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A Comparative Study of Technical Efficiency of Rice Production in Irrigated and Rainfed Environment of Uttrakhand

Rekha Rani[1*] • H. N. Singh[2]

[1]Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005, Uttar Pradesh

[2]Department of Agricultural Economics, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar 263145, Uttarakhand

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ABSTRACT

Agriculture has a key position in India's economy in respect of employment generation and contribution to the national income and international trade. Keeping its importance in view it becomes important to study how improvements can be made in the productivity of this sector. In this paper an attempt has been made to estimate farm level technical efficiency of rice production in two distinct rice growing environments viz. rainfed and irrigated environment of uttarakhand state. Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. The primary data was collected from 60 farmers, 30 each from rainfed and irrigated environment of the hill district during 2011-12 year. To determine technical efficiency of the farmers, frontier production function was estimated by using Corrected Ordinary Least Square (COLS) technique. The calculated technical efficiency of the farmers in rainfed environment varied between 68 to 89 per cent with a mean of 79 per cent whereas in irrigated environment technical efficiency of the farmers varied between 86 to 99 per cent with a mean of 94 per cent. It indicates that about 21 per cent less than maximum possible output is being obtained in rainfed environment whereas in irrigated it was 6 per cent less than the maximum possible output. The study suggest that the policy measures like effective and flexible agricultural extension network should be adopted in different environments as per their suitability so that the resources can be utilized efficiently and maximum output can be achieved from the available inputs.

1. Introduction

Agriculture is one of the strongholds of the Indian economy providing employment and livelihood to a significant proportion of the population especially in the rural areas. Approximately 50 per cent of India's total work force is employed in agriculture and allied sectors like forestry, logging and fishing. The share of agriculture in the gross domestic product has registered a steady decline yet this sector provides direct employment in the country and a large proportion of the population depends upon agro-based industries and trade of agriculture products.

In 1950-51 agriculture and allied sector contributed about 51.9 per cent of GDP at constant (2004-05) prices. It declined to 29.4 per cent and 14.4 per cent in 1990-91 and 2011-12 respectively (Central Statistics Office). The total geographical area of India is 329 million hectares of which 141 million hectares is net sown area, while 195.25 million hectares is the gross cropped area (Directorate of Economics and Statistics, Ministry of Agriculture, GOI). India is the world's largest producer across a range of commodities due to its favorable agro-climatic conditions and rich natural resource base.

*Corresponding author: rekhatamta10@gmail.com

It is second largest producer of rice, wheat, sugar, cotton, fruits and vegetables. Rice is the most important food crop of the developing world and the staple food of more than half of the world's population. More than 90 percent of the world's rice is produced and consumed in Asia which is home for more than 60 percent of earth's population. In Asia, India has the largest area under rice (44.01 million hectares) and is second in rice production (105.31 million metric tonnes) next to China accounting for 22.81% of global production in 2011-12. The productivity of rice has increased from 19.84 quintal per hectare in 2004-05 to 23.93 quintal per hectare in 2011-12. Rice is cultivated in both kharif and rabi season. Rice is basically kharif season crop contributing 88.07 per cent whereas rabi rice shares only 11.93 per cent of total rice production. Rice is grown in all the states of the country with maximum area under Uttar Pradesh (59.47 lakh hectares), production under West Bengal (14.61 million metric tonnes) and the maximum productivity is of Punjab (37.41 quintals per hectare) in the year 2011-12 (Annual Report 2013-14, Department of Agriculture and Cooperation, Ministry of Agriculture, GOI).

Out of 329 million hectares of the total geographical area of the country, hills and mountains cover 33 per cent. Uttrakhand is basically a hill state with total geographical area of 53,483 sq. km. and is divided into hills and plains contributing 86.07 and 13.93 per cent respectively to total geographical area. Total reported area under agriculture is 5.67 million hectares out of which only 12.76 per cent area is net area sown. State's important crops are wheat, rice, maize, barley, finger millet, sorghum, little millet, pulses etc. Maximum area is under wheat cultivation which covers 41.17 percent followed by rice contributing 31.24 percent of the total area under cereal cultivation. In Uttrakhand rice is grown in an area of 0.28 million hectares. The annual rice production of the state is around 5.94 lakh tonnes and the productivity is 21.20 quintals per hectare in the year 2011-12. Half of this area is in the plains and half in the hills, but the total rice production of the plain is twice to the total production of the hills. (Uttrakhand at a Glance 2011-12).
Rice is cultivated in the hills of Uttrakhand state in two distinct environments namely, rainfed and irrigated by different categories of farmers with predominance of marginal and small farmers. The promising rice establishment methods in rainfed are direct-seeded while in irrigated environment are transplanting. Therefore, there is lot of variations in costs and returns in different environments. Being such an important crop of the state its improvement in productivity level is a matter of great concern.

