Production Efficiency Analysis between Transplanting and Direct Seeded Rice Producers in Punjab, Pakistan

Hina Fatima*
Ph.D. Candidate at Fatima Jinnah Women University
Rawalpindi, Pakistan
Hinnafatima@gmail.com

Sania Shaheen
Ph.D. Candidate at Islamic International University
Islamabad, Pakistan
saniashaheen@gmail.com

Lal Almas
Associate Dean and Professor of Agricultural Business and Economics
West Texas A&M University, Canyon, TX USA
lalmas@wtamu.edu

Mallory K. Vestal
Assistant Professor of Agricultural Business and Economics
West Texas A&M University, Canyon, TX USA
mvestal@wtamu.edu

Sehrish Haroon
Fatima Jinnah Women University, Rawalpindi, Pakistan
sehrishharoon777@gmail.com

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Abstract: Rice is known as an Asian crop because 90% of global rice production and consumption takes place in Asia. It is the staple food for about 50% of the world population and 75% of the people living in developing countries. Pakistan is the 11th rice producer in the world and 5th largest exporter. Comparative economic efficiency of Transplanted (TRP) and Direct Seeded (DRS) rice production in Pakistan needs evaluation. This study analyzed the economic efficiency of TRP) and DRS producers in rice producing districts of Punjab. Primary data was collected from major rice producing areas of Punjab, Pakistan and Stochastic Frontier Analysis (SFA) was run in order to estimate the profit efficiency of rice producers. The results revealed that on average profit efficiency of TRP rice farmers and DRS farmers was 57% and 83%, respectively. Hence, there are opportunities to improve economic and technical efficiency as well as the rice production profitability through adopting improved farming practices, optimal use of inputs and production techniques. The results also demonstrated that socio-economic factors of rice producers also significantly influence the profit efficiency of rice producers. Therefore, the efficiency of rice producers can also be improved through education and enrichment of extension services in the rural areas.

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Abstract

Profit efficiency of Transplanted (TRP) and Direct Seeded (DRS) is gaining greater attention in Pakistan. This study estimated the profit efficiency of Transplanted (TRP) and Direct Seeded (DRS) farmers in rice producing districts of Punjab. Primary data was collected from major rice producing areas of Province of Punjab including Gujranwala, Hafizabad, Sheikhupura, Jhang and Sialkot. For the purpose of obtaining reliable results Stochastic Frontier Analysis (SFA) was run in order to estimate the profit efficiency of rice farmers and sample was collected through simple random sampling. The results revealed that on average profit efficiency of TRP rice farmers and DRS farmers was 57% and 83%, respectively. The results further threw light on loss of profit which is around 43% of TPR and 17% of DSR bore by farmers because of the unsuitable combinations of inputs. Direct seeded rice farmers displayed more efficiency compared to the transplanted rice farmers. However, for DSR and TPR farmers' opportunities still exist to maximize the profitability through adopting improved farming practices and production techniques. Moreover, the results also demonstrated that farmer's education, age, farming experience, extension service facility and land tenancy significantly influence the profit efficiency of rice farmers. Therefore, the efficiency of rice farmers can be improved through the addition of educated people in farming system and the enrichment of extension services in the rural areas.

KEY Words: DSR: Direct Seeded Rice, TPR: Transplanting rice, SFA: Stochastic Frontier Analysis, MLE: Maximum Likelihood Estimates.

1. Introduction

Rice is an Asian crop because of the reason that approximately 90% of rice production and consumption takes place in this region. It is the staple food for about 50% of the world population and 75% of the people living in developing countries. Rice is the second most important food crop in Pakistan, obviously taking after wheat. Pakistan is the 11th main rice producer in the world and 5th biggest exporter. Rice crop accounts for 3.2% value addition in agriculture sector and 0.7% in GDP of Pakistan. In July-March[1] 2014-15, rice crop was sown on the area of 2,891 thousand hectares, presenting growth of 3.6% in comparison to the year 2013-14. Rice production in 2014-15 was around 7005 thousand tonnes, revealing growth of 3.0 percent as compared to the year 2013-14. During this time period, Pakistan was able to earn US$ 1.53 billion foreign exchange from rice exports.

All around the world two rice sowing methods are primarily used: I) Direct Seeding Rice Method (DSR). II) Conventional or Transplanting Rice Method (TPR). In DSR sowing procedure, seeds are directly sown in the farmland. In case of TPR method, seeds are first sown in the nursery, later on rice plants are planted in the land (Akhgari and Kaviani, 2011). According to Pandey and Velasco, (2005) the DSR method was introduced in developing countries in 1950s. Currently, in developed and developing parts of the world such as America, Italy, France, Western Europe, Russia, Japan, Korea, India, Philippian and in some parts of Iran, rice farming is practiced through the DSR method (Akhgari, 2004). On the other hand, in Pakistan conventional TPR method is swiftly substituting the direct seeded broadcasting method. Shortages of mandatory labor, water scarcity and higher cost borne by the farmers are the shortcomings associated with TPR method [(Pandey et al., 2002; Tuong et al., 2005; Nguyen and Ferrero, 2006)].

