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Research Article

A comparative study on technical efficiency of cashewnut

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SUMMARY : India is the largest producer, processor, exporter and the second largest consumer of cashew nut in the world. The serious constraint in increasing Indian cashew production is the low level of productivity. The main constraints in processing industries were heavy dependence on imports due to shortage of adequate rawnuts from indigenous sources. The objectives of the study was to study the technical efficiency of cashew nut among the major growing states in India *viz.*, Andhra Pradesh and Tamil Nadu. By adopting multistage purposive sampling technique, Andimadam block of Perambalur district in Tamil Nadu and Nallajerla mandal in West Godavari district of Andhra pradesh were selected on the basis of maximum area under cashew.It indicated that the sample farms, on an average could increase the output of cashew by 18 per cent in case of high yielding varieties and 24 per cent in case of traditional farms in Tamil Nadu, whereas the output of cashew could be increased by 16 per cent in case of varietal orchards and 21 per cent in case of traditional varieties in Andhra Pradesh, through the proper adoption of technology without the additional use of resource.

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BACKGROUND AND OBJECTIVES

Cashew cultivation in India was introduced by the Portuguese during 16th century. Initially, cashew was cultivated to arrest soil erosion, afforestation and wasteland development, but later it became an important cash crop. Cashew is mainly grown in marginal and low productivity lands, where no other crop can be grown. India is the largest producer, processor, exporter and the second largest consumer of cashewnut in the world. Among the agricultural commodities exported from India during 2009-10, cashewnut held the second position contributing to 1.50 per cent of the total export earnings.

The main producers of cashewnut in India are Kerala, Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu. From the statistics it was noted that the area under cashew in Andhra Pradesh was increasing over the past decades but not reflected in the production front compared to Maharashtra (1100 kg per ha.) and Kerala (890 kg per ha). In Tamil Nadu, the cashew production is very low over a decade, with the lowest productivity of 600 kg per ha. One of the serious constraints in increasing Indian production is the low level of productivity. Out of the total area of 7.70 lakh ha under cashew, 40 per cent of area is under senile category, which lead to low productivity levels.

The reasons identified by the research studies for the very low productivity were use of seedlings propagated from seeds, poor adoption of improved planting materials (clone), low population density per unit area and adoption of poor agronomic practices. The productivity level of Tamil Nadu and Andhra Pradesh were far less than the national average of 760 kg per ha, which can be increased by employing proper planting materials and the latest farming technologies (Selvarajan and Dharmalingam,1998).

The National Research Centre for Cashew at Puttur in Karnataka, Regional Research Station at Vridhachalam in Tamil Nadu and Cashew Research Station at Bapatla in Andhra Pradesh have developed good planting materials and advanced farming technologies. The Regional Research station, Vridhachalam released a high

yielding variety, *viz.*, VRI 3 in 1992 and Cashew Research Station, Bapatla released a high yielding variety, *viz.*, BPP-8 in 1990 which has got yield potential of 2.9 tonnes per ha.

The development of cashew crop in Brazil and processing facilities in East Africa led to competition in cashew kernel market and India's share progressively has been reduced to 50 per cent of the global trade. All the processing units in India put together have a processing capacity of eight lakh tonnes of raw nuts per year, but the domestic production is less than five lakh tonnes. Hence there is a need for import of raw cashewnuts for processing and re-export.(Singh and Balasubramanian, 2002).In this scenario, a comparative study is made to estimate technical efficiency of cashew nut among the major growing states in India *viz.*, Tamil Nadu and Andhra Pradesh.

RESOURCES AND METHODS

The study was purposively carried out in two states, *viz.*, Andhra Pradesh and Tamil Nadu which accounted for 17 per cent and 12 per cent of the total area under cashew in India.

A multistage purposive sampling technique was adopted with districts forming the universe (first stage), block / mandal as second stage unit, villages at third stage and farm households cultivating cashew as the ultimate sampling units. Perambalur district of Tamil Nadu and West Godavari district of Andhra Pradesh had maximum area under cashew with 31.52 and 32.01 per cent, respectively. Hence, these two districts were purposively selected for the study.

In the second stage, Andimadam block of Perambalur district and Nallajerla mandal in West Godavari district were selected purposively which had maximum area under cashew with 41.82 and 30.35 per cent, respectively.

In the next stage, the area under cashew in each revenue village of the selected block / mandal were arranged in descending order of magnitude. Of the total number of villages in each block / mandal, the first three villages in the ranking were purposively selected. The villages namely, Kuvagam, Marudur and Alagapuram were selected in Andimadam block of Perambalur district. Similarly, the villages namely, Nallajerla, Dubacherla, and Anumunilanka were selected in Nallajerla mandal.

