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Comparative Economic Analysis of Tissue Culture Banana and Sucker Propagated Banana Production under Precision Farming Technology in Tamil Nadu

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The comparative economics of tissue culture banana and sucker propagated banana was studied under precision farming in Tamil Nadu with the primary data collected from 60 banana growers spread over two taluks in Dharmapuri district. Efficiency of farmers in banana production was assessed through stochastic frontier production technique. Sources of the productivity differences between tissue culture banana farms and sucker propagated banana farms were identified by decomposing the productivity changes. The study revealed that net income from production of banana was seven per cent higher in tissue culture banana than that of sucker propagated banana. The mean technical efficiency in tissue culture banana (88 per cent) and sucker banana (91 per cent) indicated that there is a possibility to increase banana yield by adopting the technology used by the best performers. The contribution of tissue culture technology for higher yield in precision farming was 36.94 per cent.

Key words: Banana, Precision-Farming, Partial Budgeting, Technical efficiency, Decomposition analysis

The growth in agricultural productivity varies widely across the states in India due to variations in agro-climatic conditions and adoption of technology. Enhancement in agricultural productivity is mainly through the adoption of improved agricultural technologies, and precision farming is one the feasible approaches as a sustainable agriculture is concerned. It aims at increasing productivity, decreasing production costs and minimizing the adverse environmental impact on farming (Maheswari *et al.* 2008). In Tamil Nadu, precision farming technology was first implemented as a state sponsored turnkey project in semi-arid tracts with low rainfall and low productivity districts viz., Dharmapuri and Krishnagiri in 400 ha with a total budget of Rs. 720 lakhs for a period of three years (2004-05 to 2006-07). Precision farming technique was adopted in agricultural and horticultural crops, but major focus was on vegetables and long season crops like banana, tapioca and turmeric. Among those crops grown under precision farming, banana was selected purposively for the present study. In Tamil Nadu, banana cultivation has a limitation because the state experiences strong winds during July-August that result in lodging of banana plantation. Heavy rainfall or monsoon failures and absence of proper marketing are the other limiting factors that prevent the farmer to take up banana cultivation extensively. This problem can be solved by following good management practices like drip fertigation, use of tissue culture plantlets, and strengthening the supply chain through precision farming. On this background, the present study was undertaken with the following specific objectives of estimating costs and returns of tissue culture banana and sucker propagated banana, assessing the technical efficiency in banana production and to assess the contribution of technology in increasing banana productivity.

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Materials and Methods

The study was conducted in Dharmapuri district which has the largest area under precision farming technique in Tamil Nadu. The respondents were selected randomly from ten revenue villages in two taluks (Papireddipatti and Harur) such that there were 30 tissue culture banana growers and 30 sucker propagated banana growers. Necessary primary data were collected from the sample farmers through personal interview for the agricultural year 2010-2011. Market prices during the period of survey for various items were considered for estimation of costs and returns. Partial budgets are commonly used to estimate the effects or outcome of possible adjustments in the farm business before such adjustments are actually made. It provides a method for understanding how far expenses and yields affect the adoption of tissue culture banana visàvis sucker propagated banana in precision farming technology.

In order to estimate the technical efficiency, Stochastic Frontier Production Function of the Cobb-Douglas type was chosen for this study (Coelli, 1995). $Q_i = f(X_{ki}, \beta)e^{\varepsilon_i}$, i = 1, ...n ; k = 1, .., k... (1); where Q_i is the output of the i_{th} farm, X_{ki}, is a vector of k inputs used by the i_{th} farm, β is a vector of parameters to be estimated and ε is the farm specific composite residual term comprising of a random error term v_i and an inefficiency component u_i.The individual farmer's level of technical efficiency (TE_i) was then calculated

as: $TE_i = \exp(-E[u \mid \varepsilon])$ i = 1, . . , n... (2) such that $0 \leq TE_i \leq 1$. The model[i] used[i] was $\ln Y_i = \ln\alpha_0 + \alpha_1 \ln X_{1i} + \alpha_2 \ln X_{2i} + \alpha_3 \ln X_{3i} + \alpha_4 X_{4i} + \alpha_5 X_{5i} + v_i - u_i - u_i$ ...(3). The subscript i refers to the i_{th} farmer while, Y is the total banana production (in kg/ha); X_1 denotes suckers (in numbers/ha); X_2, X_3 and X_5 denote rupees per ha of total labour and total fertilizer and cost of FYM, propping and plant protection chemicals and X_4 is irrigation water in mm per ha.

