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A comparative economics of irrigated and rainfed finger millet production in Dharmapuri district of Tamil Nadu

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Abstract
The present study focus to explore a comparative economics of irrigated and rainfed finger millet production in the Dharmapuri district of Tamil Nadu. Due to the changes in consumption pattern taking place the importance of economic analysis of such millets has increased manifold to understand the sustenance of production through time. One hundred and twenty farmers were contacted, 60 each form irrigated and rainfed finger millet production environment. Simple random sampling method was used to identify the sampling units in the Dharmapuri district. The average cost of cultivation per hectare for irrigated and rainfed finger millet was found to be Rs. 59419 and Rs. 32888 respectively. The cost of production per quintal of finger millet in irrigated and rainfed with by-product was Rs.1714 and Rs.1654 respectively. The profitability of irrigated finger millet per hectare was Rs.20288 and rainfed was Rs.10819. The average technical efficiency score was found to be 80 and 87 per cent and the scale efficiency was found to be 87 per cent both under irrigated and rainfed finger millet production environment.

Keywords: Fixed cost, variable cost, cost of production, technical efficiency

Introduction
Eleusine coracana L. Gaertn, known as finger millet, is one of the significant millets that is widely cultivated in Dharmapuri district of Tamil Nadu. It is grown over an area of around 28,500 hectares. In Kharif season, nearly 80 percent of finger millet is grown under rainfed situations. It is a resistant crop that adapts well to a variety of conditions, particularly heat, drought, and marginal or degraded soils. Expansion of irrigated agriculture is considered to play a pivotal role in reaching the broader development vision of the country; achieving sustainable economic growth, ensuring food security and poverty reduction. However, the limited financial and natural resources (water and land), Government plans to expand use of rainfed areas for agricultural production in Tami Nadu. Hence it is important to study, among other performance parameters, the production efficiency of finger millet in irrigated and rainfed conditions in Dharmapuri district of Tamil Nadu with the specific objective to investigate the economics and technical efficiency of irrigated and rainfed finger millet production.

Methodology
Among the 38 districts of Tamil Nadu, Dharmapuri district was purposefully selected for this study due to the presence of highest area under irrigated and rainfed finger millet production. Among the eight blocks in Dharmapuri district, four blocks were purposefully selected based on the highest area under irrigated and rainfed finger millet. Karimangalam and Harur blocks represented irrigated block. Nallampalli and Pennagaram blocks represented rainfed block. Two villages from each block were purposefully selected based on the highest area under finger millet. Villages namely Vedharampatti, Bhatharahalli, Mavadipatti, Navalai were select from the irrigated block and Thokkampatti, Bhalpatti, Podur and Adhakapadi villages represented rainfed block. From each village 15 farmers were selected. A pre-tested questionnaire was used to gather primary data.

Analytical tools and techniques employed
Cost and Returns
Based on the principle of cost estimation, both fixed and variable costs were categorized.

The rental value of land, land revenue, depreciation, and interest on fixed capital all comprised the fixed costs. Seed value, labor costs (both human and machine), manure, irrigation cost, cost of N, P_2O_5, and K_2O and interest on working capital, were all considered variable costs.

Data envelopment analysis

The DEA method is a frontier approach that can deal with scale difficulties and does not necessitate the specification of a functional or distributional form. The DEA methodology has been used extensively in the Western world. In India, very few studies have employed this methodology to measure farm level efficiency, particularly in agriculture or horticulture. The drawback of the DEA model is that data noise is not expressly taken into account. Due to the inclusion of the majority of crop production factors and the ease with which the DEA technique could give detailed information on technical efficiency, scale efficiency and peers, it was chosen in this instance since data noise was less of an issue.

The Data Envelopment Analysis model was used to estimate the technical, scale and return to scale. DEA uses linear programming to construct the efficient frontier with the best performing observations of the sample used so that the frontier envelops all observations. The distance from a farm to the frontier provides a measure of its efficiency. DEA also enables to assess under which returns to scale each farm operates and to calculate their scale inefficiency.

Constant returns to scale (CRS) gives the 'overall technical efficiency' score while assuming variable returns to scale (VRS) allows calculating one component of this total efficiency score, namely the 'pure technical efficiency' which captures the management practices. Estimated efficiency scores are ranging from 0 to 1. This means that a farm is operating under the fully efficient condition when the efficiency score is one.

Under the assumption of constant returns to scale, the following input-oriented linear programming model was used to measure the overall technical efficiency of farms:

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

Subject to

$-y_i + Y\lambda \geq 0$

$\theta x_i - X\lambda \geq 0$

$\lambda \geq 0$

Where,

Y_i is m × 1 vector matrix of output for i^{th} Finger millet producing farm.

X_i is k × 1 vector matrix of inputs for i^{th} Finger millet producing farm.

Y is n × m output matrix for 'n' number of Finger millet producing farms.

X is n × k input matrix for 'n' number of Finger millet producing farms.