In consideration of time the total number of respondents have been restricted to 300. A list of cashew cultivating farmers in the selected villages was prepared, and they were arranged in the descending order of magnitude of area. The ultimate sample farms were selected randomly from the list.

The 'Z' test analysis undertaken revealed that the difference in yield per hectare was highly significant between the two categories, namely seedling orchards (Traditional varieties) and varietal orchards (High yielding varieties), which are referred as category I and category II, respectively, in this study for further discussions.

Technical efficiency :

Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) independently proposed the estimation of a stochastic frontier production function, where noise is accounted for by adding a symmetric error term (u_i) to the nonnegative term to provide,

$\mathbf{L_n\ (Y_i) = f\ (X_i\ ;\ \ )} + £_i$;

$£_i = \mathbf{V_i - U_i}$; i = 1, N.

where Y_i denotes production level, X_i is input level and β is a vector of unknown parameter to be estimated.

ε_i is the composed error term. V_i is independently and identically distributed random error N (0, σ_v^2). These are the factors outside the control of the firm. U_i is non-negative random variables which are independently and identically distributed as N (0, σ_U^2), *i.e.*, the distribution of U_i is half normal. $|U_i| > 0$ reflects the technical efficiency relative to the frontier. $|U_i| = 0$ for a firm whose production lies on the frontier and $|U_i| < 0$ for a firm whose production lies below the frontier.

According to Battese and Coelli (1995), technical inefficiency effects are defined by;

$\mathbf{U_i = Z_i\ ¢ + W_i}$

i = 1, …., N

Z_i is a vector of explanatory variables associated with the technical inefficiency effects.

δ is a vector of unknown parameter to be estimated. W_i is unobservable random variables, which are assumed to be identically distributed, obtained by truncation of the normal distribution with mean zero and unknown variance σ^2, such that U_i is non-negative.

Stochastic frontier production functions can be estimated using either the maximum likelihood method or using a variant of the COLS (Corrected Ordinary Least Squares) method suggested by Richmond (1974).

According to Battese and Corra (1977), the variance ratio parameter (g) which relates the variability of U_i to total variability (σ^2) can be calculated in the following manner,

$\gamma = \sigma_u^2 / s^2$

where $\sigma^2 = \sigma_u^2 + \sigma_v^2$

So that $0 \leq g \leq 1$.

If the value of γ equals zero, the difference between farmers yield and the efficient yield is entirely due to statistical noise. On the other hand, a value of one would indicate the difference attributed to the farmer's less than efficient use of technology, *i.e.*, technical inefficiency (Coelli 1995). The following model specifications were used in the analysis.

Cobb-Douglas model:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} +$$

$$\beta_5 \ln X_{5i} + V_i - U_i.$$

where, ln denotes logarithms to base e,

Y = Yield of cashew (kg of rawnuts / ha)

X_1 = Human labour (man days / ha)

X_2 = Manures and fertilizers used (Rs / ha)

X_3 = Plant protection chemicals (Rs/ha)

X_4 = Age of trees (years)

X_5 = Number of trees per ha.

The inefficiency model specified by Battase and Coelli (1995) specification was,

$$U_i = \delta_0 + \delta_1 Z_i + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + W_i$$

Z_1 = Age of the farmer (years)

Z_2 = Education level (years)

Z_3 = Extension agency contact, if yes 1, zero other wise

Z_4 = Family size (number)

Z_5 = Occupation, if primary 1, zero otherwise

W_i = Unobservable random variables

OBSERVATIONS AND ANALYSIS

The observations of the present study as well as relevant analysis have been summarized under the following heads:

Technical efficiency of cashew plantations:

It could be seen from the Table 1 and 2 that the mean sample yield of cashew in category II (varietal orchards) farms was higher than that of the category I in both Tamil Nadu And Andhra Pradesh .Similarly, the use of inputs, *viz.*, human labour, manures and fertilizers and plant protection chemicals were higher for high yielding varieties when compared to traditional varieties. Also, the age of high yielding varieties of cashew was lesser than that of traditional varieties and the number of trees per hectare was higher in the case of high yielding varieties than the seedlings orchards in both the states.

