



RESEARCH PAPER

To analyze the technical and allocative efficiency of drill paddy cultivation in Bhandara district

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Abstract : The present study on paddy was undertaken in Bhandara district of Vidarbha region. The district was selected purposively. Three tehsils were selected. Out of the seven tehsil, Sakoli, Lakhandur and Pauni tehsil was selected for the study based on drill paddy cultivars. Three villages were selected purposively from each tahsil and from each village 10 farmers were selected overall 90 farmers were selected. The study revealed that how different cost components affect the profitability of production paddy crop and also proposes that at how much level of efficiency, the farmer is producing the paddy crop and how much level of efficiency is yet to be obtained. The maximum livelihood estimates of the stochastic production function revealed that fertilizer showed a negative and significant effect on paddy production. The co-efficient of the frontier profit function revealed that machine hours, seed and fertilizer shows a negative and significant impact on paddy farmer profitability. The mean technical, economic and allocative efficiency of paddy cultivation was found to be 97.49 per cent, 87.97 per cent and 89.86 per cent indicated that there is still scope for paddy farmers to increase the economical and allocative efficiency by operating at a full efficient level by proper utilization and allocation of existing resources and technology.

Key Words : Drill Paddy, Technology, Allocative efficiency

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INTRODUCTION

Paddy (*Oryza sativa*) is that the most vital and most generally consumed staple food for the majority of the world's population, particularly Asia and Africa. Global paddy production has been on a snow balling trend since the sixties and has risen from 605 million tonnes in 2005 to 755.48 million tonnes in 2020 and in 2021-2022 is to be a record 510.8 million tonnes (milled basis), down 0.9 million tonnes from the previous year. In 2021, China

and India produced 212.8 and 195 million tonnes of paddy, respectively. In India, agriculture is the main occupation. Around 58 per cent of the population depends upon agriculture. It's the backbone of the Indian economy and is that the oldest and largest occupation of India. In agriculture paddy is one of the vital and most important food crop of India and second in throughout the globe. It feeds around or more than 50 per cent of the world's population. It is the staple food of most of the people of

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South-East Asia. Asia accounts for about 90 per cent and 91 per cent of world's paddy area and production, respectively. One-third world's paddy cultivation area, *i.e.*, 83 million hectares in India. It's grown in the majority the states of India but is generally concentrated within the river valleys, deltas and low lying coastal areas of north eastern and southern India. The paddy producing states are Assam, West Bengal, Bihar, Madhya Pradesh, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat and state of Jammu and Kashmir, which together contribute over 95 per cent of the crop. Of these, West Bengal, Orissa, Andhra Pradesh, Tamil Nadu and Bihar are the highest cultivators of rice. The production of paddy rise from 74.3 million tons in 1990-91 to 120 million tons in 2020-21 (Statistical Abstract, Maharashtra, 2021).

Maharashtra is a significant paddy producing state in central India. Cultivation is almost entirely mono-crop, with paddy accounting for approximately 97 per cent of food grain production and approximately 80 per cent of total cropped area. The state has 14.99 lakh hectares of paddy land, producing 32.37 lakh tons with a productivity of 2.01 tons per acre in 2020-21. (Statistical Abstract, Maharashtra, 2021). The important paddy growing region in Maharashtra is all the districts of Konkan region and Bhandara, Gondia, Chandrapur and Gadchiroli and part of Nagpur district in Vidharbha. Vidarbha cover 7.36 lakh hectare area and 11.92 lakh metric ton production under paddy.

In Bhandara district around 175403 area (ha) under rice cultivation, with production of 239775 (MT) and productivity of 13.67 (Qt/ha) in year 2021-22. (District profile-KVK, Sakoli). Rice is grown to some extent in all the talukas of Bhandara district. It is grown on a large scale in Bhandara, Lakhani, Sakoli, Lakhandur, Tumsar, Pauni and Mohadi talukas in *Kharif* season as well as in summer season under irrigated condition.

Objective :

To analyze the technical and allocative efficiency of drill paddy cultivation.