In Pakistan, most of the rice growing farmers cultivate rice through the conventional TPR method. This method not only needs lot of water rather also requires number of skilled labor, along with high time consumption and is also an expensive method for raising

[1] Source: Bureau of Statistics: Pakistan Economic Survey (2014-15)

nursery, uprooting and transplantation. The existence of these limitations results in low rice yield and productivity (Younas et al., 2015). Currently, in Pakistan, rice growers have shifted from traditional method to DSR including areas like Sheikhupura, Gujranwala, Hafizabad, Jhang, Sailkot, Gujrat, and Faisalabad (Murugaboopathi et al., 1991). After comparison of both the methods, DSR turned out to be less expensive than the TPR method (Awan et al., 2007).

Therefore, this study has the objective to estimate and compare profitability of DSR and TRP users in 2014-15 during Kharif season, in the selected districts of Punjab and to examine the sources of inefficiency affecting the profit efficiency of rice farmers under DSR and TRP methods.

A. Objectives of the study

- To carry out gross margin analysis of DSR and TPR farmers.
- To compare the profit efficiency among DSR and TPR farmers.
- To estimate the sources of profit inefficiency.

II. Literature Review

Previous studies have estimated the profit efficiency of rice crop in different countries and regions. Major findings of some of the studies are highlighted in this section. Abdulai and Huffman, (1998) estimated the profit inefficiency in Northern Ghana by using farm level survey data. The results of the study concluded that educational level, access to credit and specialization in rice farming practices have a positive influence in enhancing the productive efficiency of rice farmers. Rahman (2003) estimated the profit inefficiency among Bangladeshi rice farmers in both Aman and Aus/Boro seasons by using Stochastic Frontier Analysis (SFA). The results revealed that on average, profit efficiency was 64%, and pointed out that 36% of farmers incurred loss due to the technical and allocative inefficiency in modern rice production system. The profit inefficiency was greatly influenced by Infrastructure, extension services, tenancy status and share of non-agriculture income.

Rahman et al., (2015) estimate the profitability and efficiency of rice producing methods in coastal areas of Bangladesh. The estimated results concluded that average level of technical efficiency was 87% and average output can be raised by 12.50% with the given set of technology and inputs. The study concluded that farmers' age, education and farm related trainings have a positive contribution towards cumulative profit efficiency of farmers. Younas et al., (2015) measure the economic evaluation of direct seeded and conventional rice by selecting some important districts of Punjab. The results concluded that compared to paddy yield farmers, the Direct seeded farmers get higher profit in the selected study areas. Hence, DSR is a favorable technology if farmers overcome weed problems by using chemical control procedures.

III. Research Methodology

A. Sampling Procedure of TRP and DRS systems

Primary data was collected for this study and the data set consisted of cross sections collected from 300 randomly selected farmers in five selected rice growing districts of Punjab. From each district 4 village were selected using purposive random sampling technique. The reason behind using this sampling technique was to find out both the types of farmers: Transplanting (TPR) and direct seeded (DSR) rice farmers in the selected areas. TPR and DSR farmers were randomly selected to a total of 15 famers from each village. Structured questionnaire was the instrument for data collection and the questions were asked from each farmer through interview method. Questionnaire was pre-tested through pilot testing. Data were collected for the rice crop Kharif in year 2014- 2015.

B. Materials and Methods

Farrell (1957) did the pioneer work on the concept of efficiency and produced the frame work for the development of production frontier. Production inefficiency was estimated by using Technical and Allocative efficiency. Currently, researchers have combined both elements into one measure (e.g. Ali and Flinn, 1989 & Wang et al., 1996). Technical efficiency analysis is the most recognized approach for efficiency measurement, computed with the help of production frontier function (Battesse and Collie, 1995). Ali and Flinn (1989) argued that production frontier approach was not appropriate for technical efficiency analysis in the presence of price dissimilarity due to various factor endowments, faced by farmers. As an alternative of analyzing the production and cost frontier separately, a profit frontier function is generally used for the analysis of farm efficiency (Kumbhakar and Bhattacharya, 1992; Ali et al., 1994; Wang et al., 1996).

According to Ali et al., (1994) profit function used the concept of technical and allocative efficiency together in the profit relationship, and any shortcomings on the part of production side are supposed to lower profit of the producer. Ali and Flinn (1989) define the profit efficiency as the ability of a farm to attain highest level of profit at given prices and inputs. On the other hand, profit inefficiency is explained as the loss of a farm from not operating on the frontier.