The comparative statistics of Tamil Nadu and Andhra Pradesh revealed that the usage of all productive inputs were higher in Andhra Pradesh than Tamil Nadu. The average age of traditional varieties was marginally higher in Tamil Nadu, whereas in the case of high yielding varieties, the average age was higher in Andhra Pradesh, which might be due to the earlier introduction of these varieties of cashew in Andhra Pradesh compared to Tamil Nadu. Further, it showed that the number of trees per hectare in case of traditional varieties were equal in both states whereas in the case of high yielding varieties, it was higher in Andhra Pradesh.

The maximum likelihood estimates of the Cobb-Douglas model for the category I and II farms in Tamil Nadu and Andhra Pradesh are presented in Table 3 and 4.

It could be observed from the Table 3 and 4 that among the five independent variables in the model for both the categories, human labour, plant protection chemicals and number of trees per hectare had positive co-efficient, whereas age of trees had a negative coefficient in both states. The exception was that in Andhra Pradesh the coefficient for manures and fertilizers in traditional varieties was positive while in Tamil Nadu it was negative.

The estimated co-efficients for plant protection chemicals and number of trees per hectare for both varieties

Table 1 : Summary statistics for variables in the stochastic frontier production functions for Tamil Nadu

Variable	Sample mean		Standard deviation		Minimum value		Maximum value	
	Category I	Category II	Category I	Category II	Category I	Category II	Category I	Category II
Yield of cashew (kg of raw nut/ha.)	852.48	868.72	332.51	347.97	162.14	152.12	1571.43	1666.60
Human labour (mandays)	3562.12	4021.25	2985.45	3450.16	256.14	310.23	3780.47	4484.73
Manures and fertilizers (Rs /ha)	2700.17	3500.19	2110.24	2950.26	1500.27	1900.31	3100.52	3900.41
Plant protection chemicals (Rs/ha)	618.57	636.79	137.31	145.86	126.00	125.00	1071.42	1250.00
Age of trees (years)	23.12	12.14	12.54	9.52	17.20	9.29	34.31	15.11
Number of trees per ha	146.16	185.25	110.21	142.65	124.43	162.42	159.16	192.28

Table 2 : Summary statistics for variables in the stochastic frontier production functions for Andhra Pradesh

Variable	Sample mean		Standard deviation		Minimum value		Maximum value	
	Category I	Category II	Category I	Category II	Category I	Category II	Category I	Category II
Yield of cashew (kg of raw nut/ha.)	878.56	890.75	341.55	355.42	160.00	260.72	1675.42	1715.72
Human labour (mandays)	3672.75	4122.48	2995.26	3451.25	276.00	312.12	3880.27	4554.17
Manures and fertilizers (Rs /ha)	2810.25	3590.21	2220.12	3115.25	1550.12	1972.27	3200.12	4100.21
Plant protection chemicals (Rs/ha)	40.12	670.21	147.87	140.41	126.01	140.12	1252.00	1080.42
Age of trees (years)	21.75	16.11	11.21	10.51	15.31	9.29	32.15	19.21
Number of trees per ha	145.20	195.15	114.52	134.51	110.25	155.14	162.35	198.26

Table 3 : Maximum likelihood estimates of stochastic frontier production function of cashew in Tamil Nadu

Variables	Maximum likelihood estimates	
	Category I	Category II
Constant (β_0)	2.2301 (1.5524)	2.6381 (1.9672)
Human labour (β_1)	0.11 (0.3115)	0.0309 (0.4825)
Manures and fertilizers (β_2)	-0.3413 (0.2214)	0.4651* (0.1814)
Plant protection chemicals (β_3)	0.8145** (0.3125)	0.6326** (0.2624)
Age of trees(β_4)	-0.2119 (0.1645)	–0.1814 (0.3783)
Number of trees per ha (β_5)	0.4621** (0.1312)	0.2642** (0.8171)
$\sigma^2 = \sigma^2 u + \sigma^2 v$ (Total variability)	0.12	0.07
$\sigma^2 u$ (Farmer variability)	0.09	0.05
$\sigma^2 v$ (Random variability)	0.04	0.02
Lamda $= \sigma u / \sigma v$	1.58	1.64
Gamma= $\sigma^2 u / \sigma^2$ (Variance ratio)	0.71	0.74
Log likelihood function	-74.86	-21.82
MTE. $1 - \sigma u \quad (2/3.14)^{0.5}$	75.79	81.45

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 4 : Maximum likelihood estimates of the stochastic frontier production function of cashew in Andhra Pradesh