MATERIAL AND METHODS

Technical and allocative efficiency :

In the present study stochastic production frontier function and stochastic frontier profit functions were used to determine the farm-specific technical and economic efficiencies, respectively.

Stochastic production frontier function :

In the present study, the stochastic frontier approach was used to measure the farm specific efficiencies of *Rabi* onion crop (Aigner *et al.*, 1977; Kalirajan and Shand, 1889 and Sharma and Datta, 1997). The stochastic frontier model is called a 'composed' model because the error term is composed of two independent elements, namely.

$$\Sigma_i = v_i - u_i \quad i = 1, \dots, n$$

The term v_i is the symmetric component and permits random variation in output due to factors like weather and plant disease. It is assumed to be identically and independently distributed $v_i \approx N(0, \sigma^2 n)$. A one-sided component ($u_i \geq 0$) reflects technical efficiency relative to stochastic frontier $Q_i = Q(X_k, \beta) e^{v_i}$. Thus $u_i = 0$ for any farm lying on the frontier while $u_i > 0$ for any farm lying below the frontier. Hence, expression (u_i) represents the amount by which the frontier exceeds realized output. The distribution of u_i is assumed to be half-normal.

A measure of technical efficiency was first introduced by Farrell (1957) for a cross-section of firms by using a deterministic approach. He illustrated his ideas of efficiency using a simple example involving firms that use two inputs (x_1 and x_2) to produce a single output (q), under the assumption of constant returns to scale. The curve SS2 in following figure represents the unit isoquant of fully efficient firms and permits the measurement of technical efficiency. If a given firm uses quantities of inputs, defined by the point P, to produce a unit of output, the technical inefficiency of that firm is represented by the distance QP, which is the amount in which all inputs could be proportionately reduced without a reduction in output. This is usually expressed in percentage terms by the ratio QP/OP, which represented the percentage in which all inputs can be optimally reduced to achieve technically efficient production. Hence, the technical efficiency (TE) of a firm can be measured by the ratio

$$TE = OQ/OP$$

Technical inefficiency is equal to $1 - OQ/OP$ and takes a value between zero and one. Hence, it provides an indicator of the degree of technical inefficiency of the firm. A value of one implies that the firm is fully technically efficient.

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + (V_i - U_i)$$

where,

Y_i = Output of onion crop (Quintals/ha)

X_1 = Human labour (days/ha)

X_2 = Machine hours (hrs/ha)

X_3 = Quantity of seeds (kg/ha)

X_4 = Quantity of fertilizers (kg/ha)

V_i = Random variable

U_i = Farm specific technical efficiency related variable

β_0 = Intercept/Constant.

Stochastic profit frontier function :

Stochastic frontier profit function was used to estimate economic efficiency of *Rabi* onion crop. (Ali and Flinn, 1989; Rahman, 2003 and Galawat and Yabe, 2012). The stochastic profit frontier function was estimated as :

$$\Pi_i = f(X_i, P_i) + (v_i - u_i)$$

where,

Π_i = Normalized profit at cost-A of the i^{th} farmer.

X_i = The vector of variable input prices divided by output price faced by the i^{th} farm.

P_i = The vector of fixed factor of the i^{th} farm.

V_i = Random error due to factors outside the control of the farmers.

U_i = A non- negative random variable associated with economic inefficiency component

The economic efficiency in relation to the stochastic profit frontier is given by,

$$EE_i = \exp(-u_i)$$

Specification of the model :

$$\ln \Pi_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + (V_i - U_i)$$

where,

Π_i = Normalized profit at Cost-A of the i^{th} farmer.

X_1 = Human labour wage rate per hr normalized by output price of i^{th} farm.

X_2 = Machine wage rate per hour normalized by output price of i^{th} farm.

X_3 = Price of seed per kg normalized by the output price of i^{th} farm.

