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Research Note

Resource–use Efficiency and Technical Efficiency of Turmeric Production in Tamil Nadu — A Stochastic Frontier Approach

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Abstract

The resource-use efficiency and technical efficiency of turmeric production have been computed using primary data collected from 90 turmeric growers spread over three blocks in Dharmapuri district of Tamil Nadu. The study has revealed that planting material, nitrogen, potash, harvesting and curing cost, machine hours and irrigation have a positive and significant influence on turmeric yield. Economic efficiency of these variables, except harvesting and curing cost, is more than one, indicating that these resources are being used at sub-optimum levels and there exists the possibility of enhancing the yield of turmeric by increasing their use. The technical efficiency of about 69 per cent of sample farmers has been found more than 80 per cent, which indicates the possibility of increasing the yield of turmeric by adopting better technology. Non-availability of labour has been reported the major production constraint by the turmeric growers. The study has suggested some measures to increase productivity and income of farmers in the study area.

Key words: Turmeric, resource-use efficiency, technical efficiency, stochastic frontier function, Tamil Nadu

JEL Classification: Q11, Q12, Q13

Introduction

Turmeric (*Curcuma longa*) is an important commercial spice crop. India is the largest producer, consumer and exporter of turmeric. Its share in global turmeric production was about 78 per cent in 2008-09. The state of Tamil Nadu accounted for about 17 per cent of total area under turmeric in India and its share in production was 21 per cent during 2008-09. The increase in production is possible mainly through improvement in productivity of the crop that could be achieved by efficient utilization of available resources. In this context, assessment of the existing level of resource-use and technical efficiency in production of turmeric assumes paramount importance. Hence, the present study was conducted with the overall objective of assessing the efficiency of turmeric production, with the following specific objectives: (i) to find resource-use efficiency in turmeric production, (ii) to estimate technical efficiency of turmeric farms, (iii) to identify the constraints in production of turmeric, and (iv) to suggest measures for improvement.

Methodology

Sampling and Data Collection

The area chosen for study was Dharmapuri district, which is one of the major turmeric growing districts in Tamil Nadu. It accounted for 15.2 per cent of the total state area and12.8 per cent of the total state production. But, the productivity of turmeric was only 4194 kg/ha (2009-10), which is low in comparison to the state

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average of 5067 kg/ha. Based on the criterion of highest area under turmeric, three blocks and from each block, two villages were selected. From each selected village, fifteen turmeric growers were selected at random with the sample size of 90 farmers. Primary data were collected using pre-tested interview schedule through personal interviews.

Analytical Framework

Production Function

The resource-use efficiency of the inputs used by the turmeric-growing farmers was estimated using Cobb-Douglas (CD) production function, as given below:

$$Y = a\, X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} U_t \qquad \ldots(1)$$

where, Y is the yield of turmeric (dry rhizome) (kg/ha); X_1, X_2, X_3 and X_4 denote quantities (in kg/ha) of planting material, nitrogen, phosphorus and potash, respectively; X_5 is the cost of harvesting and curing (Rs/ha), X_6 is the machine hours (hour/ha), and X_7 is the irrigation (No./crop season).

Resource-use Efficiency

The estimated coefficients of significant independent variables were used to compute the marginal value products (MVP) and the resources-use efficiency (r) was worked out using Equation (2) (Rahman and Lawal, 2003):

$$r = MVP/MFC \qquad \ldots(2)$$

where, $MVP_i = \beta_i \dfrac{\overline{Y}}{\overline{X}_i} \times P_y$

Here,

MVP_i = Marginal value product of the i[th] input,

$\overline{Y}$ = Geometric mean of the value of output,

$\overline{X}_i$ = Geometric mean of the i[th] input,

β_i = Estimated co-efficient (or) elasticity of the i[th] input, and

P_y = Price of output.

The relative percentage change in MVP of each resource was required to obtain optimal resource allocation estimated using Equation (3):

$$D = (1 - MFC/MVP) \times 100 \qquad \ldots(3)$$

where, D is the absolute value of percentage change in MVP of each resource (Mijindadi, 1980).

Stochastic Frontier Production Function

Given the inherent nature of India's agricultural production, stochastic frontier production function was employed to assess the technical efficiency of turmeric. The model for cross-sectional data as defined by Aigner *et al*. (1977); Meeusen and Broeck (1977); Battese and Coelli (1988) is given in Equation (4):

$$Y_i = f(X_i \beta)\, e^{\varepsilon i} \qquad \ldots(4)$$

where,

Y_i = Output of the i[th] farmer,

X_i = (1 × K) vector of input quantities used by the i[th] farmer,

β = (K × 1) vector of parameters to be estimated,

ε_i = A stochastic error-term consisting of two independent components U_i and V_i, and

ε_i = $V_i - U_i$

The symmetric component V_i accounts for random variations in output, i.e. due to factors outside the farmer's control such as weather and occurrence of pest and diseases. It is assumed to be independent and identical as $V_i \approx N(0, \sigma^2 v)$. A one-sided component that captures deviations from the frontier due to inefficiency ($U_i > 0$) is assumed to be non-negative of the N (μ_i, σ^2) distribution (half normal distribution) or has exponential distribution.

