Visit us - www.researchjournal.co.in ■ DOI : 10.15740/HAS/IRJAES/8.1/43-50
International Research Journal of Agricultural Economics and Statistics
Volume 8 | Issue 1 | March, 2017 | 43-50 ■ e ISSN-2231-6434

Research Paper

Production of banana in peri-urban areas of Coimbatore city – An economic analysis

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Paper History :
Received : *12.08.2016;*
Revised : *12.01.2017;*
Accepted : *22.01.2017*

ABSTRACT : In this paper, resource use efficiency and technical efficiency of banana cultivation were measured in peri-urban areas of Coimbatore city of Tamil Nadu. The study revealed that quantity of nitrogen and the number of irrigations had a positive and significant influence on the yield of banana. The ratio of MVP to MFC was greater than one for nitrogen and number of irrigation indicated that the under utilization of resources, hence there exists the possibility of enhancing their yield by increasing their efficiency. The overall mean technical efficiency of banana was 0.73, which indicated the possibility of increasing the yield of the crops by adopting better technology and cultivation practices. The scale efficiency among the farmers ranged between 0.49 and 1.00 with mean scale efficiency score of 0.74. Further, it was found that 84.93 per cent of farms were below the optimal scale size, have the scope of increasing their scale efficiency and thereby operate at optimal scale to increase their farm productivity and income. It is concluded that the sample farms were operating either with increasing returns to scale or constant returns to scale. This implies that the input use could be increased thereby to realize higher output.

KEY WORDS : Banana, Resource use efficiency, Data envelopment analysis (DEA), Returns to scale

HOW TO CITE THIS PAPER : Sahaanaa, N., Alagumani, T. and Velavan, C. (2017). Production of banana in peri-urban areas of Coimbatore city – An economic analysis. *Internat. Res. J. Agric. Eco. & Stat.*, **8** (1) : 43-50, **DOI : 10.15740/HAS/IRJAES/8.1/43-50.**

INTRODUCTION :

Banana is an important fruit crop cultivated in 50.14 million hectares with the production of 1020 million tonnes in the world. The world average productivity of banana is 20.35 tonnes per hectare. The major banana producing countries are India, China, Philippines, Ecuador, Brazil and Indonesia. India ranks first in banana production with 29780 thousand tonnes accounts to 29 per cent of the world production. Banana production in India has increased from 18887 thousand tonnes in 2004-05 to 29724 thousand tonnes in 2013-14. The productivity variation is an important limiting factor which ranged from 27 to 37 tonnes per hectare during the last decade. Banana productivity in India is less than Indonesia and Guatemala.

Tamil Nadu ranks first in both area and production of banana in India with 118 thousand hectares and 5650 thousand tonnes. The average productivity of banana in the state is 47.87 tonnes per hectare which is lower than other major banana producing states *viz.*, Madhya Pradesh, Gujarat, Maharashtra and Punjab. Though the state is leading producer of banana in the country, the productivity is comparatively lower than other leading banana producing states. Hence, production analysis of banana production would provide a better insight about the efficient utilization of the resources through which productivity can be improved further. Enhancing and sustaining productivity on the other hand would help to meet out the growing urban demand in the state.

Coimbatore is an important industrial city in Tamil Nadu. Urban population of the city has increased from 14.61 lakhs in 2001 to 21.51 lakhs in 2011. Hence, the demand for fresh fruits and vegetables has also increased over the years. Cultivation of fruits and vegetable is picking up in the peri-urban areas of the city due to better demand prediction, easy market access, reduced transportation cost and assured market. Hence, the demand of fruits and vegetable of Coimbatore city is mostly met from the peri-urban areas. Banana is an important fruit commonly present in the food basket of most of the consumers in the city. Among the banana producing districts, Coimbatore district ranks fourth position in banana production in the state. The banana production is also predominant in peri urban areas of the Coimbatore city. With this background, the present study was aimed to study the economic analysis of banana production in peri-urban areas Coimbatore. The specific objectives are (i) to estimate cost and returns in banana production and (ii) to assess the technical efficiency and allocative efficiency.

MATERIALS AND METHODS :

Coimbatore district is purposively selected for the study. At first stage, three blocks were purposively selected based on the area under horticultural crops. The blocks selected for the study were Thondamuthur, Madukkarai and Karamadai. In each block, one peri-urban cluster villages were selected. From each cluster, 30 farmers were selected at random and the total sample size was 90. The sample farmers were personally interviewed and the data were obtained using structured interview schedule. The data relating to the year 2013-14 were collected during December 2014 to February 2015.