X_4 = Price of fertilizer per kg normalized by the output price of i^{th} farm

V_i = Random variable

U_i = Farm-specific economic efficiency related variable

β_0 = Intercept

Factor price is obtained by dividing the price of input with the output price. Allocative efficiency was estimated by dividing economic efficiency with technical efficiency for each farm.

$$AE_i = EE_i / TE_i$$

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads :

Technical and allocative efficiency of drill paddy : Estimation of co-efficient of stochastic frontier production function (Drill paddy) :

Maximum likelihood estimates (MLE) of stochastic frontier production function along with mean technical efficiency are presented in Table 1.

The results of the stochastic frontier production function estimates for drill paddy crop are shown. Area

Table 1 : Co-efficient of stochastic frontier production function

Variables	Co-efficient	Standard error
Intercept	1.32563	0.89152
Area (Ha)	0.89534*	0.35944
Human labour (Hrs/ha)	0.18604	0.18462
Machine hours (Hrs/ha)	0.00692	0.08808
Seed (Kg/ha)	0.12038	0.07965
Fertilizer (Kg/ha)	-0.07437***	0.36811
Manures	0.16068*	0.02155
Sigma-squared	0.15478	
Gamma	0.79422	
Log-likelihood function	71.78	
Mean TE (%)	97.49	

Note: Figures in parenthesis indicate standard errors of the respective co-efficients

*and *** indicate significance of values at P=0.01 and 0.1, respectively

is positive and statistically significant (0.89534). This implies large operational area is an important contributor to improvement of technical efficiency in agricultural production practices. Statistically significant and positive value of the estimated co-efficient indicated that farmers could increase per hectare yield by applying more units of these inputs. The estimated elasticity of manures is 0.16 and statistically significant. This means that a amount of manures used in the paddy production increases by 0.16 per cent. The elasticity of fertilizer (-0.07437) present a negative and it's statistically significant. This implies that as the fertilizer increases, paddy output decreases by 0.07 per cent. The co-efficients of human labour, machine hour and seed were positive though non-significant. The gamma value of MLEs of stochastic frontier production model is 0.79. This value is implying that 79 per cent of variability of revenue from agricultural production is attributed to the technical efficiency in agricultural production techniques and rest (21%) is due to random noises. The estimate of sigma squared (0.15)

was positive elasticity. The log likelihood function (71.78) was positive and significantly different from zero indicating a good fit and the correctness of the specific distribution assumption.

From the Table 2 it is observed that, the minimum technical efficiency was 81.24 and the maximum technical efficiency was 99.94. The mean technical efficiency was 97.49.

Estimation of co-efficient of stochastic frontier profit function (Drill paddy)

The maximum likelihood estimates of the stochastic profit frontier production are represented in Table 3.

The co-efficient of fertilizer (-0.44847) and seed (-0.16796) showed a significant negative effect on the profits. The result showed that one per cent increase in the prices of fertilizer and seed decrease the profit by 0.45 and 0.17 per cent, respectively. The log likelihood

function (-53.36) was negative and significantly different from zero indicating a good fit and the correctness of the specific distribution assumption. The mean economic efficiency of the sample farms was 87.97 per cent which means, in principle that the sample farms can potentially reduce their overall cost of production, on average, by 12 per cent and still achieve the existing level of output. These results indicate the potential to further improve the economic efficiency by 12 per cent.

Economic efficiency of sample farm :

The frequency distribution of sample farms by the level of economic efficiency in rising the paddy crop is shown in Table 4.

From above Table 4 it was observed that, mean economic efficiency was 87.97 per cent. The minimum economic efficiency was 27.66 per cent and maximum economic efficiency was 99.72 per cent.

Table 2 : Distribution of sample farmers under different levels of technical efficiency

TE (%)	No. of farm	Percentage to total	Average	Percentage to increase production to achieve maximum efficiency
20.01-30	0	0	0	0
30.01-40	0	0	0	0
40.01-50	0	0	0	0
50.01-60	0	0	0	0
60.01-70	0	0	0	0
70.01-80	1.00	1.11	79.94	20.01
80.01-90	5.00	5.56	87.10	12.85
>90	84.00	93.33	98.31	1.63
Mean TE (%)	97.49			
Min TE (%)	81.24			
Max TE (%)	99.94			

