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Impact of Technology on Paddy Farms in Karaikal Region of Union Territory of Pondicherry

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Abstract

The present study conducted in Karaikal region of the Union Territory of Pondicherry during 2002-03 has revealed that paddy production through the direct-sown method is more profitable as compared to the traditional transplanting method. Direct-sown method reduces the requirements of plant nutrients, irrigation and labour and thereby costs of production. The productivity, however, has been found less with the direct sowing than the traditional sowing. But, due to reduction in production costs, farmers could realize higher net income from the adoption of direct-sown method. The technical efficiency is also less on direct seeded farms, indicating a need for improving farmers' skills in the application of new technology.

Introduction

Rice is a staple food of the millions of people in India, and occupies a prominent place in Indian agriculture. India produces 76 million tonnes of rice from an area of 40 million hectares. Over the last four decades, area and production have witnessed substantial growth. However, in recent years the growth in production has decelerated from 4 per cent during 1980s to 1.7 per cent during 1990s. This deceleration is largely on account of slowing down in the yield growth, from 3.6 per cent during the 1980s to 1.3 per cent during the 1990s. The mean yield of rice in India is about 1900 kg/ha.

There is a considerable scope in raising the yield even with the technologies currently on the shelf. The yield gap is estimated to be 40 per cent. This is because of imperfect adaptation to local environments, insufficient provision of nutrients and improper utilization of water and indifferent methods of controlling pests and diseases. An integrated approach

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is necessary to remove the technological, infrastructural and social and policy constraints responsible for the productivity gap and in some cases, productivity decline (Ramasamy and Mahesh, 2003). With this backdrop, this study has examined the impact of adoption of direct-sown paddy in the Karaikal region of the Union Territory of Pondicherry.

Methodology

Sampling Design

Amongst the four paddy growing regions in the Union Territory of Pondicherry, Karaikal region was selected for the present study. Sixty farmers from transplanting method and another 60 from direct-sown method, that is 120 sample farmers were selected randomly. The data and information pertaining to the agriculture year 2002-03 were collected by personal interview method using a pre-tested interview schedule.

Analytical Approach

Production Frontier

Frontier production represents the maximum possible output for any given set of inputs making use of the best available technology and thus sets a limit or frontier on the observed values of dependent variables; no observed value of output is expected to lie above this frontier. Any deviation of a farm from the frontier indicates the extent of farmer's inability to produce maximum output from the given set of inputs and hence represents the degree of technical inefficiency.

A production process may be inefficient in two ways, only one of which can be detected by an estimated production frontier. It can be technically inefficient, in the sense that it fails to produce maximum output from a given input bundle. The other type of inefficiency could be allocative inefficiency in the sense that the marginal revenue product of input might not be equal to the marginal cost of that input even though the technology is efficient. Allocative inefficiency results in utilization of inputs in the wrong proportion with the given input prices. Since, estimation of production frontiers is carried out with observations on output and inputs only, such an exercise cannot provide evidence on the matter of allocative inefficiency, and cannot be used to draw inferences about the total or economic inefficiency (Schmidt and Lovell, 1979, Banik, 1994 and Chattopadhyay and Sengupta, 2001).

The technical efficiency in production was estimated by using the stochastic frontier production function, which was independently proposed

by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). The estimation of stochastic frontier production function enabled us to find whether the deviation in technical efficiency from the frontier output is due to the firm-specific factors or external random factors (Baltese, 1991 and Baltese and Coelli, 1988). The stochastic frontier model can be represented by Equation (1):

$$Y_t = f(X_i, ß) \exp(v_i - u_i) \quad \ldots(1)$$

where,

Y_t = Production of the ith farm
X_i = A suitable function of the vector X_i of inputs for the ith farm
ß = The vector of unknown parameters
v_i = Symmetric component of the error-term, and
u_i = Non-negative random variable which is under the control of the farm.

Given the density function of u_i and v_i, the frontier production function can be estimated by Maximum Likelihood Technique.