Production function:

The Cobb-Douglas production function was fitted to establish the input-output relations and to calculate the efficiency of the inputs used. The dependent and independent variables used in the model are given below.

The model is specified as follows:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} X_7^{\beta_7} X_8^{\beta_8} X_9^{\beta_9} e^U$$

The logarithmic expression of the model is

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9$$

Y- Banana output (t/ha),

$\beta_0 \ldots \beta_9$ - Parameters to be estimated,

X_1 - Number of seedlings

X_2 - Machine labour (hrs/ha)

X_3 - Human labour (man-days/ha)

X_4 - Farm yard manure (tonnes/ha)

X_5 - Quantity of nitrogen (kg/ha)

X_6 - Quantity of phosphorus (kg/ha)

X_7 - Quantity of potassium (kg/ha)

X_8 - Plant protection chemicals (Rs. /ha)

X_9 - Irrigation (No. /ha)

Resource-use efficiency:

Marginal productivity analysis was done to study the efficiency of various resources used for production. The efficiency of resources is determined as follows

$$r = \frac{\text{Marginal value product (MVP)}}{\text{Marginal factor cost (MFC)}}$$

where,

r = Efficiency ratio

MVP = Product of marginal physical product and unit price of output (MPP. PY)

MFC = Cost of one unit of a particular resource

If, r = 1, it implies efficient use of the particular resource.

r < 1, it implies inefficient (over-utilizing resources) use of the particular resource.

r > 1, it implies inefficient (underutilizing resources) use of the particular resource.

Technical efficiency:

Technical efficiency refers to the farm's ability to produce the maximum possible output from a given combination of inputs and technology. Data envelopment analysis (DEA) advocated by Charnes *et al*. (1978) is used in the present study to examine the technical efficiency.

Data envelopment analysis (DEA):

The DEA method is a frontier method that does not require specification of a functional or distributional form, and can accommodate scale issues. This approach was first used by Farrell (1957) as a piecewise linear convex hull approach to frontier estimation and later by Boles (1966) and Afriat (1972). In the present study, Data

Envelopment Analysis (DEA) technique was employed to estimate the technical and allocative efficiencies of the various crops raised by the peri-urban farms.

The DEA was applied by using both classic models CRS (constant returns to scale) and VRS (variable returns to scale) with input orientation, in which one seeks input minimization to obtain a particular product level.

Constant returns to scale:

Under the assumption of constant returns to scale, the linear programming model for measuring the efficiency of farms are:

$\text{Min}_{\theta,\lambda}\ \theta$

Subject to (i) $-y_i + Y\lambda \geq 0$

(ii) $\theta x_i - X\lambda = 0$

(iii) $\lambda \geq 0$ ..... (1)

where,

y_i is a vector (m × 1) of output of the i^{th} farm,

x_i is a vector (k × 1) of inputs of the i^{th} farm,

Y is the output matrix (n × m) for n farms,

X is the input matrix (n × k) for n farms,

θ is the efficiency score, a scalar whose value will be the efficiency measure for the i^{th} farm. If θ =1, the farm will be efficient; otherwise, inefficient, and λ is a vector (n × 1) whose values are calculated to obtain the optimum solution.

For an inefficient farm, the θ values will be the weights used in the linear combination of other, efficient farms, which influence the projection of the inefficient farm on the calculated frontier.

The specification of constant returns is only suitable when the farms work at the optimum scale. Otherwise, the measures of technical efficiency can be mistaken for scale efficiency, which considers all the types of returns to production, *i.e.*, increasing, constant and decreasing.

Variable returns to scale:

The CRS model was reformulated by imposing a convexity constraint. The measure of technical efficiency obtained in the model with variable returns is also named as 'pure technical efficiency', as it is free of scale effects. The following linear programming model estimated it:

$\text{Min}_{\theta,\lambda}\ \theta$

Subject to (i) $-y_i + Y\lambda \geq 0$

(ii) $\theta x_i - X\lambda \geq 0$

(iii) $N_1\lambda = 1$

(iv) $\lambda \geq 0$ .... (2)

where, N_1 is a vector (n × 1) of ones.