Variables	Maximum likelihood estimates	
	Category I	Category II
Constant (β_0)	3.5492 (1.5821)	4.5171 (2.1562)
Human labour (β_1)	0.2154 (0.3252)	0.07195 (0.0615)
Manures and fertilizers (β_2)	0.6423* (0.2162)	0.5177* (0.1482)
Plant protection chemicals (β_3)	0.6252** (0.1983)	0.7251** (0.2452)
Age of trees(β_4)	0.4814 (0.3152)	–0.2824 (0.4182)
Number of trees per ha (β_5)	0.7856** (0.2313)	0.4185** (0.1172)
$\sigma^2 = \sigma^2 u + \sigma^2 v$ (Total variability)	0.07	0.04
$\sigma^2 u$ (Farmer variability)	0.07	0.04
$\sigma^2 v$ (Random variability)	0.004	0.003
Lamda $= \sigma u / \sigma v$	4.3	4.10
Gamma= $\sigma^2 u / \sigma^2$ (Variance ratio)	0.95	0.93
Log likelihood function	-30.75	-41.82
MTE. $1 - \sigma u \quad (2/3.14)^{0.5}$	78.73	83.84

* and ** indicate significance of values at P=0.05 and 0.01, respectively

showed positive and significant values in both the states. The manures and fertilizers coefficient was positive and significant for both the varieties in Andhra Pradesh and it was positive for high yielding varieties alone in Tamil Nadu.

This would indicate that the increment of plant protection chemicals by one per cent would increase the output by 0.63 per cent in varietal orchards, 0.81 per cent in seedlings orchards in Tamil Nadu and 0.73 per cent in varietal orchards and 0.63 per cent in seedlings orchards in Andhra Pradesh. Similarly the increment of manures and fertilizers by one per cent, will increase the output by 0.52 per cent in varietal orchards (HYV), 0.64 per cent in seedlings orchards (Traditional varieties) in Andhra Pradesh and 0.47 per cent in varietal orchards in Tamil Nadu. The increment of number of trees by one per cent, will increase the output by 0.26 per cent and 0.41 per cent for high yielding varieties in Tamil Nadu and Andhra Pradesh, respectively.

Hence, it could be interpreted that in both the states the high yielding varieties responded better than traditional varieties for manures and fertilizer application. The trees population maintained in a hectare was the other important significant variable both in Tamil Nadu and Andhra Pradesh and its positive impact towards productivity was felt much in traditional varieties than in HYV.

Further the Tables revealed that in both the states though the age of trees did not have statistical significance, the coefficient exhibited a positive sign in high yielding varieties, whereas in the case of traditional varieties it had negative sign.

It could be inferred that the increase in the age of the trees above the mean value contributed favourably in the case of high yielding varieties, where mean value was lesser, whereas in the traditional varieties the increase in the age pulled down the productivity because of its higher mean value. Hence, it could be construed that the varietal orchards were in their productive age range, whereas the seedling orchards had crossed the productive age which were needed to be replaced with new saplings.

The estimated values of $\sigma^2 u$ and $\sigma^2 v$ were 0.05 and 0.02 for category II farm and they were 0.09 and 0.04 for category I farms in Tamil Nadu. The estimated values $\sigma^2 u$ and $\sigma^2 v$ were 0.04 and 0.003 for category II farms and they were 0.07 and 0.004 for category I farm in Andhra Pradesh. These values indicated that the difference between observed output and frontier output was due to technical inefficiency of farms and not due to statistical variability.

The estimate of gamma, which measures the effect of technical inefficiency in output variation, was 0.74 per cent for category II farms and 0.71 per cent for category II farms in Tamil Nadu. Similarly, the gamma value was 0.93 per cent for category II farms and 0.95 per cent for category I farm in Andhra Pradesh.

The gamma values indicated that dominance of technical inefficiency over the random effect, which attributed for the yield variation from the frontier output. Both in traditional varieties and high yielding varieties, the gamma values were higher in Andhra Pradesh than Tamil Nadu. This revealed that

the technical inefficiency was attributed as major reason for less productivity in Andhra Pradesh compared to Tamil Nadu.

The estimated Mean Technical Efficiency (MTE) of high yielding varieties and traditional varieties were 82 per cent and 76 per cent, respectively, in Tamil Nadu. Similarly, MTE of high yielding varieties and traditional varieties were 84 per cent and 79 per cent, respectively, in Andhra Pradesh. It indicated that the sample farms, on an average could increase the output of cashew by 18 per cent in case of category II farms and 24 per cent in case of category II farms in Tamil Nadu through the proper adoption of technology without the additional use of resources.