Jondrow *et al.* (1982) had demonstrated that the farm-specific technical efficiencies can be estimated from the error-terms. It is possible because $\varepsilon_i = v_i + u_i$, can be estimated and it obviously contains information on u_i. One can evaluate by considering the conditional distribution of u_i in the given ε_i. This distribution contains all the information ε_i yields about u_i. For the commonly used cases of half-normal and exponential u_i, these expressions can be easily evaluated (Kalirajan and Chand, 1989; Mythili and Shanmugam, 2000). In the case of half-normal model, for each farm, the technical efficiency is the expected value of u_i conditional on ε_i.

The primary advantage of the stochastic frontier production function is that it enables the estimation of u_i and thereby the farm-specific technical efficiencies (Reddy and Sen 2003 and Shanmugam, 2003). The measure of technical efficiency is equivalent to the ratio of the production of the ith farm to the corresponding production value if the farm effect u_i were zero.

Following Baltese and Coelli (1988) and Thomas and Sundaresan (2000), when output is measured in logarithms, the farm-specific technical efficiency can be estimated by Equation (2):

$$TE_i = \text{Exp}(-u_i) \quad \ldots(2)$$

$$i = 1,2,3,\ldots,n, \; 0 \leq TE_i \leq 1$$

Model Specification

The stochastic frontier production function of the Cobb - Douglas type with the following specification was used for this study [Equation (3)]:

$$Y_i = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + v_i - u_i \quad \ldots(3)$$

where,

Y_i = Total output (yield/ha)
X_1 = Seed rate (kg/ha)
X_2 = Labour use (mandays/ha)
X_3 = Value of fertilizers and farmyard manure (Rs/ha)
X_4 = Value of plant protection chemicals (Rs/ ha)
X_5 = Number of irrigation (Number/ha)
X_6 = Value of capital services (Rs/ha)
β_0 = Constant term
u_i = Specific technical efficiency related factors
v_i = Random variable and
i = 1,2,3 ....., n.

The farm specific technical efficiencies were estimated from the residuals.

Results and Discussion

Estimates of the Frontier

The maximum likelihood estimates of the frontier production function are presented in Table 1. In the case of direct-sown method, the estimate of λ (640.8) was significantly different from zero, indicating a good fit and the correctness of the distributional assumption. The variance ratio (γ) showed that 99 per cent of the difference between the observed and the frontier outputs was due to differences not related to the random variability, but with the factors under the control of the farmers. With an upward shift in the constant term, the coefficient of seed rate, labour, value of FYM and fertilizers and number of irrigations remained significant in the stochastic production function. It implied that the farmers could use more of seed, labour and FYM and fertilizer and also number of irrigations.

In the case of transplanting method, the estimate of λ (728.4) was also significantly different from zero. The variance ratio showed that 99 per cent of the differences between the observed and the maximum production sector's level technical efficiency due to different management practices adopted was not related to random variability. With a positive shift in the intercept term, the coefficient of labour, value of FYM and fertilizers and plant protection chemicals remained significant in the stochastic production function. It implied that the farmers could use more of fertilizers and FYM, and reduce the use of labour and plant protection chemicals.

Table 1. Estimated parameters of MLE for direct-sown and transplanting of paddy in Karaikal region

Variables	Symbol	Coefficients of	
		Direct-sown	Transplanting
Constant term	β_0	0.1278	0.2374
		(1.5468)	(1.6426)
Seed rate (kg/ha)	X_1	0.4312**	0.4517
		(3.1248)	(1.7642)
Total labour (mandays/ha)	X_2	0.4754**	-0.5421**
		(3.4215)	(3.5176)
Value of FYM and fertilizers (Rs/ha)	X_3	0.1486**	0.1024**
		(2.9842)	(3.7648)
Value of plant protection chemicals (Rs/ha)	X_4	0.0163	-0.0148**
		(1.4256)	(2.6482)
Number of irrigations (No./ha)	X_5	0.0012**	0.0042
		(3.1028)	(1.6248)
Value of capital service (Rs/ha)	X_6	0.0742	0.0984
		(1.2846)	(1.4864)
λ		640.8	728.6
		(6752.4)	(8754.6)
γ		0.99	0.99
No. of observations		60	60