When there are differences between the values of efficiency scores in the models CRS and VRS, scale inefficiency is confirmed, indicating that the return to scale is variable, *i.e.* it can be increasing or decreasing (Färe and Grosskopf, 1994).

The scale efficiency values for each analyzed unit can be obtained by the ratio between the scores for technical efficiency with constant and variable returns as follows:

$\theta s = \theta_{CRS}(X_K, Y_K) / \theta_{VRS}(X_K, Y_K)$ ....(3)

where,

θs = Scale efficiency,

$\theta_{CRS}(X_K, Y_K)$ = Technical efficiency for the model with constant returns, and

$\theta_{VRS}(X_K, Y_K)$ = Technical efficiency for the model with variable returns.

It could be seen that model (2) makes no distinction as to whether the farm is operating in the range of increasing or decreasing returns (Coelli *et al.*, 1998). The only information one has is that if the value obtained by calculating the scale efficiency in Equation (3) is equal to one, the farm will be operating with constant returns to scale. However, when θs is smaller than one, increasing or decreasing returns can occur. Therefore, to understand the nature of scale inefficiency, it is necessary to consider another problem of linear programming, *i.e.* the convexity constraint of model (2), $N_1\lambda = 1$, is replaced by $N_1\lambda \leq 1$ for the case of non-increasing returns, or by $N_1\lambda \geq 1$, for the model with non-decreasing returns. Therefore, in this work, the following models were also used for measuring the nature of efficiency.

Non-increasing returns:

$\text{Min}_{\theta,\lambda}\ \theta$

Subject to (i) $-y_i + Y\lambda \geq 0$

(ii) $\theta x_i - X\lambda \geq 0$

(iii) $N_1\lambda \geq 1$

(iv) $\lambda \geq 0$ ..... (4)

Non-decreasing returns:

Min θ, λ θ

Subject to (i) $-y_i + Y\lambda \geq 0$

(ii) $\theta x_i - X\lambda \geq 0$

(iii) $N_1\lambda \geq 1$

(iv) $\lambda \geq 0$ ..... (5)

It is to be stated here that all the above models should be solved n times, *i.e.* the model is solved for each farm in the sample. The quantity banana produced (t/ha) was used as an output (Y) in the present case and total labour days (man days), machine power (hours), seeds/plant population (No.), farm yard manure (t), plant nutrients N (kg), P (kg), K (kg) separately, capital inputs (Rs.) on plant protection, other input costs and fixed input costs as inputs (X). The models were solved using the DEAP version 2.1 taking an input orientation to obtain the efficiency levels (Murthy *et al.*, 2009).

RESULTS AND DATA ANALYSIS :

In peri-urban areas, banana crop is raised since there is ready market for banana both as vegetable and also fruit. The banana varieties grown in the study area are Robusta, Poovan, Grand Naine and Nendran. Major planting season of banana falls from August to September and the major harvesting season is from November to April.

Land holding pattern:

The land holding pattern of the farmers in the study area are analyzed and presented in Table 1. It could be clearly understood from the table that 11.11 per cent of the sample farmers were marginal farmers with less than one hectare of land and small farmers accounted for 64.44 per cent of the sample farmers. Semi-medium farmers accounted for 20 per cent and only 4.45 per cent of the total sample farmers were medium farmers. This clearly shows that majority of farmers are marginal and small landholders indicating the scope for making more intensive use of land and adopting new technologies to increase farm productivity.

With respect to the sample blocks, Thondamuthur

Table 1 : Land holding pattern of the sample farmers **(Numbers)**

Sr. No.	Farm size (ha)	Thondamuthur	Madukkarai	Karamadai	Total sample
1.	Marginal (less than 1)	2 (6.67)	4 (13.33)	4 (13.33)	10 (11.11)
2.	Small (1 – 2)	22 (73.33)	17 (56.67)	19 (63.34)	58 (64.44)
3.	Semi-Medium (2 – 4)	4 (13.33)	7 (23.33)	7 (23.33)	18 (20.00)
4.	Medium (4 – 10)	2 (6.67)	2 (6.67)	-	4 (4.45)
	Total	30 (100.00)	30 (100.00)	30 (100.00)	90 (100.00)
	Average farm size	2.09	2.51	2.03	1.94