It seems like a big challenge for the farmers insuch a hill district where many farmers are with low literacy rates, inadequate physical infrastructure and small land holdings. These biophysical and socio-economic constraints resulted into low productivity. In this context increasing technical efficiency assumes significance to improve productivity of rice. Since rice being the most staple food in the region, improvement in the efficiency level is one of the major means of sustaining their food production and thereby ensuring food security. Efficiency is a very important factor of productivity growth especially in developing agriculture economies. Efficiency studies help countries to determine the extent to which they can raise productivity by improving the neglected source i.e. efficiency, with the existing resource base and the available technology. Such studies could also support decisions on whether to improve efficiency first or to develop a new technology in the short run. More importantly, enhanced technical efficiency will not only enable farmers to increase the use of productive resources, it will also give direction for the adjustments required in the long run to achieve food sustainability and thereby ensuring food security.

2. Materials and methods

Among hill districts of Uttarakhand Champawat was selected for the study. It has significant area of 7360 ha under rice cultivation with production of 9130 metric tonnes in 2011-12. The rice productivity was 12.41 quintals per hectare which was much lower than the state's productivity. The rice productivity in the district is stagnating for the past several years. Rice occupied second highest cropped area with 28.60 per cent after wheat covering 32.94 per cent among cereal crops in the district. The district comprises of four blocks, which are Champawat, Lohagahat, Barakot, Pati. Both irrigated and rainfed rice is grown in all the four blocks. Out of four blocks, Champawat block was selected for irrigated rice since it accounts for maximum area under cultivation. Lohaghat block was selected from remaining blocks as it has maximum area under rainfed rice cultivation (District statistical view – 2013, Champawat). From each block one village was selected having maximum geographical area and from selected village 30 farmers were selected randomly. The data was collected by personal interview of the selected respondents using a pre- tested schedule designed particularly for this study. The technical efficiency has been defined as the ratio of actual output to potential output given by the frontier production function as defined by Leibenstein (1966) for a given set of inputs and technology. Most of the farmers operate under uncertain conditions therefore the current study employed the Stochastic Production Frontier

Approach (Kadiri et al. 2014). Stochastic frontier production function can be estimated using either the Maximum likelihood (ML) method i.e. a non-parametric approach or using a variant of the Corrected Ordinary Least Squares (COLS) method i.e. a parametric approach suggested by Richmond in 1974 (Ogunniyi et al. 2011). In this study the COLS approach is used because it is simple and is not as computational demanding as ML and is very widely used method to calculate technical efficiency

Corrected Ordinary Least Squares Method:

First, the Cobb- Douglas production function was estimated at the average resource use level of the sample farmers.

$\ln Y_j = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + \ln u_j$…………(1)

Then the frontier production function was estimated by finding the largest error amount and shifting the intercept of estimated Cobb Douglas production by this largest error amount.

$\ln u_j = \ln Y_j – \ln \hat{Y}_j$

$\ln Y^*_j = (\ln a + u_j \max) + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5$……....... (2)

$\ln Y^*_j = \ln a_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5$ …………………... (3)

Thus the frontier production was obtained showing the largest possible output level at the average resource use of the sample farmers. The technical efficiency indices were then calculated for each farmer.

TEj = Yj / Y*j OR ln TEj = ln Yj – ln Y*j ……………………(4)

Where,

TEj = Technical efficiency of j^{th} farmer

Yj = Actual gross return in Rs/ ha of j^{th} farmer

Y*j = Potential (maximum possible) gross return of j^{th} farmer at present input use.

ln = Natural logarithm.

In this study, five variables were used for each rainfed and irrigated environment. Out of these five variables viz. expenditure on human labour(X_1), expenditure on FYM (X_2), expenditure on fertilizer (X_3), expenditure on seeds (X_4), were common for both the environments. Expenditure on bullock labour(X_5) and expenditure on plant protection chemicals (X_5) was the only variable selected separately for rainfed and irrigated environment respectively as per their applicability in the study area. The unit used for each variable was Rs/ha. Thus two different Cobb- Douglas production functions were estimated separately for both the environments.

3. Results And Discussion

The study shows that rice was grown in kharif season only in both the environments. Rice accounted for 52.30 and 95.12 per cent to total cropped area in rainfed and irrigated environment respectively. The study further reveals that the sources of income of rice growing farmers in both the environments were highly diversified. Government jobs were the main source of income in both the environment. Agriculture including rice, wheat and livestock production together contributed small share i.e. 2.35 per cent and 9.82 percent to total income of sample households in rainfed and irrigated environment respectively. The study reveals that share of income from rice was negative i.e. 0.29 per cent in rainfed, while it was 4.56 per cent in irrigated environment. It indicates that rice growing farmers of rainfed environment were sacrificing their 0.29 per cent share of income by cultivating rice. Despite of negative net return from rice cultivation, farmers continued this practice due to the zero opportunity cost of family labour especially women and to meet the food sufficiency goal of the households. The study also finds that in case of adult female literates there was a great difference between both the environments. In irrigated environment it accounted for 37.79 per cent whereas in rainfed it was 13.95 per cent only.