The output decomposition model as developed by Bisaliah (1977) was used for the study. Two separate production functions, one for tissue culture banana and another for sucker banana were fitted. In logrithmic form, Cobb-Douglas production functions for tissue culture banana:

$$\ln Y_t = \ln b_{t0} + b_{t1} \ln SEED_t + b_{t2} \ln LAB_t + b_{t3} \ln FERT_t + b_{t4} \ln IRRI_t + b_{t5} \ln OC_t + u_t \quad ... (4)$$

Logrithmic form of Cobb-Douglas production function for sucker banana is:

$$\ln Y_s = \ln b_{s0} + b_{s1} \ln SEED_s + b_{s2} \ln LAB_s + b_{s3} \ln FERT_s + b_{s4} \ln IRRI_s + b_{s5} \ln OC_s + u_s \quad ... (5)$$

where, Y-Total banana production in kg per ha; SEED -Seed rate in numbers per ha; LAB -Total labour in rupees per ha; FERT-Total fertilizer in rupees per ha; IRRI -Irrigation water in mm per ha and OC-Cost of FYM, propping and plant protection in rupees per ha. Taking differences between (4) and (5) and rearranging becomes;

$$\ln (Y_t/Y_s) = \{\ln [b_{t0}/ b_{s0}) + \{(b_{t1} - b_{s1}) \ln SEED_{t1} + (b_{t2} - b_{s2}) \ln LAB_{t2} + (b_{t3} - b_{s3}) \ln FERT_t + (b_{t4} - b_{s4}) \ln IRRI_t + (b_{t5} - b_{s5}) \ln OC_t \} + \{ b_{t1} \ln (SEED_t/SEED_s) + b_{t2} \ln(LAB_t/LAB_s) + b_{t3} \ln FERT_t/FERT_s) + b_{t4} \ln(IRRI_t/ IRRI_s) + b_{t5} \ln(\ln OC_t/ \ln OC_s) \} + [(u_t - u_s)] \quad ...(6)$$

Equation (6) forms decomposition model. The summation of first and the second terms on the right hand side of the decomposition model together represented the productivity difference between the two methods of banana cultivation, attributable to the difference in the technological practices. The third term provided the productivity difference between the two methods of cultivation attributable to the differences in the input use.

Results and Discussion

Economics of banana production

Economics of banana production was estimated for tissue culture and sucker propagated method of cultivation and the results are presented in Table 1. On an average, total cost was higher (Rs. 1,70,356) in case of precision farming tissue culture propagated banana farmers (TCB) than that of precision farming sucker propagated farms (SPB) (Rs 129345). Out of

Table 1. Economics of banana production under tissue culture and sucker propagated methods (Rs/ha)

S.No	Particulars	Precision Farming			
		Sucker propagated		Tissue culture	
		Amount (Rs)	Percentage to total	Amount (Rs)	Percentage to total
A.	**Variable Cost**				
1	Human labour	26961	20.84	25584	15.02
2	Machine power	12279	09.49	9799	05.75
3	Plantlets/sucker	7533	05.82	33205	19.49
4	Manure and Fertilizers	38675	29.90	53398	31.34
5	Plant protection chemicals	1716	01.33	3528	02.07
6	Propping	5639	04.36	5361	03.15
7	Drip system	9857	07.62	9857	05.79
8	Interest on working capital	7186	05.56	9670	05.68
	Sub-Total	109845	84.92	147810	88.29
B.	**Fixed Cost**				
1	Rental value of land	16250	12.56	16745	09.83
2	Interest on owned fixed capital	1851	01.43	1926	01.13
3	Depreciation of implements & buildings	1158	0.90	1060	0.62
4	Payment of land Revenue and Cess	240	0.19	223	00.13
	Sub-Total	19499	15.08	19954	11.71
	Total (A+B)	129345	100	170356	100
C	Main Product (kg/ha)	30459		59538	
D	Price (Rs/kg)	13.60		8.00	
E	Gross Income	414152		476188	
F	Net Income	284807		305832	
G	Cost of Production (Rs/kg)	4.25		2.89	
H	Net Returns (Rs/ kg)	9.35		5.14	

