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Coconut production in Tamil Nadu – an efficiency approach

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Abstract

Coimbatore district holds the largest area under coconut cultivation in Tamil Nadu with an area of 88467.14 ha. A sample of 90 coconut farms in Coimbatore district was selected purposively to study its resource use and technical efficiency. The results of production function analysis showed that all the inputs were found to be positively influencing the yield and increasing returns to scale was found to be operating in the study area. Resource use efficiency also confirms the same and showed that except manures and potassic fertilizers, all the other inputs were used in sub-optimal levels and hence, profits can be increased by further increasing those input levels to reach maximum production. The mean technical efficiency was found to be 82.67 per cent which showed almost 17.33 per cent shortfall to the total efficiency. The study concluded that farmers may not be conscious about the optimal level of input use and hence the suggested policy measure in this study includes education and training of farmers with latest agronomic practices to improve technical efficiency and timely application of optimal level of inputs to improve efficiency.

Keywords: Coconut, Resource use efficiency, technical efficiency.

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Coconut is called as Kalpavriksha, which means tree of heaven, because of its usefulness from each part of the tree[12]. It is also called as Tree of Abundance, Tree of life, etc.,[17]. Coconut can adapt wide range of rainfall, soil and temperature, as seen growing in coastal areas, inlands, tropics etc., with available resources to give profit[11] and hence can be seen cultivating in all climatic and soil conditions throughout the country. Coconut is a perennial crop and its life span ranges from 50 to 60 years from planting and gives yield till lifespan if provided with proper management and care[18]. It can be harvested 4 - 10 times per year and it depends upon the yield, variety and purpose. The yield also varies for each harvest and year from planting.

India stands third place in terms of area under coconut cultivation followed by Indonesia and Philippines, first place in terms of production and second place in terms of productivity followed by Vietnam[10]. More than 12 million people in the country depends upon coconut cultivation, marketing and other related activities[15]. In India, coconut production is dominated in the Andhra Pradesh, Tamil Nadu, Kerala and Karnataka.

Tamil Nadu ranks third place in terms of area under coconut cultivation, second place in terms of production and productivity. (Coconut development board Statistics 2020 - 2021). Compound growth rate of coconut area in Tamil Nadu and western Tamil Nadu was 1.73 and 2.70 per cent respectively over the years from 2001 to 2019. During the same period compound growth rate of coconut production in Tamil Nadu and western Tamil Nadu was -3.20 and 3.38 per cent respectively, but the productivity was 1.10 and -0.057 in Tamil Nadu and Western Tamil Nadu respectively[7]. This clearly showed that western Tamil Nadu is dominated in coconut cultivation but with slightly negative trend in productivity compared to the state.

With this background, a field study was carried out in the Western Tamil Nadu with the objective to access the resource use and technical efficiency of coconut farms and to suggest policy measures to improve efficiency of farms.

The western region of Tamil Nadu comprises of Coimbatore, Tiruppur, Erode and Dindigul districts. Coconut cultivation is dominant in Western Tamil Nadu and hence Coimbatore district of Tamil Nadu is purposively selected for the study which has the largest area under coconut cultivation in Tamil Nadu with an area of 88467.14 ha (almost 20 per cent of the total coconut cultivation area of the Tamil Nadu state and 75 per cent of Coimbatore district's agricultural area). Multistage purposive and random sampling was followed and 90 coconut growers in the Coimbatore district was selected randomly to collect primary data using well-structured questionnaire related to coconut cultivation aspects.

Production function analysis - OLS :

To study the Resource use efficiency of coconut production among the sample farms, Cobb-Douglas type of production function analysis was employed. The production function employed was

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} X_6^{\beta 6} U_i \quad (1)$$

where, Y – Coconut yield (in nuts/ ha)

X_1,- manures (in kg/ha),
X_2, - DAP (in kg/ha),
X_3, - potash (in kg/ha),
X_4 - No. of irrigations (in No./ha),
X_5 - Micronutrient mixture (in litre/ha) and
X_6 - plant protection chemicals (in litre/ha)
β_0 -Constant, U_i-Error term, β_i's-Parameters to be estimated.

This equation (1) was transformed into the logarithmic form (log linear) as represented below and analysed :

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \ldots\ldots\beta_6 \ln X_6 + \ln U_i \quad (2)$$

Resource use efficiency :

The ratio of MVP to MFC was also calculated. Marginal value products (MVP) and the resource use efficiency were calculated by using estimated coefficient values[16].

$$r = MVP/MFC \text{ where, } MVP_i = \beta_i \frac{\bar{Y}}{\bar{x}i} P_Y$$

MVP_i = Marginal value product of the ith input,
MFC = Marginal factor cost of ith input
2 = Geometric mean of output,
x_i = Geometric mean of the ith input,
β_i = Estimated co-efficient (or) elasticity of the ith input, and
P_y = Price of output[6,13].