Technical efficiency of the sample households were estimated by using stochastic frontier production function approach. The estimates of parameters of frontier production function for rainfed environment is presented in table 1. Table reveals that only expenditure on bullock labour was significant and has a negative coefficient implying a negative impact on the gross return. The estimated coefficients for expenditure on human labour, expenditure on FYM and expenditure on fertilizer in the production function though not significantly different from zero but have positive values implying that increasing these variables will also increase the gross return. The coefficients for expenditure on seeds were also not significantly different from zero and have a negative sign implying negative influence on the output. The value of R^2 indicates that the 43.6 per cent variation in gross return is due to selected variables of the model. The estimates of parameters of frontier production function for irrigated environment is presented in table 2. The table reveals that in irrigated environment the variable inputs such as expenditure on human labour, expenditure on plant protection chemicals, expenditure on FYM, expenditure on fertilizer, and expenditure on seeds are significant factors influencing the gross return.

Table 1. Estimated coefficient of frontier production function for rainfed environment

Variables	Parameter	Estimated Coefficient	SE	t – value
Constant	β_0	3.8847	4.138	0.938
Expenditure on human labour (Rs/ha)	β_1	1.3062	1.019	1.281
Expenditure on bullock labour (Rs/ha)	β_2	-0.763*	0.342	-2.231
Expenditure on FYM (Rs/ha)	β_3	0.799	0.874	0.091
Expenditure on fertilizer (Rs/ha)	β_4	0.035	0.073	0.487
Expenditure on seeds (Rs/ha)	β_5	-0.732	1.166	-0.627
Multiple Determination	R^2	0.436		

*means significant at 5 % level of significance

Table 2. Estimated coefficient of frontier production function for irrigated environment

Variables	Parameter	Estimated Coefficient	SE	t - value
Constant	β_0	1.436	2.022	0.709
Expenditure on human labour (Rs/ha)	β_1	0.175*	0.035	4.929
Expenditure on plant protection chemicals (Rs/ha)	β_2	-0.247*	0.039	-6.309
Expenditure on FYM (Rs/ha)	β_3	1.325*	0.645	2.052
Expenditure on fertilizer (Rs/ha)	β_4	0.106*	0.048	2.186
Expenditure on seeds (Rs/ha)	β_5	-0.425*	0.147	-2.88
Multiple Determination	R^2	0.705		

*means significant at 5 % level of significance

The estimated coefficient of expenditure on human labour, expenditure on FYM, expenditure on fertilizer are positive, implying that rice output increases with increasing these factors. But the estimated coefficient of expenditure on plant protection and seeds were negative implying a negative influence on the gross return, if applied more. Further result shows that 70.5 per cent variation in the gross return is explained by the variables employed in regression model.

The distribution of farmers in different groups of technical efficiency ranges is presented in table 3. The wide variations were observed in the level of technical efficiency across the two different environments in cultivating the rice. The calculated technical efficiency of the farmers in rainfed environment varied between 68 to 89 per cent with a mean of 79 per cent and about 73 per cent farmers were in between the technical efficiency 70-80 per cent. In irrigated environment technical efficiency of the farmers varied between 86 to 99 per cent with a mean of 94 per cent. In irrigated environment around 67 per cent of rice growing farmers were operated closer to the frontier level with technical efficiency of more than 90 per cent. Thus the table concludes that the rice growing farmers in irrigated environment were technically more efficient than the farmers in rainfed environment.

Table 3. Distribution of farmers under different levels of technical efficiency

Efficiency (%)	Rainfed	Per cent to total	Irrigated	Per cent to total
Less than 70	2	6.67	0	0
70-80	22	73.33	0	0
80-90	6	20	10	33.33
90-100	0	0	20	66.67
Total farmers	30	100	30	100
Mean TE	79		94	

Conclusions

Uttrakhand is primarily an agricultural state where rice shares maximum area after wheat under cereal cultivation. Rice is grown in irrigated and rainfed environment of the state.

Being such an important crop of the state its improvement in productivity level is a matter of great concern. In this context increasing technical efficiency assumes significance to improve productivity of rice. For estimating technical efficiency, stochastic production function approach was used. The parameters of frontier production function were estimated using the COLS method. The study undertaken shows that the rice growing farmers in irrigated environment were technically more efficient than the farmers of rainfed environment. The technical efficiency of the farmers indicated that about 21 per cent less than maximum possible output is being obtained in rainfed environment whereas in irrigated it was 6 per cent less than the maximum possible output. This is the significant measure of yield gaps existing at the farm level at the available resource use and technology adopted in the area. Though efficiency measured in value terms, it is directly related to yield gaps because uniform prices of inputs and outputs were used for this purpose. This gap can be minimized by proper management and proper allocation of the existing resources and technology. So there is a need that policy makers should focus not only on adoption of improved technology but also on promoting efficient utilization of resources. This may be done firstly, through strengthening the extension machinery to improve farmers' practices through extension service and training programmes, so that farmers can apply available agricultural technology more efficiently. Secondly, providing inputs to the farmers timely even in the remotest area. Thirdly, since female significantly contributes in the agriculture as a farm labour, their education is the foremost need of the time.

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