Figures in parentheses indicate percentages to the respective total

Table 2 : Cropping pattern of the sample farmers **(Hectares)**

Sr. No.	Crops	Thondamuthur	Madukkarai	Karamadai	Total sample
1.	Banana	16.80 (15.27)	19.23 (20.25)	18.42 (27.09)	54.45 (20.28)
2.	Tomato	22.67 (20.61)	20.65 (21.75)	13.36 (19.65)	56.68 (21.12)
3.	Small onion	23.28 (21.16)	-	-	23.28 (8.53)
4.	Chillies	9.72 (8.83)	5.47 (5.76)	0.40 (0.59)	15.59 (5.71)
5.	Brinjal	2.02 (1.84)	2.63 (2.77)	7.09 (10.43)	11.74 (4.30)
6.	Okra	7.29 (6.63)	3.85 (4.05)	5.87 (8.63)	17.01 (6.23)
7.	Cauliflower	8.50 (7.73)	-	-	8.50 (3.11)
8.	Turmeric	6.28 (5.71)	2.43 (2.56)	-	8.71 (3.19)
9.	Tapioca	-	3.04 (3.20)	-	3.04 (1.11)
10.	Gourds	0.60 (0.55)	16.40 (17.27)	2.43 (3.57)	19.43 (7.12)
11.	Maize	2.23 (2.03)	5.87 (6.18)	-	8.10 (2.97)
12.	Greens and Coriander	1.32 (1.20)	2.23 (2.35)	1 (1.47)	4.55 (1.67)
13.	Curry leaves	-	-	5.87 (8.63)	5.87 (2.15)
14.	Jathi malli	-	-	6.88 (10.12)	6.88 (2.52)
15.	Coconut	9.31 (8.46)	13.16 (13.86)	6.68 (9.82)	29.15 (10.86)
	Total cropped area	108.7 (100.00)	92.73 (100.00)	67.00 (100.00)	268.43 (100.00)
	Net area sown	62.7	75.3	60.9	174.6
	Cropping intensity	173.37	123.15	110.02	153.74

Figures in parentheses indicate percentages to the respective total cropped area had highest percentage of small farmers with 73.33 per cent followed by Karamadai with 63.34 per cent and Madukkarai with 56.67 per cent. Semi-medium farmers in the three blocks accounted for 13.33 per cent, 23.33 per cent and 23.33 per cent, respectively. The average farm size of Thondamuthur, Madukkarai and Karamadai blocks were 2.09 hectares, 2.51 hectares and 2.03 hectares, respectively. The results revealed that 75.55 per cent of the sample farmers were marginal and small farmers and 20 per cent were semi-medium farmers

Area under various crops in the sample farms:

The cropping pattern of the sample farmers are presented in Table 2. It could be seen from the table that the crops constituting major share of the total cropped area were tomato, banana and coconut accounting for about 21.12 per cent, 20.28 per cent and 10.86 per cent, respectively. It is evident from the table that vegetables constituted major share in the cropping pattern of the sample farmers. It could also be observed from the table that certain crops were cultivated only in the particular blocks. With respect to the individual blocks, crops like onion and cauliflower were cultivated only in Thondamuthur, whereas tapioca was confined only to Madukkarai block. Similarly, curry leaves and jathi malli were grown only in sample farms of Karamadai block. Crops like banana, tomato, chillies, brinjal, bhendi and coconut were cultivated in all the three blocks. Crops such as greens and coriander were cultivated in small areas in each block which constituted only 1.67 per cent of the total cropped area.

It could be observed from the table that the cropping intensity was high in Thondamuthur block with 173.37 per cent, followed by Madukkarai with 123.15 per cent and Karamadai with 110.02 per cent. With respect to the total samples, the cropping intensity was 153.74 per cent.

Input use in banana cultivation:

The level of input use for banana cultivation is presented in Table 3. The total number of suckers used for banana cultivation was the highest in Karamadai block with 2750 suckers per hectates and lowest in Madukkarai block with 2500 suckers per hectares. Machine labour usage hours varied from 6-8 hours among the selected block. Human labour varied from 122 -127 days. The farm yard manure usage was the highest in Madukkarai block with 24 tonnes per hectare. However, the NPK usage was the highest among Karamadai and Thondamuthur block farmers. The expenditure on plant protection chemicals was the highest among Karamadai block farmers.