Numerous studies have used efficiency measurement as a tool to calculate level of efficiency. The estimated efficiency indices were regressed on a number of socio-economic factors in order to describe the observed difference in farm level efficiency by using a two-step process (Sharif & Dar, 1996). Battese and Coellie (1995) integrated the SFA model with an inefficiency model that is based on the linear function of independent variables (farm-specific factors). This model comes with the benefit of calculating the farm specific efficiency and to estimate the factors that describe farmer's efficiency difference by using a single estimation process. In the present research, the model of Battese and Collie (1995) was used to estimate the profit function by using stochastic frontier approach.

The basic functional form of stochastic profit function is as:

$$\boldsymbol{\pi_i = f\left(P_{ij}\, Z_{ik}\right).\exp(\varepsilon_i)} \tag{1}$$

$\boldsymbol{\pi_i}$ = It shows the normalized profit which is calculated as total revenue-total cost divided by the rice output prices.

$\mathbf{P_{ij}}$= Price of jth input variable of ith farm divided by the rice output prices.

$\mathbf{Z_{ik}}$ = Level of fixed input of the ith farm and K are the number of fixed inputs and i= 1, 2, 3…n number of sample farmers.

$\boldsymbol{\mathcal{E}_i}$ = error term is supposed to be consistent with frontier model (Ali and Flinn, 1989).

$$\boldsymbol{\mathcal{E}_i = V_i - U_i} \tag{1a}$$

$\mathbf{V_i}$ = estimate the random effects like statistical noise, measurement errors, omitted explanatory variables.

$\mathbf{U_i}$ = estimate the profit inefficiency. It is Non-negative one sided error term.

U_i is supposed to be identically distributed with mean is defined as:

$$\boldsymbol{U_i = \delta_0 + \textstyle\sum_d \delta_d W_{di}} \tag{2}$$

and variance $\delta^2 u$. W_{di} is the dth independent variables which is connected with ith farm inefficiency and δ_0 and δ_d are the unknown parameters.

The profit efficiency of firm i is defined in the form of stochastic frontier profit function as:

$$\boldsymbol{EEF = E[\exp(-u_i)/\varepsilon_i] = E[exp(-\delta_o - \sum_{d=1}^{D} \delta_d W_d)/\varepsilon_i} \qquad \textbf{(3)}$$

E shows the expectation error. For estimating the unknown parameters maximum likelihood estimates are used in the SFA frontier and inefficiency effects model, simultaneously. According to Battese and Collie (1995) variance parameters in the maximum likelihood function is defined as: $\boldsymbol{\delta^2 = \delta^2{}_u + \delta^2{}_v}$ and $\boldsymbol{\gamma = {}^{\delta^2{}_u}/_{\delta^2}}$.

$\boldsymbol{\delta^2}$ estimates the total deviation from the frontier which can occur due to profit inefficiency (Battese and Coellie, 1995). The parameter γ shows the inefficiency share from the total variance errors. γ value lies between 0 and 1. Value of 1 show that frontiers are deterministic and 0 signifies the sign in accordance of OLS estimation. Under the SFA model the test of test-statistic is measured as:

$$\boldsymbol{LL = -2[lnL(H_o)/lnL(H_1)] = = -2[lnL(H_o) - lnL(H_1)]} \qquad \textbf{(4)}$$

The log likelihood values L (H_0) and L (H_1) under the condition of null and alternative hypothesis.

C. Empirical Model

This study has estimated flexible translog profit[2] function. The functional form of translog profit function is given in the following equation as:

$$\boldsymbol{ln\pi' = \alpha_0 + \sum_{i=1}^{6} \alpha_i \, lnp'_i + \frac{1}{2}\sum_{i=1}^{6}\sum_{j=1}^{6} \varphi_{ij} lnp'_i lnp'_j + \sum_{i=1}^{6}\sum_{k=1}^{2} \tau_{ik} lnp'_i lnz_k +}$$

$$\boldsymbol{\sum_{k=1}^{2} \beta_k \, lnz_k + \frac{1}{2}\sum_{k=1}^{2}\sum_{l=1}^{2} \theta_{kl} lnz_k lnz_l + v_i - u_i} \qquad \textbf{(4a)}$$

[2] Rahman.S, (2002) used translog profit function to estimate the profit efficiency of Bangladesh rice farmers. T.S. HYUHA et al., (2007) used flexible translog profit function for estimating the profit inefficiency in Northern and Eastern UGANDA.

Where

$$U_i = \delta_o + \sum_{d=1}^{D} \delta_d \omega_{di} + \omega_i \qquad \textbf{(4b)}$$

Where $\varphi_{ij} = \varphi_{ji}$ for all j and i.

π'= restricted normalized profit is explained as total revenue- total variable cost divided by farm specific rice price (Pj).

