiency for HYV (0.9027) and Aman (0.8505). Mean efficiency is also illustrated here and HYV production shows the higher efficiency than Hybrid and Aman.

Estimates of the stochastic frontier production function: Hybrid Rice

The maximum likelihood (ML) estimates of the parameters of the Cobb-Douglas frontier production model for HB rice are presented in table 2.2.1.The coefficients of the frontier production were regarded as elasticity. The empirical results indicate that signs of the βi coefficients are all positive and significant. The highest elasticity of output is for land which indicates that land is the dominant factor of production. Irrigation is the next important input followed by fertilizer. The estimated ML coefficient for Land, labor, fertilizer, irrigation and pesticides showed positive values of 0.39, 0.11, 0.20, 0.17, and 0.12 reflecting that increment of the inputs land, labor, fertilizer, irrigation and pesticides by one percent will increase output 0.39, 0.11, 0.20, 0.17, and 0.12 percent.

Technical inefficiency: Hybrid rice

The estimates δ-coefficients of the explanatory variables in the model are interesting and worthy of deeper discussion. The signs of δ have to explain carefully. Given the model specifications, the results indicate that the farm specific variables are involved in the inefficiency model contribution significantly as a group to explain the technical inefficiency which effects on HB rice cultivation. Among the inefficiency variables, the coefficients for farmers' age were negative and insignificant indicating that, farmers who were involved in farming for a considering amount of time, tended to be lesser inefficient or in other words, they were technically more efficient than those who were into farming for lesser number of year (Table-2.2.1).The coefficients for education was positive but insignificant indicating that educated farmers tended to be more inefficient and hence implies less technically efficient. This also implies that farmers, who were more educated, were reluctant in rice farming as they had a tendency to engage themselves in off-farm jobs and consequently, obtained lower yield, which is reflected in table 2.2.1 of this section. The δ coefficient associated with the occupation is negative and insignificant implying that the farmers with more occupations are technically inefficient. The inefficiency variable, the coefficients for training farmers are estimated to be negative and significant indicating that the farmers who were given training on agriculture especially in rice production, their inefficiency decreased significantly. Similarly the coefficients for lack of suitable seeds are also negative and significant. The other coefficients for IPM, use of electronic tools in agriculture, increasing input price and sources of agricultural information are also negative and insignificant.

Estimates of the stochastic frontier production function: HYV

The maximum-likelihood estimates of the parameters of the Cobb-Douglas stochastic frontier production model for HYV rice are presented in table 2.2.2 The estimated ML coefficients for land, labor, and irrigation which are important yield-determining factors for High Yielding Variety, coefficients for these variables are statistically significant and show positive values of 0.187,0.131 and 0.181, reflecting that increment of the inputs land, labor and irrigation by one percent would increase output by 0.187,0.131 and 0.181 percent. Fertilizer and pesticides are the most costly inputs in the context of rice cultivation in Bangladesh and coefficients of both of the variables are highly significant and show positive values of 0.415 and 0.161, indicating that increment of the inputs fertilizer and pesticides by one percent would increase output by 0.415 and 0.161percent.

Technical inefficiency: HYV

Among the inefficiency variables, the coefficient for farmers' age is estimated to be positive and significant implying that farmers who are engaged in HYV rice cultivation for a considerable amount of time, tended to be inefficient table 2.2.2. The coefficient for source of agro-information for technical inefficiency of HYV rice production of our sample farmers is negative and significant. This indicates that more source of agro-information provides more efficient for the producers. The coefficients for training, IPM, and occupations are negative and insignificant of HYV. This implies that it has positive effects on efficiency of HYV rice producers. As we increase the quality of training, more use of IPM, and changes to better occupations, farmers become able to allocate their inputs more efficiently and cost of production decreases.

The other coefficients of use of electric tools in agriculture, lack of suitable seeds and education from Cobb-Douglas stochastic frontier technical inefficiency for HYV are positive and insignificant implying that the farmers with more use of electric tools, more lack of suitable seeds, and more education are more technically inefficient. More formal educated farmers are technically more inefficient. On the other hand less formal educated farmers are comparatively efficient.