Stochastic frontier production function :

In order to assess the technical efficiency of coconut production, Stochastic frontier production function was employed. The model for cross-sectional data is $Y = f(X_i\alpha)\, e^{\varepsilon i}$ (i = …..n) as defined by Aigner *et al.*[1]; Meeusen and Broeck[9]; Battese and Coelli[2] where, Y_i = Output of the i^{th} farmer, X_i = input quantities used by the i^{th} farmer, α = parameters to be estimated, ε_i = A stochastic error-term consisting of two independent components U_i and V_i, and $\varepsilon_i = V_i - U_i$.

Variables like weather, occurrence of pest and diseases and other random variables are captured by the systematic, independent component V_i, which is equal to $V_i \approx N(0, \sigma^2_v)$. Another component U_i, accounts for the variation due to inefficiency from the frontier. This component is non-negative and follows normal distribution or exponential distribution[5]. 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.

Indicator of relative variability is represented by $\gamma = \sigma^2_u / (\sigma^2_u + \sigma^2_v)$, which differentiates the actual yield from the frontier. When the value of σ^2_v is closer to zero, then the predominant error is U_i, it implies $\gamma = 1$. This means yield differences are mainly due to non-adoption of best practice or technique. Alternatively, when the value of σ^2_u tends to zero, then the symmetric error-term, V_i is the predominant error and leads γ to zero. This means the yield differences are mainly due to randomness[8,19].

The model :

The stochastic frontier production

function used in the study for coconut production is given by Equation (3):

$$\ln(Y) = \alpha_0 + \alpha_1 \ln(X_1) + \alpha_2 \ln(X_2) + \alpha_3 \ln(X_3) + \alpha_4 \ln(X_4) + \alpha_5 \ln(X_5) + \alpha_6 \ln(X_6) + V_i - U_i \quad (3)$$

The mean technical efficiency is given by $1 - \sigma_u (2/\pi)^{1/2}$ [14]. The technical efficiency of individual farm was worked out by TE = Y_i / Y_i^* where, Y_i is the individual farmers actual yield obtained and Y_i^* is the frontier yield[3].

Based on the analysis of data collected, results and discussions are as follows:

Table-1. OLS estimates of Cobb-Douglas production function

Variables	Parameters	Coefficient	Standard error	P value
Intercept	β_0	4.556 *	0.9077	0.0000
Manures	β_1	0.0479*	0.0253	0.0841
DAP	β_2	0.2585 **	0.1001	0.0127
Potash	β_3	0.0514	0.0338	0.1338
Irrigation	β_4	0.0724	0.0527	0.175
Micronutrient mixture	β_5	0.4298 *	0.251	0.074
Plant protection Chemicals	β_6	0.3622 ***	0.1034	0.0009
Sum of elasticities	$\sum \beta$	1.22		
Coefficient of determination	R^2	0.6972		
Adjusted R^2	$\bar{R}^2$	0.6753		
No. of observations	N	90		

***, ** and * refers to significance at 1 %, 5 % and 10 % levels respectively

The results of Ordinary Least Square estimates could be inferred from the table-1. The results showed that value of R^2 was 0.6972, which means 69.72 per cent of variations in Coconut production was explained by the variables included in the production function. The variables manures and Micro-nutrient mixture were found to be positive and significant at 10 per cent level and one per cent increase in manure and micronutrient mixture, *ceteris paribus*, causes 0.04 per cent and 0.42 per cent increase in nut production respectively. The variable DAP was positive and significant at 5 per cent level, on increasing the DAP by one per cent from geometric mean level, *ceteris paribus*, increases nut production by 0.25 per cent. Similarly, the plant protection chemicals were also positive and significant at 1 per cent level, whose elasticity is 0.36. This indicates that one percent increase in PPC from geometric mean level, *ceteris paribus,* would increase the nut production by 0.36 per cent. The sum of elasticities is 1.22, which is greater than one, indicating the increasing returns to scale and also profits can be increased by increasing the input levels.

Table-2. Resource use efficiency of coconut production

Variable	GM	Regression coefficients	MVP	MFC	r = MVP/MFC
Output (in nuts)	18099.35			11	
Manures (in Kg)	6149.88	0.0479	1.550	21	0.07
DAP (in Kg)	612.76	0.2585	83.988	27	3.110
Potash (in Kg)	608.80	0.0514	16.809	34	0.494
Irrigation (in No.)	55	0.0724	261.98	251.33	1.042
Micronutrient tonic (in L)	40.63	0.4298	2105.909	320	6.580
Plant protection (in L)	7.35	0.3622	9811.077	610	16.083

Resource use efficiency for coconut production can be traced from table-2. It could be seen that the ratios of MVP to MFC was found to be positive and greater than one for all the inputs except manures and potassic fertilizers. It can also be stated that these inputs were used in sub-optimal levels and hence, profits can be increased by further increasing these input levels to reach maximum production. Similarly excessive use of manures and potash could be found by the ratios of MVP to MFC which is lesser than 1. Hence, manures and potassic fertilizer input level have to be reduced.