P_i (P_j)= Price of variable inputs, normalized by rice price (Pj).

P_p = Pesticide cost normalized by rice price (Pj)

P_s = Seed cost normalized by rice price (Pj).

P_{irr} = Irrigation cost normalized by rice price (Pj).

P_w = Weedicide cost normalized by rice price (Pj).

P_L = Labor cost normalized by rice price (Pj).

P_F = Fertilizer cost normalized by rice price (Pj).

Z_{CI} = Capital Intensive cost measured as (sum of animal cost + mechanical power) in farm j.

Z_{AR} = Area under rice crop (hectare under rice) in farm j.

U_i = inefficiency effects

V_i = unknown random variable.

ω_d = 6 variables clarifying inefficiency effects describes as:

ω_1 = Age (years)

ω_2 = Education (farmer years of schooling)

ω_3 = Experience (No of farming experience)

ω_4 = Access to extension service (Dummy variable 1 if farmers have a contact to extension officer otherwise zero).

$\boldsymbol{\omega_5}$ = Household size (measured as no of working person in the family)

$\boldsymbol{\omega_6}$ = Tenancy status (Dummy variable if farmer is an owner otherwise zero which represents farmer status as a tenant)

Ln is the natural logarithm and $\boldsymbol{\alpha_0, \alpha_i, \varphi_{ij}, \tau_{ik}, \beta_k, \theta_{kl}, \delta_o, \delta_d}$ are the estimated parameters. This model is adopted from Rehman (2002) with certain amendments.

IV. Results and Discussions

IV-I. Descriptive analysis of TRP and DRS systems

The socio-economic characteristics of farmers are presented in Table 1. The average age of traditional farmers and direct seeded farmers is 50 and 45 years, respectively which suggests that majority of sample farmers engaged in farming activities are older. The average education of conventional and direct seeded sample farmers is about the same which is primary level indicating low level of academic qualification due to limited availability of education in the selected areas. The average farm size of conventional famers is between 5 to 15 acres while direct seeded rice farmers' ranges between 5 and 10 acres. The average years of farming experience between conventional and direct seeded sample farmers is 35 and 40 years, respectively. The average size of farmers' households for both TRP and DSR is approximately 8 to 11 people in each home.

This study also estimates the comparative gross margin analysis of transplanting and direct seeded rice. For computing the descriptive analysis results in this study, SPSS 20 is used. The results are given in Table 2. The average gross margin of rice from a transplanted rice field is Rs.20001.00, and Rs.30407.09 from a direct seeded field. This demonstrates that broad variation exists in the gross margin of rice produced from transplanted and direct seeded fields. A reason for this is that direct seeded rice fields, on average require 22 units of irrigation per hour per acre while transplanted field requires 15 units of irrigation per hour per acre. Thus, DRS fields saved 7 units of irrigation per hour per acre compared to transplanted rice fields. On the other hand, TPR fields required an average of 5-6 kg of seed per acre while DSR fields needed of 15-16 kg per acre. Overall results reveal that DSR field can achieve higher yield by appropriately managing weedicide issues. It indicates that the potential rice productivity from direct seeded fields is higher than from a TPR field.

IV-II. Empirical results and discussion

A. Hypothesis testing for TRP and DRS systems

Table 3 presents a different hypothesis regarding various inefficiency conditions by utilizing likelihood ratio test statistics. The first null hypothesis $\gamma = 0$, is rejected at 5% significance, indicating that inefficiency effects exists in the profit frontier model. It confirms that variability exists in farmers' profit level due to technical and allocative inefficiencies.

The second null hypothesis indicates farm level inefficiencies are not affected by the independent variables included in the profit model which is rejected at 5% significance. This confirms that inefficiency is affected by the explanatory variables included in the profit model.

B. Profit frontier estimates for TPR and DRS systems

The maximum likelihood estimates of the profit frontier results are presented in Table 4. The estimated parameters of pesticide and weedicide costs are negative and significant at 1% in both TPR and DRS systems. This implies that an increase in pesticide and weedicide cost would lead to significant reduction in farmer profits. This occurs because of unlimited usage of pesticides and weedicides which is harmful for rice crops, thus reducing rice productivity. Rahman, (2002) and Hyuha et al., (2007) demonstrated the same results.

The estimated parameters of seed cost are also positive and significant at 1%, indicating that increase in seed cost would lead to increased farmer profit in both TPR and DRS systems. An increase in seed usage has a significant impact on rice productivity, and this result meets the theoretical expectation. Consequently, farmers achieve higher profits by sale of rice productivity in the market. Ansah et al., (2014) displayed same results.

The coefficient of irrigation cost, fertilizer cost and dummy variable area under rice crop are positively significant at 1%. This is the expected result as the variables significantly contribute to increased rice productivity in both TRP and DSR systems and are also given by Aung, (2011).