Note: The figures within the parentheses are 't' values
** indicates significance at 1 per cent level

Farm-specific Technical Efficiencies

The farm-specific technical efficiencies were estimated and the frequency distribution is presented in Table 2. In the case of direct-sown paddy, 10 per cent of the farms were most efficient (91-99 %) and 72 per cent were least efficient (64-80 %) with a mean technical efficiency of 63 per cent.

On the other hand, in the case of transplanted paddy, about 25 per cent farms belonged to the most efficient category and 22 per cent to the least efficient group, with the mean technical efficiency of 79 per cent. It was also observed that the farm-specific technical efficiency varied between 0.64 and 0.99 in both the groups of paddy farmers.

Therefore, in short-run it is possible to increase paddy yield on an average by 37.55 per cent in the case of direct-sown and 21.36 per cent in the case transplanting methods by adopting better management practices used by the best performers.

Table 2. Frequency distribution of technical efficiency

Efficiency level	Direct-sown	Transplanting
Low	43	13
(64-80)	(71.66)	(21.67)
Medium	11	32
(81-90)	(18.34)	(53.33)
High	06	15
(91-99)	(10.00)	(25.00)
Mean	62.45	78.64
Total Farms	**60.00**	**60.00**

Note: Figures within the parentheses indicate percentage to total

Table 3. A comparison of direct-sown and transplanted paddies

Particulars	Direct-sown paddy	Transplanted paddy	Change, %
Seed rate (kg/ha)	150	80	46.67
FYM and fertilizer (Rs/ha)	4100	5200	-26.83
Number of irrigations (No./ha)	07	15	-114.29
Labour use (mandays/ha)	305	422	-38.36
Total costs (Rs/ha)	15040	19735	-31.22
Yield (kg/ha)	3590	4185	-16.57
Net returns (Rs/ha)	6500	5375	17.31

Impact of Direct-sown Method

The level of inputs used and output obtained with the direct-sown and tranplaning methods are depicted in Table 3. Seed rate was 47 per cent higher with the direct-sown method than in the transplanting method. The costs on fertilizers and Farm Yard Manure (FYM), however, were less by 27 per cent in the former method. The number of irrigations given to the direct-sown paddy was 7 compared to 15 in the transplanted paddy. This suggested considerable water saving due to practising of direct sowing. Labour use with direct sowing was less by 39 per cent.

The direct sowing of paddy resulted in less production; the per hectare production was about 17 per cent less as compared to that in the transplanted paddy. The total cost per hectare however was less by more than 31 per cent in direct sowing of paddy. The reduction in costs resulted in higher net returns to the extent of 17 per cent in the direct-sown paddy.

Conclusion and Implications

It has been found that direct sowing of paddy requires lesser quantities of resources (FYM, fertilizers, labour and irrigation) and reduces the cost

of cultivation also. The reduction in costs is to the extent of 31 per cent. But, the direct sowing has resulted in 17 per cent less output per hectare. Yet, substantial reduction in production costs, makes the direct sowing more profitable compared to the conventional transplanting method. The technical efficiency estimates have indicated that there is a considerable scope to improve rice yield under direct-sown method as well as under transplanting method. With the direct transplanting, paddy yield can be improved by 38 per cent under direct-sown method and 21 per cent under transplanting method by adopting better management practices. The findings have suggested that there is a scope for improving the productivity through proper allocation of the existing resources. Hence, a proper extension strategy needs to be taken to popularize the adoption of direct sown method among the farmers with rational use of inputs. To achieve this, an interactive interface has to be created with the researchers, farmers and extension workers for realizing the economic benefits through adoption of the total package of direct-sown method.

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