Estimates of the stochastic frontier production function: Aman

The maximum-likelihood estimates of the parameters of the Cobb-Douglas stochastic frontier production model for Aman rice are highlighted in table 2.2.3. For all five inputs variables of Aman are positive and significant. Significant parameters are land, labor, fertilizer, irrigation and pesticides. The highest elasticity of output is for land which denotes that land is the dominant factor of production. Labor is the next important input followed by pesticides. All of the positive values of input variables such as 0.30, 0.18, 0.10, 0.15, and 0.19, indicates that increment of the inputs land, labor, fertilizer, irrigation and pesticides by one percent would increase output by 0.30, 0.18, 0.10, 0.15 and 0.19 percent.

Technical inefficiency: Aman

Among the inefficiency variables, the coefficients for dummy variable-training, use of electric tools, lack of suitable seeds and socio-economic variables; education and occupation are positive and insignificant. It implies that farmers with more training, use of more electric tools, lack of suitable seeds, education and occupation are more technically inefficient. This is unexpected but the coefficients are insignificant in Aman.

The coefficients of IPM, increasing input price, source of agro-information dummy and age are estimated to be negative implying that technical efficiency of farmers has increased because of using IPM, more increasing input price, source of agro-information. Similarly the coefficient for the variable age is negative indicating aged farmers were technically more efficient than those who were involved in farming for a lesser number of years.

CONCLUSION

The maximum likelihood estimates the parameters of the Cobb-Douglas frontier production model for hybrid rice, high yielding variety and Aman which are described. Input variables land, labor, fertilizer, irrigation and pesticide are positive and significant for hybrid rice, HYV and Aman. Inefficiency variables are considered as age, education, occupation, training, IPM, use of electric tools, lack of seeds, increasing input price and source of information for hybrid rice, HYV and Aman rice production. For hybrid rice, the coefficients for farmers' age and occupation are negative and insignificant. Education is positive but insignificant. The coefficients for suitable seeds and farmers training are estimated to be negative and significant. The other estimated coefficients for IPM, use of electronic tools in agriculture, increasing input price and sources of agricultural information are also negative and insignificant (Table-2.2.1). For HYV, the coefficient for farmers' age is estimated to be positive and significant but source of agro-information is negative and significant. The coefficients for training, IPM, and occupations are negative and insignificant and the others coefficients of use of electric tools in agriculture, lack of suitable seeds and education from Cobb-Douglas stochastic frontier technical inefficiency for HYV are positive and insignificant (Table-2.2.2). The coefficients for Aman variable; training, use of electric tools, lack of suitable seeds and socio-economic variables; education, occupation, are positive and insignificant and IPM, increasing input price, source of agro-information dummy and age is estimated to be negative (Table-2.2.3).For fulfilling the goal of quality education which denotes better skills and best career for the students I always seek the trainings for teachers to improve their quality which ultimately ensures good future for the nation.

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TABLES OF CONTENTS/APPENDIXES

Table 1.1: Estimated coefficient of the Cobb-Douglas production function for HYV

Name of Variables	Parameters	Coefficients	t-ratios
Intercept	β_0	3.2848	9.7227
Land	β_1	0.1902	2.7592
Labor	β_2	0.1059	2.1876
Fertilizer	β_3	0.3433	3.4047
Irrigation	β_4	0.2359	2.9386
Pesticides	β_5	0.1603	2.4463
R^2	0.8619		
$\bar{R}$	0.8589		
F	292.13		

Table 1.2: Estimated coefficient of the Cobb-Douglas production function for hybridrice

Name of Variables	Parameters	Coefficients	t-ratios
Intercept	β_0	2.7943	8.4958
Land	β_1	0.2070	5.2890

Labor	β_2	0.2385	3.6455
Fertilizer	β_3	0.3461	5.9163
Irrigation	β_4	0.1717	3.9219
Pesticides	β_5	0.0864	2.2586
R^2	0.8427		
$\bar{R}$	0.8393		
F	250.75		

Table 1.3: Estimated coefficient of the Cobb-Douglas production function for Aman

Name of Variables	Parameters	Coefficients	t-ratios
Intercept	β_0	3.5811	11.5917
Land	β_1	0.2943	4.9099
Labor	β_2	0.2081	3.4341
Fertilizer	β_3	0.1830	2.7200
Irrigation	β_4	0.1708	2.3787
Pesticides	β_5	0.1554	2.3413
R^2	0.8547		
$\bar{R}$	0.8516		
F	275.37		