The coefficient of labor cost is negative and significant at 1% in the TPR system and in the DRS system, and is in line with the theory. Huge amount of labor is required for the transplantation of rice in the TPR system. Hence, an increase in labor cost would significantly contribute to increased profit under the TPR and DRA systems.

The coefficient of capital intensive cost is negative and significant at 5%. This indicates that an increase in capital intensive cost leads to reduced farmer profit in both the TPR and DRS systems. The same results are seen in Rehman, (2004) and Akramove and Malek, (2012).

The square term pesticide cost in the profit frontier model is statistically significant at 1% and maintains a negative sign at both initial and later stages. The result points out to the continued increase in pesticide cost leading to decrease in rice output at initial and later stages under both the systems. The square term of seed cost is negative and significant at

1% in the DSR system and positively significant in the TPR system indicating that an increase in seed cost would significantly contribute to increased rice productivity under the TPR system, therefore, TPR farmer profit will tend to increase.

The square terms of irrigation are negative and significant under the TPR system and positively significant under the DSR system, suggesting that increase in irrigation hours will increase rice productivity at both initial and later stages in the TPR system. Conversely, an increase in irrigation hours will adversely impact rice productivity at later stages under the DSR system thus, lowering DSR farmer profits.

Area under rice crop square term is statistically significant and positive both at initial and later stages under the two systems. On the other hand, the square terms of weedicide cost, labor cost, fertilizer cost and capital intensive cost are insignificant under both TPR and DSR systems.

The two interaction terms for the profit frontier model are statistically significant with some cross-term coefficients having positive signs and others having negative signs. The negative value of a cross term indicates the existence of substitute relationship between two input costs. Furthermore, the positive terms indicate complementary relationship between two input costs.

The second part of the table reports the result of hypothesis test that the inefficiency effects are not only the random errors. The value of key parameter $\boldsymbol{\gamma} = {\boldsymbol{\delta}^2}_u / \boldsymbol{\delta}^2$ which is the ratio of error and it varies between zero and one. When $\boldsymbol{\gamma}$=0, no inefficiency is present and when $\boldsymbol{\gamma}$=1, no random noise exists. In this table, the value of $\boldsymbol{\gamma}$ is close to 1 and significantly different from zero. Thereby, establishing the fact that high level of inefficiency exists in the rice farming.

Moreover, in table 2 the estimated gamma parameter (γ) 0.9456 in TRP system and 0.9789 in DSR system are highly significant at 1% level. This implies that one-sided random inefficiency component strongly dominates the measurement errors and other random disturbance indicates (94 percent under TRP system and 98 percent under DSR system) the variation in actual profit from maximum profit (profit frontier) between farms which primarily arise from differences in farmers' practices rather than random variability [Kolawole, (2006)].

C. Profit inefficiency model of TRP and DRS systems

Inefficiency model results are reported in Table 5. The estimated parameter of farmer age carries a negative sign and is statistically significant at 1% in both TRP and DSR profit inefficiency indices. The result show that higher the farmer age, lower the farmer profit inefficiency will be, implying that Pakistani farmers falling in higher age brackets will demonstrate significantly more profit than younger farmers. The reason behind the results may be due to older farmers having more information about their land and traditional practices [Aung, (2011)].

The coefficient of education is also significant and carries the negative sign in both TPR and DSR profit inefficiency index. The scale of the estimated parameter reveals the profit inefficiency of farmer being reduced as number of famer education increases. In the targeted area, average number of farmers' education is up to the level of primary. According to Abdulrahman et al., (2015) education has a positive and significant impact on farmers' efficiency in production. The literacy level greatly influences the decision making and adoption of innovative methodologies by farmers, which may bring about increase in production of crop. The educational level of farmers does not only enhance productivity but also increase his ability to understand and evaluate new techniques. Consequently, efficiency of farmers to obtain maximum profit increases. The result is in line with Huffman (1974) for the united states, Ali and Flinn,(1989) for Pakistan, Kumbhakar and Bhattarcharya, (1992) for India.

The estimated coefficient of the farmer's experience is also significant but carries negative sign in both TPR and DSR. This result reveals that profit inefficiency of farmers reduces as number of farmers' experience increases and is in accordance with findings of Abedullah, (2006). According to Fatima et al., (2011) stated that farming experience is an important factor affecting productivity of any crop. The experienced farmers could manage various farm practices in much more efficient manner.

The estimated parameter of extension contact is significant and negative in both TPR and DSR systems. In the area under study, the trend of farmers' availing extension services is very slow. If farmers' visits towards extension services center increases than farmers' knowledge about new farm practices, adoption of new seed varieties and adoption of new ideas might be increased and these are in line the findings of Abeduallah et al., (2006), and Fatima and Khan, (2015).