Yield of banana crop among the sample farms:

The yield banana crop among the selected farms is presented in Table 4. Average yield of Thondamuthur block was the highest when compared to other two blocks. The maximum yield was reported as 49 tonnes per hectares and minimum was 25 tonnes per hectrare in Thondamuthur block. However, Madukkarai block farmers achieved maximum yield of 49 tonnes but the variability was highest among the selected blocks.

Table 3 : Input use for banana cultivation in selected blocks of Coimbatore district

Sr. No.	Particulars	Karamadai block	Madukkarai block	Thondamuthur block
1.	Seeds and seed materials (No. of suckers)	2750**	2500**	2599**
2.	Machine labour (hours)	6.5	6	8
3.	Human labour (man days)	122	127	124
4.	Farmyard manure (tonnes)	21	24	21
5.	Nitrogen (kg)	167	158	160
6.	Phosphorus (kg)	140	120	130
7.	Potassium (kg)	270	260	280
8.	Plant protection chemicals (Rs.)	25711	17151	17133

Table 4 : Yield of banana in sample farms in selected blocks of Coimbatore districts **(tonnes/ha)**

Sr. No.	Block	Minimum	Maximum	Average	C.V. (%)
1.	Thondamuthur	25	49	32	18.85
2.	Madukkari	20	49	28	23.53
3.	Karamadai	20	37	28	18.26

Costs and returns:

The cost and returns of banana crop raised by the sample farmers are presented in Table 5. The cost of cultivation of banana was the highest among the Karamadai block farms with Rs.2.26 lakhs per hectare and lowest in Madukkarai block with Rs.2.18 lakhs per hectare. Though the cost of cultivation was higher in Karamadai block the net return was lowest among the selected blocks. The benefit cost ratio was the highest in Thondamuthur block (2.87) followed by Madukkarai (2.57) and Karamadai (2.47) blocks. This showed that Thondamuthur block farmers got better returns when compared to other block farmers.

Resource-use efficiency in banana:

The results of the production function analysis for banana are presented in Table 6. A perusal of the table shows that the adjusted R^2 value is 0.91 which indicates that about 91 per cent of the variation in banana yield is explained by the variables included in the model. The quantity of nitrogen and number of irrigations had positive influence on the yield of banana and the co-efficients are significant at 1 per cent level. The co-efficient for irrigation and nitrogen is 1.3298 and 0.9908 which implies that one per cent increase in irrigation and nitrogen, increases the yield by 1.33 per cent and 0.99 per cent, respectively.

Marginal productivity analysis:

The efficiency in the use of the various resources is estimated using marginal productivity analysis and are presented in Table 7.

It is evident from the Table 7 that MVP is greater than MFC for nitrogen and number of irrigations, indicating the under-utilization of the resources. This shows that there is scope for increasing the output per hectare by increasing the use of these resources.

Technical efficiency in banana production:

Banana is one of the major fruit crops produced in the study area and cultivated in 73 out of the 90 sample farms. The technical efficiency was calculated for these 73 banana producing farms and the results are presented in Table 8.

Table 5 : Costs and returns of banana crop among the sample farmers (Rs. / ha)

Sr. No.	Block	Total cost of cultivation	Gross returns	Net returns	B-C ratio
1.	Thondamuthur	222771	640000	417229	2.87
2.	Madukkari	218139	560000	341861	2.57
3.	Karamadai	226489	560000	333511	2.47

Table 6 : Production function estimates of banana

Sr. No.	Particulars	Co-efficient	t-value
1.	Constant	-7.9778	-5.54
2.	Plant population (X_1)	0.0141 NS	0.09
3.	Machine labour (X_2)	-0.0291 NS	-0.62
4.	Human labour (X_3)	0.0368 NS	0.34
5.	Farmyard Manure (X_4)	0.0992 NS	1.48
6.	Nitrogen (X_5)	0.9908*	5.50
7.	Phosphorous (X_6)	-0.0008 NS	-0.05
8.	Potassium (X_7)	0.0535 NS	1.43
9.	Plant protection chemicals (X_8)	0.0092NS	0.28
10.	Irrigation (X_9)	1.3298*	6.14
	Adjusted R^2	0.9120	

*indicates significance of value at P=0.01 NS=Non-significant

Table 7 : Resource use efficiency in banana

Sr. No.	Variables (units/ha)	Geometric mean	Regression co-efficient	MVP	MFC	Ratio of MVP to MFC
1.	Nitrogen (kg)	164	0.9908	4346.4	123	35.34
2.	Irrigation (No.)	67	1.3298	14279.1	250	57.11