Table 2.1.1: Average efficiency of HB, HYV and Aman

Union/Rice varieties	Hybrid Rice	HYV	Aman
Puranapoil	0.8124	0.8042	0.8039
Jamalpur	0.8121	0.8737	0.8332
Atapur	0.8347	0.9027	0.8505
AymaRasulpur	0.8633	0.8784	0.8308
Mean efficiency	0.8306	0.8648	0.8296

Table 2.2.1: Maximum likelihood estimates of stochastic frontier model for HB

Variables	**Parameters**	**Coefficients**	**t-ratios**
Intercept	β_0	4.0855	15.5710
Land	β_1	0.3965	10.7967
Labor	β_2	0.1118	1.9365
Fertilizer	β_3	0.2026	4.6971
Irrigation	β_4	0.1749	4.9147
Pesticides	β_5	0.1217	3.4187

Inefficiency Variables

Intercept	δ_0	-0.7819	-0.7410
Age	δ_1	-0.0309	-1.3309
Education	δ_2	0.0055	0.2059
Occupation	δ_3	-0.6132	-1.5462
Training	δ_4	-0.3756	-2.2639
IPM	δ_5	-0.6481	-1.8773
Use of ele tools	δ_6	-2.5444	-1.7814
Lack of seeds	δ_7	-0.9819	-1.9667
Increasing input price	δ_8	-1.0907	-1.7090
Source of information	δ_9	-0.6399	-1.6440

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Sigma-squared	σ^2	1.3404	1.5388
Gamma	γ	0.9911	151.5895
Log-likelihood function		37.4708	

Table 2.2.2: Maximum likelihood estimates of stochastic frontier model for HYV

Variables	Parameters	Coefficients	t-ratios
Intercept	β_0	3.1191	10.0707
Land	β_1	0.1877	2.9257
Labor	β_2	0.1317	2.9674
Fertilizer	β_3	0.4152	4.6928
Irrigation	β_4	0.1819	2.8724
Pesticides	β_5	0.1617	3.0066

Inefficiency Variables

Intercept	δ_0	-3.3518	-1.6223
Age	δ_1	0.0226	2.2293
Education	δ_2	0.2247	1.8844
Occupation	δ_3	-0.0303	-0.2552

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Training	δ_4	-1.1110	-1.6673
IPM	δ_5	-1.0788	-1.7766
Use of ele tools	δ_6	0.7683	1.6516
Lack of seeds	δ_7	0.3291	1.4516
Increasing input price	δ_8	0.1034	0.8475
Source of information	δ_9	-0.7139	-2.0009
Sigma-squared	σ^2	0.3891	2.0142
Gamma	γ	0.9181	21.2506
Log-likelihood function		10.4739	

Table 2.2.3: Maximum likelihood estimates of stochastic frontier model for Aman

Variables	**Parameters**	**Coefficients**	**t-ratios**
Intercept	β_0	**4.3795**	**13.4013**
Land	β_1	**0.3077**	**5.0224**
Labor	β_2	**0.1803**	**3.2532**
Fertilizer	β_3	**0.1087**	**1.8019**
Irrigation	β_4	**0.1513**	**2.3275**

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Pesticides	β_5	**0.1918**	**3.0902**

Inefficiency Variables

Intercept	δ_0	-1.4795	-0.7424
Age	δ_1	-0.0071	-0.5563
Education	δ_2	0.0363	0.6196
Occupation	δ_3	0.4947	0.8810
Training	δ_4	0.3663	0.9364
IPM	δ_5	-0.4840	-0.8763
Use of ele tools	δ_6	0.2517	1.0265
Lack of seeds	δ_7	0.5119	1.1322
Increasing input price	δ_8	-0.1915	-0.7802
Source of information	δ_9	-0.1006	-0.5464
Sigma-squared	σ^2	0.3714	0.9655
Gamma	γ	0.9204	11.1319
Log-likelihood function		-3.4848	

HB-Hybrid
HYV- High Yielding Variety
IPM-Integrated Pest Management
MLE-Maximum Likelihood Estimates
ML-Maximum Likelihood
OLS-Ordinary Least Square
SPSS- Statistical Packages for the Social Science
TE-Technical Efficiency