The variance of ε is given by

$$\sigma^2 = \sigma^2_u + \sigma^2_v$$

where, the term σ^2 is the variance parameter that denotes the total deviation from the frontier, σ^2_u is the deviation from the frontier due to inefficiency, and σ^2_v is the deviation from the frontier due to stochastic noise.

$$\gamma = \sigma^2_u / (\sigma^2_u + \sigma^2_v)$$

where, γ is an indicator of relative variability of U_i and V_i that differentiates the actual yield from the frontier. When σ_v^2 tends to zero, it implies that U_i is the predominant error, then $\gamma = 1$. This means yield difference is mainly due to non-adoption of best practice or technique. When σ_u^2 tends to zero, it implies that the symmetric error-term, V_i is the predominant error and γ will be tending to zero. This means that yield differences from the frontier yield is mainly due to either statistical error or external factors that are not included in the model.

The Model

The stochastic frontier production function used in the study is given by Equation (5):

$$\ln(Y) = \alpha_0 + \alpha_1 \ln(X_1) + \alpha_2 \ln(X_2) + \alpha_3 \ln(X_3) + \alpha_4 \ln(X_4) + \alpha_5 \ln(X_5) + \alpha_6 \ln(X_6) + \alpha_7 \ln(X_7) + V_i - U_i \quad \ldots(5)$$

The model for assessing technical inefficiency is given by Eq. (6):

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 \quad \ldots(6)$$

where, U_i is the technical inefficiency in the i[th] farm, Z_1 is the experience in turmeric farming (in years), Z_2 is the education of a farmer (in years), Z_3 is the farm size (in ha), and $\delta_1, \delta_2, \delta_3$ are the inefficiency parameters.

The technical efficiency of individual farm was worked out using formula (7):

$$TE = Y_i / Y_i^* \quad \ldots(7)$$

where, Y_i^* is the frontier yield and Y_i is the actual yield.

Garrett's Ranking Technique

The constraints in turmeric production were analysed using Garrett's ranking technique. The ranks given by each respondent were converted into per cent position by using formula (8):

$$\text{Per cent position} = \frac{100 \times (R_{ij} - 0.5)}{N_j} \quad \ldots(8)$$

where,

R_{ij} = Rank given to i[th] constraint by the j[th] individual, and

N_j = Number of constraints ranked by the j[th] individual.

The estimated per cent positions were converted into scores using Garrett's table. The mean score values estimated for each factor were arranged in the descending order. The constraint with the highest mean value was considered as the most important one and the others followed in that order.

Results and Discussion

Resource-use Efficiency in Turmeric Farms

The estimated resource-use efficiency in turmeric production is furnished in Table 1. The R^2 value was 0.58 which indicates that 58 per cent of the variations in turmeric yield were influenced by the explanatory variables included in the model. It is evident from Table 1 that except potash, all variables included in the model were positive and significant. Hence, increase in the use of inputs such as planting material, nitrogen, potash, harvesting and curing, machine hours, and irrigation would increase the yield of turmeric by 0.29 per cent, 0.12 per cent, 0.15 per cent, 0.24 per cent, 0.32 per cent and 0.33 per cent, respectively.

Table 1. Resource-use efficiency in turmeric production

Variables	Regression coefficient	Standard error	Significance
Regression constant	0.38	0.93	NS
Planting material (kg/ha)	0.29	0.10	**
Nitrogen (kg/ha)	0.12	0.06	*
Phosphorus (kg/ha)	-0.01	0.05	NS
Potash (kg/ha)	0.15	0.06	**
Harvesting and curing (₹/ha)	0.24	0.06	**
Machine hours (hours/ha)	0.32	0.12	**
Irrigation (No./ crop season)	0.33	0.12	**

Note:

$R^2 = 0.58$** $\bar{R}^2 = 0.54$** F- ratio = 16.26 N = 90

**Significant at 1 per cent level, *Significant at 5 per cent level, NS Non-significant

Table 2. Economic efficiency of resource use in turmeric production

Variable	Geometric mean	Regression coefficients	MVP	MFC	MVP/MFC	Percent adjustment required
Yield (kg/ha)	4113	-	-	-	-	-
Planting material (kg/ha)	1992	0.29	38.67	12.84	3.01	66.8
Nitrogen (kg/ha)	189	0.12	182.41	10.87	16.78	94.0
Potash (kg/ha)	78	0.15	543.28	7.67	70.83	98.6
Harvesting and curing cost (₹/ha)	15040	0.24	4.24	8.50	0.49	100.00
Machine hours (hours/ha)	19.4	0.32	4376.29	370	11.82	91.6
Irrigation (No./ crop season)	24.6	0.33	3670.91	224.35	16.36	93.9

Economic Efficiency

The economic efficiency of resource use was computed using marginal value productivity (MVP) and marginal input cost (MIC) and is presented in Table 2. It could be seen from Table 2 that the ratio of MVP to MFC of planting material, nitrogen, potash, machine hours and irrigation is more than one in each case. It indicates that these resources are being used at sub-optimum level and there exists the possibility of enhancing the yield of turmeric by increasing their use. On the other hand, the cost of harvesting and curing had to be reduced from the existing mean level since the ratio has been found to be less than one. The level of adjustments for use of various resources to earn optimum returns presented in Table 2 will serve as a bench-mark for the turmeric growers in the study area, government, agricultural agencies and agro-based companies.