Table 8 : Efficiency measures and descriptive statistics for banana producing farms

Sr. No.	Descriptive statistics	CRSTE	VRSTE	SE±
	No. of Efficient Farms (≥ 0.90)	11 (15.07)	73 (100.00)	11 (15.07)
1.	Mean	0.73	0.98	0.74
2.	Standard deviation	0.15	0.03	0.14
3.	Minimum	0.47	0.91	0.49
4.	Maximum	1.00	1.00	1.00

Note: Figures in parentheses indicate percentages to total number of farms (n=73)
CRSTE- Technical Efficiency under Constant Returns to Scale; VRSTE- Technical Efficiency under Variable Returns to Scale;
SE - Scale Efficiency

Overall technical efficiency:

A perusal of Table 8 shows that, out of the 73 banana producing farms, only 11 farms (15.07 %) were operating with the overall technical efficiency of more than 0.90 under the assumption of Constant Returns to Scale (CRS). This shows that majority of the banana producers were technically inefficient when constant returns to scale was assumed. The overall technical efficiency of the farms ranged from 0.47 to 1.00 with mean technical efficiency of 0.73. This implies that the efficiency could be increased by 27 per cent, through better use of the resources, with the given technology.

Pure technical efficiency:

Assuming variable returns to scale, the pure technical efficiency ranged from 0.91 to 1.00 with mean efficiency score of 0.98. Under VRS assumption, the farms operating with pure technical efficiency was 100 per cent.

Scale efficiency:

Farms with scale efficiency of more than 0.90 constituted about 15.07 per cent, indicating that the remaining 84.93 per cent were operating in less than optimal scale size. The scale efficiency among the farmers ranged between 0.49 and 1.00 with mean scale efficiency score of 0.74. It is concluded that the remaining 84.93 per cent of farms below the optimal scale size have the scope of increasing their scale efficiency and thereby operate at optimal scale to increase their farm productivity and income.

Scale of operations:

The distribution of farms in the regions of production frontier is presented in Fig. 1. It could be observed that 89 per cent of the farms were operating in the region of increasing returns or sub optimal region. This implies that nearly 11 per cent of the farms operated in the constant region frontier.

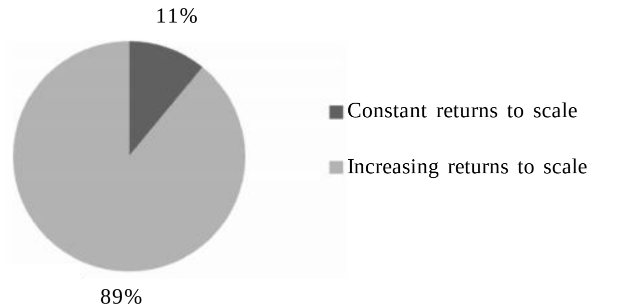

Fig. 1 : Returns to scale in banana production

It can be concluded that the sample farms were operating either with increasing returns to scale or constant returns to scale. This implies that the input use could be increased thereby to realize higher output.

Conclusion:

The yield of banana varied from 20 to 49 tonnes among the sample with the average of 29 tonnes per hectare. The maximum net return received by the farmers was Rs. 4.17 lakhs with the benefit cost ratio of 2.87 in Thondamuthur block and the minimum net return was Rs. 3.33 lakhs with the benefit cost ratio of 2.47. The co-efficients of nitrogenous fertilizer and number of irrigation had positively and significantly influence the yield of banana. Further, marginal productivity analysis indicated that the under utilization of nitrogen and number of irrigations. This indicated that there is scope for increasing the output per hectare by increasing the use of these resources. Out of the 73 banana producing farms, only 11 farms (15.07 %) were operating with the overall technical efficiency. Farms with scale efficiency of more than 0.90 constituted about 15.07 per cent, indicating that the remaining 84.93 per cent were operating in less than optimal scale size. Hence, it is concluded that there is a scope for increasing efficiency of the farms in the study area.

Acknowledgement:

This is a part of the post graduate thesis entitled "An Economic Analysis of Peri-Urban Horticulture in Coimbatore District" of the first author, submitted to Tamil Nadu Agricultural University, Coimbatore in the supervision of second author.

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