Table 3 : Co-efficient of stochastic frontier profit function

Variables	Co-efficient	Standard error
Intercept	11.27587***	3.13048
Human labour (Rs/hrs)	0.51900*	0.74757
Machine labour (Rs/hrs)	- 1.42495	0.82106
Seed (Rs./Kg)	- 0.16796*	0.13904
Fertilizer (Rs./Kg)	- 0.44847***	0.48241
Manures (Rs./Kg)	0.09095	0.26486
Sigma squared	0.64499	
Gamma	0.86878	
Log -likelihood function	-53.36	
Mean EE (%)	87.97	

Note: Figures in parenthesis indicate standard errors of the respective co-efficients * and *** indicate significance of values at P=0.01 and 0.1, re

Allocative efficiency of sample farmers (Drill paddy):

The mean allocative efficiency of the sample farms was 89.86 per cent which means, the potential to further improve the allocative efficiency by 10.14 per cent. In the area the allocative efficiency ranges from 29.86 to 108.61 per cent with a mean efficiency of 89.86 per cent. For the average efficient farmers in the area, to achieve the allocative efficiency level of the most efficient farmers could only bring about 18.75 per cent increase in production. The least efficient farmers can increase the production of 78.75 per cent to achieve the

required alloc ative efficiency of the most efficient farmers.

An examination of Table 5 indicates that majority 72.22 per cent of the sample farmers achieved allocative efficiency of above 90 per cent followed by 8.89 per cent of the sample farmers achieved 80 to 90 per cent efficiency level. 6.67 per cent of the sample farm achieved efficiency level between 70 to 80 per cent. 5.56 per cent and 2.22 per cent of the sample farm achieved efficiency level between 60 to 70 per cent and 50 to 60 per cent, respectively.

Table 4 : Distribution of sample farmers under different levels of economic efficiency

EE (%)	No. of farm	Percentage to total	Average	Percentage to increase production to achieve maximum EE
20.01-30	1.00	1.11	27.66	72.26
30.01-40	1.00	1.11	30.54	69.37
40.01-50	4.00	4.44	45.48	54.39
50.01-60	2.00	2.22	57.22	42.62
60.01-70	4.00	4.44	64.85	34.97
70.01-80	7.00	7.78	74.59	25.20
80.01-90	7.00	7.78	86.29	13.47
>90	64.00	71.11	96.51	3.22
Mean EE(%)	87.97			
Min EE (%)	27.66			
Max EE (%)	99.72			

Table 5 : Distribution of sample farmers under different levels of allocative efficiency

AE (%)	No. of farm	Percentage to total	Avarage	Percentage to increase production to achieve maximum AE
20.01-30	1.00	1.11	29.86	72.71
30.01-40	1.00	1.11	38.21	65.00
40.01-50	2.00	2.22	49.32	54.74
50.01-60	2.00	2.22	50.46	53.69
60.01-70	5.00	5.56	64.53	40.70
70.01-80	6.00	6.67	76.92	29.26
80.01-90	8.00	8.89	86.29	20.61
>90	65.00	72.22	97.62	10.15
Mean AE(%)	89.86			
Min AE (%)	29.86			
Max AE (%)	108.61			

Conclusion :

The mean level of technical efficiency has been estimated as 97.49 per cent for farms as a whole Hence, on an average, approximately 3 per cent of technical potentials were not realized. Therefore, it is possible to improve the yield by 3 per cent by following efficient crop management practices.

The economic efficiency of selected farmers ranges from 27.66 to 99.72 with a mean efficiency of 87.97 per cent. For the average efficient farmers in the area, to achieve the economic efficiency level of the most efficient farmers could only bring about 11.75 per cent increase in profit. The least efficient farmers can increase the profit of 72.06 per cent to achieve the required economic efficiency of the most efficient farmers.

The allocative efficiency ranges from 29.86 to 108.61 per cent with a mean efficiency of 89.86 per cent. For the average efficient farmers in the area, to achieve the allocative efficiency level of the most efficient farmers could only bring about 18.75 per cent increase in production. The least efficient farmers can increase the production of 78.75 per cent to achieve the required allocative efficiency of the most efficient farmers.

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