The estimated parameter of household size is significant and carries positive sign in both TPR and DSR systems meaning that an increase in the farmer household size would significantly lead to increase profit inefficiency of farmers. The same results are found by Oluwaranti and Oladeebo, (2014), Munir et al., (2015).

The estimated parameter of tenancy status is significant at 1% level with negative sign in both TPR and DSR system. The results point out that tenants are efficient as compare to owner. So, they get high profit as compared to owner and Rehman (2002) obtained the same results. According to Chuadhary et al., (2002) the tenants mostly hold small area under cultivation and are generally under economic pressure paying the rent of land, alongside facing high variable cost and also having pressure to save for the security of their families. Hence, all these factors make tenants struggle more in order to achieve higher level of production.

D. Farm specific profit efficiency estimates

The summary statistics of the profit efficiency estimates are presented in figure 1. The direct seeded rice farmers are more proficient as compared to transplanting rice farmers. The average profit efficiency of direct seeded and transplanted rice farmers is 0.83 and 0.57, respectively showing that on average direct seeded and transplanting rice farmers can increase profit by improving technical and allocative efficiencies. Around 42.9 percent transplanted rice farmers face profit efficiency less than 50%. While, 42 percent direct seeded rice farmers may attain profit efficiency ranging up to even 90-100%. Hence, there exists broad variation between direct seeded and transplanted rice farmers profit efficiency. On average, Direct seeded rice farmers have 26% more profit efficiency as compared to transplanted rice farmers.

Conclusion and policy implications:

The results entail that direct seeded farmers' profit efficiency is high as compare to transplanted rice farmers. By adopting direct seeded technique farmers can get higher economic return. Further, the results of inefficiency model suggest that government should focus on increasing the educational level of farming communities by opening more educational institutes in rural areas and ought to develop policies to extend support to educated farmers by providing attractive incentives. Moreover, the government should allocate more funds to strengthen the agriculture department and improve the network of extension services in the rural areas.

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Appendix Tables:

Table 1: Socio-economic characteristics of Rice farmers

S.#	**Variables**	**Conventional field Average**	**Direct Seeded field average**	**Unit**
1	Age	50	45	Years
2	Education	5	5	Years
3	Experience	35	40	Years
4	Farm to market distance	5	4	KM
5	Farm size	5-15	5-10	Acre
6	Household size	8-11	8-11	Number of person in each household

Table 2: Comparative Gross Margin analysis of Transplanting Rice & Direct seeded rice

Gross Margin Analysis of Transplanting Rice					Gross Margin analysis of Direct Seeded Rice				
Inputs	**Unit**	**Average Quantity**	**Price**	**Value**	**Inputs**	**Unit**	**Average Quantity**	**Price**	**Value**
Leaser leveller	Rs	1	2100	2100	Leaser leveller	Rs	1	2100	2100
Motivator	Rs	1	2000	2000	Rotavator	Rs	1	2000	2000
Ploughing	Rs	4 to 5	656	3280	Ploughing	Rs	3 to 4	660	2640
Planking	Rs	1 to 2	597	1194	Planking	Rs	1 to 2	564	1128
Tractor	Rs	1	2000	2000	Tractor	Rs	1	1750	1750
Seed	Cost	5-6 kg	96	576	Seed	Cost	15-16 kg	90	1440
Urea	Price per 50kg/ bag	1 to2	1800	3200	Urea	Price per 50kg/ bag	2	1800	3600
DAP	Price per 50kg/ bag	1 to 2	3800	7600	DAP	Price per 50kg/ bag	1 to 2	3800	7600
FYM	Rs/per trolley	4 to 5	1200	6000	FYM	Rs/pe r trolle y	4 to 5	1200	6000
Weedicide	Cost	2-3 litre	648	1944	Weedicide	Cost	5 to 6 litre	1600	9600
Insecticide	Cost	2-3 litre	2100	6300	Insecticide	Cost	2 litre	2045	4090
Pesticide	Cost	2-3 litre	884	1768	Pesticide	Cost	3 to 4 litre	1700	6800
Irrigation	#	22	1400	30800	Irrigation	#	15	1200	18000
Total variable cost				**70762**	**Total variable cost**				**66748**
Price of Rice straw	Rs			8820	Price of Rice straw	Rs			9112
Total Price of conventional rice output	Rs			81389.94 3	Price of rice output	Rs			88043.09
Gross Margin Effect				**20001**	**Gross Margin Effect**				**30407.09**

Table 3. Testing of Hypothesis

Likelihood ratio statistics calculation				
Hypothesis	**Transplanting Rice Test statistics values**	**Direct Seeded Rice Test Statistics Values**	**Critical Value**	**Decision**
$H_0 = \gamma = 0$	31.88	69.42	$\chi^2_{(1, 0.95)} = 1.58$	Rejected
$H_0 = \delta_o = \delta_d = 0$	16.08	37.09	$\chi^2_{(6, 0.95)} = 11.07$	Rejected