Technical efficiency in Turmeric Farms

The yield of turmeric varied between 2157 and 6789 kg/ha with average of 4240 kg/ha. The technical

Table 3. Estimated stochastic frontier production function for turmeric

(N = 90)

Variables	Regression coefficient	Standard error	Significance
Frontier production function			
Constant	-0.065	0.907	NS
Planting material (kg/ha)	0.321	0.092	**
Nitrogen (kg/ha)	0.152	0.064	*
Phosphorous (kg/ha)	-0.032	0.041	NS
Potash (kg/ha)	0.122	0.057	*
Harvesting and curing (₹/ha)	0.287	0.061	**
Machine hours (hours/ha)	0.212	0.119	NS
Irrigation (No./ha)	0.491	0.104	**
Technical inefficiency effects			
Constant	-0.170	0.461	NS
Education (years)	-0.121	0.013	NS
Farm size (ha)	0.031	0.023	NS
Farming experience (years)	-0.002	0.008	NS
Diagnosis statistics			
Sigma-square (σ^2)	0.055	0.019	**
Gamma (γ)	0.901	0.071	**
log- likelihood	45.22		
Mean technical efficiency (%)	84.13		

Note: N= 90, ** Significant at 1 per cent level, * Significant at 5 per cent level, NS = Non-significant efficiency was estimated by the maximum likely-hood estimation (MLE) method using stochastic frontier production function and the results are given in Table 3. The estimated variance parameter of the model (γ) was 0.90 which implies that about 90 per cent of the variation in turmeric output was due to farmers' practices rather than random variability. The results showed that all the variables included in the model were significant, except phosphorus and machine hours.It implies that the productivity of turmeric can be increased by increasing the use of planting material, nitrogen, potash, harvesting and curing and irrigation. The coefficients of inefficiency variables such as education, farm size and farming experience were non-significant, though the signs of these variables were as per expectations.

The percentage distribution of farms based on technical efficiency in turmeric production is presented in Table 4. A perusal of Table 4 reveals that 35.6 per cent of the sample farmers were in the most efficient category (> 90) and 33.3 per cent were in 81-90 per cent category. The mean level of technical efficiency was 84.1 per cent, which indicated that on an average only 15.9 per cent turmeric growers fell short of maximum possible frontier level of technology. These results are similar to the findings of Bhendi and Kalirajan (2007) who have shown that mean technical efficiency was 86 per cent in sorghum and 84 per cent in maize (Wakili, 2012).

Constraints

The constraints being faced by the sample turmeric growers were ranked using Garrett's ranking technique and the results are given in Table 5.

The most significant constraint (63.6) was non-availability of farm labourers as most of the labourers work under Mahatma Gandhi National Rural Employment Guarantee Scheme. The second major constraint was attack of pest and diseases, followed by high wage rates, high cost of fertilizers and plant protection chemicals and water scarcity. The recommended level of irrigation was 40 numbers, whereas farmers in the study area could irrigate only 25-times which resulted in low productivity of turmeric crop.

Table 4. Frequency distribution of turmeric farms based on technical efficiency

Technical efficiency class (%)	No. of farms	Percentage to total farms
51-60	4	4.4
61-70	8	8.9
71-80	16	17.8
81-90	30	33.3
> 90	32	35.6

Table 5. Constraints faced by turmeric farmers

Constraint	Mean score	Rank
Non-availability of labour	63.6	I
Pest and disease attack	53.0	II
High wage rates	50.3	III
High cost of fertilizer and plant protection chemicals	43.8	IV
Water scarcity	39.6	V

Conclusions and Policy Implication

The resource-use efficiency of turmeric production has been estimated by Cobb-Douglas production function and technical efficiency by stochastic frontier production function. The study has shown that inputs such as planting materials, nitrogen, potash, cost of harvesting and curing, machine hours, and irrigation have positive and significant influence on the yield of turmeric. Frontier production function analysis has revealed that the efficiency of two-third farmers was more than 80 per cent and hence output of turmeric can be increased by improving the technical efficiency of less efficient farms through suitable extension services delivery. The technical efficiency is influenced by education level and farming experience of farmers. Therefore, there is the need to educate farmers through adult education programme so as to increase their productivity and income levels. The problem of non-availability of labour may be addressed by using low cost machineries and implements. For water scarcity, use of drip irrigation and precision farming may be popularised.

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