the total cost, 88.29 per cent was incurred as variable cost and remaining 11.71 per cent was fixed cost in TCB. The shares of variable and fixed costs to the total cost of cultivation in SPB farms were 84.92 per cent and 15.08 per cent respectively. Of the total variable cost, manure and fertilizers accounted for the highest proportion (31.34 per cent) followed by plantlets (19.49 per cent) and human labour (15.02 per cent) in TCB farms. In case of SPB farms, the cost of manures and fertilizers was the major component accounting for 29.90 per cent of the total variable cost. Cost of human labour was higher in SPB farms when compared with that of TCB farms and this was due to the engagement of more number of labourers for de-suckering as the quick emergence of side suckers in sucker propagated banana fields was a menace. Plant protection cost was higher in TCB farms (2.07 per cent) than that of SPB (1.33) and this was owing to the fact that the tissue culture plantlets were more susceptible to Erwinia wilt and Sigatoka leaf spot. The gross return per hectare of banana cultivation realized was higher in TCB farms (Rs. 476188) than SPB farms (Rs. 414152). The results were in line with that of a study by Alagumani (2005) and Hanumantharaya *et al*. (2009) where gross return per hectare was higher in TCB than SPB farms. Net income realized by the total sample farmers was higher in TCB farms (Rs. 305832) followed by SPB farms (Rs. 284807). Cost of production per kg was Rs.4.25 in SPB and Rs. 2.89 in TCB farms. Net return realized per kg was Rs. 9.35 and Rs. 5.14 respectively in SPB and TCB farms. Even though cost of production and profit from per kg of banana production were more in sucker propagated banana than that of tissue culture farms, ratooning was possible with tissue culture variety when compared with sucker propagated variety, thereby reducing the initial cost of establishment besides shortening of the crop duration.

Table 2. Partial budgeting of tissue culture vs sucker propagated banana in precision farming

S.No	Debit	Value (Rs/ha)	S.No	Credit	Value (Rs/ha)
1	Increase in cost		1	Decrease in cost	
	Plantlets / Sucker	25672		Human labour	1377
	Manures & fertilizers	14723		Machine power	2479
	Plant protection	1811		Propping	278
	Total	42206		Total	4134
2	Decrease in return	-	2	Increase in return	
		-		Gross income	62036
	Total increased cost and reduced returns	42206		Total reduced cost and increased returns	66170
	Net Gain				23964

Table 3. Descriptive statistics for dependent and independent variables

Particulars	Mean	Standard Deviation	Minimum	Maximum
		Yield (kg/ha)		
TCB	55641.13	1971.54	35000.00	75000.00
SPB	31583.18	776.35	22584.00	45650.00
		Plantlet/Sucker (Numbers/ha)		
TCB	2786.76	59.23	1832.60	3320.00
SPB	2478.88	45.62	2000.00	3000.00
		Human Labour (Rs/ha)		
TCB	20605.89	756.02	11248.00	30920.00
SPB	22277.3	742.25	16410.00	30770.00
		Fertilizer (Rs/ha)		
TCB	25675.06	1812.47	10248.00	42225.00
SPB	19011.95	1153.57	8514.45	31367.19
		Irrigation (mm/ha)		
TCB	2052.57	50.16	1319.47	2650.00
SPB	1838.46	27.31	1512.00	2160.00
		Other costs (Rs/ha)		
TCB	22424.32	1239.52	11995.20	38750.00
SPB	18311.92	1365.02	2399.76	34105.00

Partial budgeting of tissue culture banana cultivation

For estimating additional costs and returns for growing tissue culture banana in place of sucker banana, partial budgeting was employed and the results are presented in Table 2. An additional return of Rs.66170 and net gain of Rs.23964 were realized by

Table 4. Maximum likelihood estimates of stochastic frontier production function

Independent Variables	Precision farming	
	Tissue culture	Sucker
Intercept	1.283	-1.152
	(0.922)	(0.747)
Plantlets/Sucker (numbers)	1.008**	0.911**
	(3.819)	(4.634)
Human labour (Rs/ha)	0.331**	-0.062
	(2.731)	(0.549)
Fertilizers (Rs/ha)	0.036	0.076*
	(0.384)	(2.356)
Irrigation (mm/ha)	0.254	0.491**
	(0.858)	(3.387)
Other costs (Rs/ha)	0.004	0.067*
	(0.040)	(2.301)
Sigma-squared	0.030**	0.014**
	(2.681)	(2.901)
Gamma	0.816**	0.982**
	(5.829)	(7.746)
Log likelihood	21.49	38.69

(Figures in parentheses denotes t value of estimate) ** Significant at 1% level, * Significant at 5% level

way of adopting tissue culture technique under precision farming method in banana cultivation. The result established that the adoption of tissue culture propagated variety in precision farming resulted in more net return.