Table 4: profit Frontier Results:

Maximum Likelihood estimates of Profit Frontier Function						
			Transplanting Rice		**Direct Seeded Rice**	
	Variables	**Parameters**	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
	Constant	α_0	28.30	28.24***	7.491	7.645***
1	**ln P_p**	α_P	-30.04	-29.11***	-60.99	-65.57***
2	**ln P_s**	α_S	23.26	23.02***	122.83	124.1***
3	**ln P_{irr}**	α_{Irr}	6.054	6.809***	5.329	7.12***
4	**ln P_w**	α_w	-7.034	-7.536***	-1.596	-1.812*
5	**lnP_L**	α_L	-6.867	5.729***	-3.647	-3.763***
6	**lnP_F**	α_F	2.013	1.835*	1.5424	1.7831*
7	**lnZ_{CI}**	β_{CI}	-9.663	-7.020***	-2.6443	-4.5738***
8	**lnZ_{AR}**	β_{AR}	25.58	27.91***	5.294	5.886***
9	**1/2 lnP_px lnP_p**	φ_{pp}	-105.61	-11.77***	-88.57	-92.04***
10	**1/2ln$p_s$xlnP_s**	φ_{ss}	13.13	12.48***	-3.551	-3.62***
11	**1/2lnP_{irr}xlnP_{irr}**	φ_{irrirr}	-0.623	-10.72***	-4.183	-2.107**
12	**1/2lnP_W xlnP_w**	φ_{ww}	-0.1734	-0.8721^{ns}	1.182	1.381^{ns}
13	**1/2ln$P_L$xlnP_L**	φ_{LL}	71.86	72.89***	0.387	0.867^{ns}
14	**1/2ln$P_F$xlnP_F**	φ_{FF}	0.2517	0.4391^{ns}	0.328	0.227^{ns}
15	**1/2lnZ_{CI} xlnZ_{CI}**	θ_{CICI}	0.1920	1.8223*	0.212	1.45^{ns}
16	**1/2lnZ_{AR} x lnZ_{AR}**	θ_{ARAR}	65.47	73.87***	1.905	2.479*
17	**LnP_px LnP_s**	φ_{PS}	2.370	6.624***	3.211	8.425***
18	**LnP_p x lnP_{irr}**	φ_{pIrr}	-6.452	-15.59***	-2.274	-5.008***
19	**LnP_p xlnP_w**	φ_{pW}	69.19	63.17***	10.51	14.61***
20	**LnP_p xlnP_L**	φ_{pL}	-4.162	-9.277***	-0.253	-0.452^{ns}
21	**Ln$P_p$xlnP_F**	φ_{pF}	-3.945	-8.663***	-3.63	-6.658***
22	**LnP_px lnZ_{CI}**	τ_{PCI}	-0.5458	-1.141^{ns}	1.58	4.431***

23	**LnP_P xlnZ_{AR}**	τ_{PAR}	-34.71	-36.91***	-7.936	-10.67***
24	**LnP_sxLnP_{irr}**	φ_{sirr}	20.51	11.79***	8.397	9.674***
25	**LnP_sx LnP_w**	φ_{sw}	-203.58	-20.88***	-36.81	-42.49***
26	**LnP_s xLnP_L**	φ_{sL}	11.76	12.21***	-0.192	-0.283^{ns}
27	**LnP_s xLnP_F**	φ_{SF}	11.85	10.83***	12.98	16.98***
28	**LnP_s xLnZ_{CI}**	τ_{SA}	2.817	2.073**	-5.647	-7.161***
29	**LnP_s xLnZ_{AR}**	τ_{SL}	104.88	10.95***	30.88	34.49***
30	**LnP_{irr} xLnP_w**	φ_{Irrw}	-0.996	-0.1363^{ns}	0.452	0.892^{ns}
31	**LnP_{irr} xLnP_L**	φ_{irrL}	0.520	1.942*	0.0458	0.222^{ns}
32	**LnP_{irr} xLnP_F**	φ_{irrF}	0.3870	3.469***	-0.097	-1.213^{ns}
33	**LnP_{irr} xLnZ_{CI}**	τ_{irrCI}	-0.3529	-3.8117***	0.2434	1.979**
34	**LnP_{irr} xLnZ_{AR}**	τ_{irrAR}	-0.4568	-0.5698^{ns}	-0.226	-0.674^{ns}
35	**LnP_W xLnP_L**	φ_{WL}	-1.886	-6.793***	-0.541	-1.876*
36	**LnP_W xLnP_F**	φ_{WF}	-0.1379	-1.0551^{ns}	-0.0294	-0.237**
37	**LnP_w xLnZ_{CI}**	τ_{WCI}	-0.2677	-2.336**	-0.0294	-0.1298^{ns}
38	**LnP_w xLnZ_{AR}**	τ_{WAR}	4.8499	6.8082***	0.403	1.149^{ns}
39	**LnP_L xLnP_F**	φ_{LF}	-6.5334	-7.4704***	0.653	1.384^{ns}
40	**LnP_L xLnZ_{CI}**	τ_{LCI}	-0.8397	-0.8210^{ns}	-0.788	-2.197**
41	**LnP_L xLnZ_{AR}**	τ_{LL}	0.0207	0.0215^{ns}	-0.063	-0.469^{ns}
42	**LnP_F xLnZ_{CI}**	τ_{FCI}	-0.1668	-0.7821^{ns}	-0.179	1.5778^{ns}
43	**LnP_F xLnZ_{AR}**	τ_{FAR}	-0.5718	-3.1364***	-0.206	2.774***
44	**LnZ_{CI} xLnZ_{AR}**	θ_{AL}	1.5796	1.3395^{ns}	-0.781	-1.914*
	Variance Parameter					
	$\delta^2 = \delta^2{}_u + \delta^2{}_v$	δ^2	0.6906	12.15***	0.0689	11.05***
	$\gamma = {\delta^2}_u / \delta^2$	γ	0.9456	38.05***	0.9789	65.05***
	Log likelihood		-81.70		70.43	
	No of observation	N	150		150	