Similarly, the output of cashew could be increased by 16 per cent in case of varietal orchards and 21 per cent in case of traditional varieties in Andhra Pradesh through the proper adoption of technology with out the additional use of resources. The distribution of technical efficiencies band on the Cobb-Doughas production function is presented in Table 5 and 6.

Table 5 : Distribution of technical efficiencies in Tamil Nadu

Technical efficiency	No. of farmers			
	Category I	Percentage	Category II	Percentage
90-100	16	15.6	6	12.5
80-89	12	11.7	18	37.5
70-79	34	33.3	5	10.4
60-69	12	11.7	8	16.6
50-59	9	8.8	-	
40-49	5	4.9	7	14.5
30-39	10	9.8	-	
20-29	4	8.3	4	8.3
10-19	-		-	
Total	102	100	48	100

Table 6 : Distribution of technical efficiencies in Andhra Pradesh

Technical efficiency	No. of farmers			
	Category I	Percentage	Category II	Percentage
90-100	26	23.2	4	10.52
80-89	10	8.9	12	31.5
70-79	36	32.14	6	15.78
60-69	15	13.39	5	13.1
50-59	9	8.03	7	18.4
40-49	2	1.78	4	10.52
30-39	3	2.67	-	
20-29	11	9.8	-	
10-19	-		-	
Total	112	100	38	100

It could be observed from the Tables 5 and 6 that the higher percentage of farmers were falling the technical efficiency ranges between 80-89 in category II farms and in the ranges between 70-79 it was higher in category I farms in both Tamil Nadu and Andhra Pradesh.

Similarly, the percentage of farmers falling in the low range (<50) was in the case of traditional varieties compared to high yielding varieties in both states . Hence, it could be understood that the technical efficiency has to be improved a lot in the case of traditional varieties rather than high yielding varieties or instead the traditional varieties may be replaced with high yielding varieties in both the states.

Factors influencing the technical efficiency:

The factors influencing the technical efficiency in cashew plantations were analysed and the estimated coefficients are given in Table 7 and 8.

Table 7 : Determinants of efficiency in cashew plantation in Tamil Nadu

Variable	Category I	Category II
Constant (δ_0)	0.548 (0.197)	0.76 (0.16)
Age of farmer (δ_1)	0.038 (0.348)	0.47 (0.031)
Education level (δ_3)	0.306 (0.227)	0.55** (0.27)
Extension agency contact (D1) (δ_4)	0.12** (0.048)	0.207** (0.09)
Family size (δ_5)	0.14 (0.37)	–0.199 (0.33)
Occupation (D2) (δ_6)	0.059 (0.53)	0.037 (0.464)

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 8 : Determinants of efficiency in cashew plantation in Andhra Pradesh

Variable	Category I	Category II
Constant (δ_0)	0.63 (0.19)	0.42 (0.16)
Age of farmer (δ_1)	0.047 (0.41)	0.34 (0.033)
Education level (δ_3)	0.24 (0.217)	0.36** (0.17)
Extension agency contact (D1) (δ_4)	0.48** (0.114)	0.39** (0.129)
Family size (δ_5)	0.124 (0.37)	–0.179 (0.33)
Occupation (D2) (δ_6)	0.159 (0.23)	0.124 (0.46)

* and ** indicate significance of values at P=0.05 and 0.01, respectively

From the above Table 7 and 8, it could be seen that coefficients of extension agencies contact in both categories were positively significant which would indicate that the frequent contact with extension agencies might increase the yield of cashew in both the states.

Further, it could be seen that inefficiency has been positively correlated with education level in category II, farms which indicates that the educated farmers are more efficient than other category farms. Also, the other variables included

in the model, *viz.*, age of farmer, family size and occupation were not significant which might be due to the nil maintenance of cashew crop in the study area.

Conclusion:

The estimated Mean Technical Efficiency (MTE) of high yielding varieties and traditional varieties were 82 per cent and 76 per cent, respectively, in Tamil Nadu. Similarly, MTE of high yielding varieties and traditional varieties were 84 per cent and 79 per cent, respectively, in Andhra Pradesh. It indicated that the sample farms, on an average could increase the output of cashew by 18 per cent in case of high yielding varieties and 24 per cent in case of traditional farms in Tamil Nadu, whereas the output of cashew could be increased by 16 per cent in case of varietal orchards and 21 per cent in case of traditional varieties in Andhra Pradesh, through the proper adoption of technology with out the additional use of resource.The study suggested replacing the traditional cashew orchards with high yielding variety, adopting modern production technologies like top working of existing senile plantations with high yielding variety to increase domestic production and to meet out the requirements of the processing industries.

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