Table-3. Estimates of stochastic frontier production function

Variables	Parameters	Coefficient	Standard error	P value
Frontier production function				
Intercept	α_o	6.0434 *	0.6835	0.0000
Manures	α_1	0.0337	0.0487	0.5231
DAP	α_2	0.0399	0.0274	0.1363
Potash	α_3	0.1018 ***	0.0545	0.0670
Irrigation	α_4	0.0736 ***	0.0414	0.0810
Micronutrient tonic	α_5	0.2594 *	0.0757	0.0003
Plant protection chemicals	α_6	0.3142 *	0.0774	0.0000
Diagnostic statistics				
Sigma square	σ^2	0.05 **	0.0226	0.0126
Gamma	γ	0.944 **	0.4188	0.0381
Farmer variability	σ^2_u	0.0472		
Random variability	σ^2_v	0.0028		
Log likelihood		29.33		
Mean technical efficiency		82.67		
No. of observations	N	90		

***, ** and * refers to significance at 1 %, 5 % and 10 % levels respectively

Technical efficiency was estimated by using stochastic frontier production and estimates of technical efficiency of coconut production could be traced from table-3. The gamma estimate, which is an indicator of relative variability of U_i and V_i that differentiates the actual yield from the frontier; was significant at 5 per cent level and the value of gamma was 0.944 which means that 94.4 percent variation between observed and frontier output was due to differences in the farmers practices or technology adopted. The estimated σ^2_u and σ^2_v were 0.0472 and 0.0028, indicated that the difference in the yield was higher due to farmers practices rather than random variability. The results showed that except manures and DAP all the variables were significant and their production elasticities ranges from 0.03 to 0.31. The variables potash and irrigation were found to be significant at 10 per cent level and one percent increase from the geometric mean level, *ceteris paribus*, would cause 0.10 and 0.07 per cent increase in the nut production respectively. Similarly, the variables PPC and micronutrient mixture was significant at 1 per cent level and one per cent increase from the geometric mean level, *ceteris paribus*, would cause 0.31 and 0.25 per cent increase in the nut production respectively.

The percentage distribution of technical efficiency was presented in the table-4. The results showed that technical efficiency of farms ranged from 58.92 per cent to 97.33 per cent This difference between least and best is the potential zone to increase the efficiency which may increase the profits. The mean technical efficiency was found to be 82.67 per cent which showed that almost 17.33 per cent shortfall exists to the total efficiency. In other words, the maximum technical efficiency was not reached among some of the sample farms. It could also be stated that only 32.22 per cent sample farmers were below 80 per cent technical efficiency and 67.78 per cent sample farmers were above 80 per cent of technical efficiency. The reason

Table-4. Frequency distribution of technical efficiency of coconut production farms

Technical Efficiency class (%)	No. of farms	Percentage to total farms
<50	-	-
51 – 60	2	2.22
61 – 70	18	20.00
71 – 80	9	10.00
81 – 90	34	37.78
>90	27	30.00
Total	90	100.00
Maximum Technical Efficiency (%)	97.33	
Minimum Technical Efficiency (%)	58.92	
Mean Technical Efficiency (%)	82.67	

for difference in technical efficiency might be due to different kind of farming practices adopted by the farmers.

Coconut is a perennial crop and it starts bearing from the fifth year and attain its maximum potential from the seventh or eighth year. The inputs like Manures, Fertilizers, Plant protection chemicals and Micronutrient mixture were positive and significantly affects coconut production and these inputs were used in sub-optimal levels. Increasing returns to scale was found to be operating in the study area and results of resource use efficiency also confirms the same. In order to increase returns and profits, application of these inputs should be increased to optimal levels. Technical efficiency results indicated that 94.4 percent variation between observed and frontier output was due to differences in the farmers practices or technology adopted. Technical efficiency of farms ranged from 58.92 per cent to 97.33 per cent. The mean technical efficiency was found to be 82.67 per cent which showed that almost 17.33 per cent short fall to the total efficiency.

The findings of the study have policy implications for increasing the coconut production to improve and sustain farmers livelihood. From the study, it was found that farmers were may not be conscious about the optimal levels of input application and hence continuous efforts are required to train the farmers in the optimal use of inputs towards achieving the full benefit from coconut production. It is suggested that there is scope for increase in productivity of coconut by using various resources efficiently and adoption of better management practices in the study area. In order to boost the output farmers can be educated and trained with latest agronomic practices and to apply inputs efficiently and effectively on time. Through adult education and literacy efforts, farmers' educational standing could be raised in the long run, leading to improved technical efficiency.

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