Note: *** Significant at 1 percent level
** Significant at 5 percent level
* Significant at 10 percent level

Table 5: Factor explaining inefficiency:

Inefficiency Model					
		Transplanting Rice		Direct Seeded Rice	
Variables	**Parameter**	**Coefficient**	**T-ratio**	**Coefficient**	**T-ratio**
Constant	ω_0	-12.38	-26.71***	-6.137	-3.991***
age	ω_1	-0.028	-3.285***	-0.939	-2.598***
Education	ω_2	-0.092	-2.247**	-0.058	-2.603***
Experience	ω_3	-0.043	-3.675***	-0.011	-1.967**
Extension Service	ω_4	-0.138	-1.706***	-0.125	-1.903*
Household size	ω_5	0.059	3.116***	0.013	1.923*
Tenancy Status	ω_6	-1.104	-4.420***	-0.292	2.403**
Number of observation	**300**	**150**		**150**	

Note:
*** Significant at 1 percent level
** Significant at 5 percent level
* Significant at 10 percent level

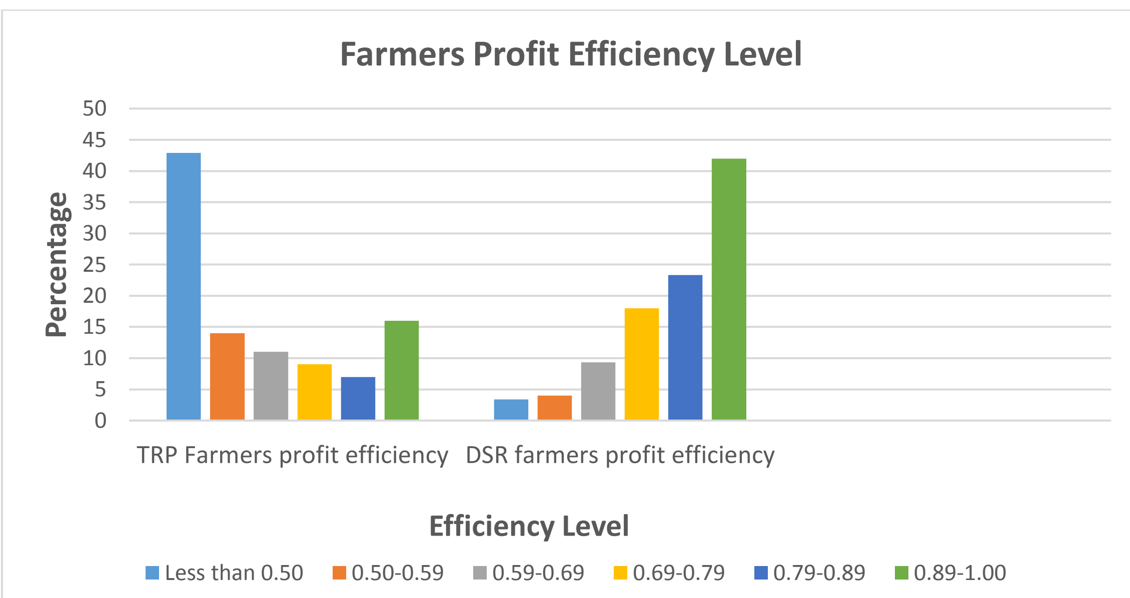

Figure 1. Profit efficiency of TRP and DRS farms