Table 5. Frequency distribution of technical efficiency of the selected banana growers

Technical efficiency rating	Precision Farming	
	Tissue culture	Sucker propagated
<0.70	1 (03.33)	0 (00.00)
0.71-0.80	4 (13.34)	2 (06.67)
0.81-0.90	13 (43.33)	11 (36.67)
0.91-0.99	12 (40.00)	17 (56.66)
Total	30 (100.00)	30 (100.00)
Maximum efficiency	0.96	0.98
Minimum efficiency	0.68	0.76
Mean efficiency	0.88	0.91

(Figures in parentheses indicate percentage to total of number of farmers)

Technical efficiency in banana production

Descriptive statistics for the dependent and independent variables are presented in Table 3. The technical efficiency in banana production was estimated by Maximum Likely-hood Estimation (MLE) method using Stochastic Frontier Production Function and the results are furnished in Table 4. The results showed that plantlets and human labour were significant and other variables included in the model were non significant in tissue culture banana . All the variables except human labour were significant in sucker banana farWms. Similarly, seed and fertilizer were significantly influencing the crop production from the study conducted by Sekhon *et.al*, (2010) and Donkoh *et.al*., (2013). This implied that the productivity of sucker propagated banana can be increased by increasing the use of sucker, fertilizer, irrigation and other cost.

The percentage distribution of farms based on technical efficiency in banana production is presented in Table 5. The farm specific technical efficiency showed wide variations and the predicted mean technical efficiencies for banana farms were estimated to be 0.88 in TCB and 0.91 in SPB. The

Table 6. Decomposition of productivity difference in tissue culture banana against sucker propagated banana yield of precision farming.

S.No	Source of productivity difference	Percentage contribution
1	Observed difference in output	46.38
2	Sources of contribution	
	a. Output difference due to Technology	36.94
	b. Due to difference in Input use	09.16
	Plantlets/Sucker (Numbers/ha)	12.11
	Human labour (Rs/ha)	-02.28
	Fertilizers (Rs/ha)	02.09
	Irrigation (mm/ha)	-03.25
	Other costs (Rs/ha)	00.49
	Estimated difference in output	46.10

results are similar to the findings of Bifarin *et al.* (2010). The mean technical efficiency indicated that, the sample farmers in Dharmapuri district were producing banana upto about 88 per cent and 91 per cent of the potential (stochastic) frontier production levels in TCB and SPB respectively, given the levels of their inputs and technology currently being used. There were 40 per cent and 57 per cent of the total sample farms in TCB and SPB respectively belonged to the most efficient category (> 0.90) and there was no farmer in both the categories of farms with technical efficiency of less than 0.70. This would reveal the presence of technical inefficiencies whose elimination could lead to the improvement of technical efficiency of both tissue culture as well as sucker propagated banana farms.

Sources contributing to the yield differences in banana cultivation

Chow test was performed to understand the structural change in the relationship between the regressand and the regressors after introducing the new technology. It is showed that the calculated 'F' value (14.30) exceeded the table 'F' value (3.29) at

one per cent level of significance. This implied that the introduction of the tissue culture technology in banana caused structural break in the production response and shifted the banana production function in the process of technological change. The results of decomposition analysis (Table 6) reveal that there was slight discrepancy between the observed (46.38) and the estimated (46.10) differences in the productivities of TCB and SPB. The technological and input use differentials between the two technologies together contributed to form the total productivity differences of the order of 46.10 per cent, whereas the technological component alone accounted for 36.94 per cent. This implies that with the present level of resource used by the SPB farmers the productivity could be increased by about 37 per cent if the farmers could just switch over from SPB to TCB. Such an increase in productivity exclusively due to technological improvement is brought about through a shift in the scale and/or slope parameters of the production function (Basavaraja *et.al*, 2008). If, however, the farmers could simultaneously raise the input use level to the same level as on the TCB farms, the productivity could be further raised by another nine percentage points from 36.94 per cent to 46.10 per cent. There was large gap in the per hectare input use levels between the SPB and TCB. Therefore, it might not be possible for the SPB farmers to completely adopt the input use package of the TCB growers due to their poor resource base. But perhaps, they could adopt the modern cultivars with the existing or, possibly, higher level of input use, which could earn them better returns.

Thus the study suggested that even though 95 per cent increase in yield was observed in tissue culture banana than sucker banana only 7 per cent higher net income was realized from tissue culture banana due to low price (41.18 per cent) received for tissue culture banana. Therefore, improving the technical efficiency and strengthening marketing infrastructure to get better prices for tissue culture banana would enhance the net returns of banana farms.

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