θ is an efficiency score, it is a scalar whose value would be the efficiency measure for each 'i' farm and it ranges from 0 to 1.

If θ = 1, then the farm would be efficient; otherwise, the farm would be below the efficient level, and λ is n × 1 vector of the matrix which provides the optimum solution. The λ values are used as weights in the linear combination of other efficient farms for an inefficient farm, which influences the projection of the inefficient farms on the calculated frontier.

Thus, the VRS model to measure the pure technical efficiency is specified as the following linear programming model:

$\min_{\theta, \lambda} \theta$

Subject to

$-y_i + Y\lambda \geq 0$

$\theta x_i - X\lambda \geq 0$

$\lambda \geq 0$

$N_1 \lambda = 1$

Where,

N_1 is n × 1 vector matrix of ones.

When there are the difference between the values of efficiency scores in the models CRS and VRS, scale inefficiency is confirmed, indicating that return to scale is variable, i.e. it can be increasing or decreasing. 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:

$\theta s = \theta\, CRS\,(XK, YK)/\theta\, VRS\,(XK, YK)$

Where,

θ_{CRS} (XK, YK) = Technical efficiency for the model with constant returns.

θ_{VRS} (XK, YK) = Technical efficiency for the model with variable returns.

θs = Scale efficiency.

Result and Discussion

Cost and returns of irrigated and rainfed Finger millet

The details on the costs incurred on variable and fixed factors in rainfed and irrigated Finger millet production are presented in Table 1.

Table 1: Cost and Returns of Irrigated and Rainfed Finger millet. (In Rs/ha)

S. No.	Particulars	Irrigated Finger millet	Rainfed Finger millet	Mean Difference
I.	**Fixed cost**			
	Land revenue	8.25 (0.014)	3.97 (0.012)	4.27*
	Rental value of land	6939.48 (11.68)	4299.66 (13.07)	2639.82*
	Depreciation	10187 (17.14)	2061.67 (6.27)	8125.35*
	Interest on fixed capital	1663.38 (2.80)	979.14 (2.98)	685.13*
	Total fixed cost	18798.11 (31.64)	7344.44 (22.33)	10109.16*

	Variable cost			
II.	Seed value	197.35 (0.33)	361.5 (1.10)	164.13*
	Human labor	21913.6 (36.88)	9653.01 (29.35)	12260.56*
	Machine labor	6912.04 (11.63)	7831.48 (23.81)	-919.44NS
	Manure	3978.8 (6.70)	3816.2 (11.60)	162.59NS
	Nitrogenous fertilizer	518.72 (0.87)	473.15 (1.44)	45.57NS
	P_2O_5	2025.19 (3.41)	514.72 (1.57)	1510.46*
	K_2O	452.57 (0.76)	195.83 (0.60)	256.73*
	Irrigation cost	291.72 (0.49)	0.00 (0.00)	291.71*
	Interest on working capital	4330.98 (7.29)	2698.13 (8.20)	1632.85*
	Total variable cost	40620.97 (68.36)	25544.02 (77.67)	15075.81*
III	Total cost(I+II)	59419.08 (100)	32888.46 (100)	25184.98*
IV	Grain yield (Qtl/ha)	29.43	20.83	8.60*
V	Grain value	82499	47911.3	34587.63*
VI	Straw yield (Qtl/ha)	16.34	7.57	8.7NS
VII	Straw value	3756.94	2413.89	1343.05NS
VIII	Gross return	85991.5	51341.9	34649.58
IX	Cost of Production			
	With by product	1714.53	1635.56	339.9*
	Without by product	2309.82	1969.94	78.95NS
X	Net return	20284.7	10819.2	9464.6*

*-significant NS-Non-significant.

The details of costs incurred on variable and fixed factors in irrigated and rainfed Finger millet production are presented in Table 3. It could be inferred from the table that, there was a significant difference in the total variable cost between irrigated and rainfed finger millet cultivation (Rs. 40620.97 per ha and Rs. 25544 per ha). Working expenses accounted about 68.36 per cent and 77.66 per cent of the total cost in irrigated and rainfed Finger millet cultivation, respectively.

In rainfed finger millet cultivation, the major cost item in variable cost was the cost on human labour (36.88%) followed by machine labour (11.63%), interest on working capital (7.29%), cost on FYM (6.70%) and fertilizer (5.04%). There was significant difference in cost between irrigated and rainfed finger millet cultivation except in FYM, Nitrogen and machine labour. Out of the total variable cost, 22.30 per cent was incurred only on the labour, which clearly implied that human labour was the most important input in finger millet cultivation which was mainly required for activities such as sowing/transplanting, weeding, harvesting and post-harvest operations (threshing, cleaning and bagging).

Fixed costs accounted for 22.33 per cent and 31.63 per cent of the total cost of cultivation in rainfed and irrigated finger millet cultivation. Among fixed cost, rental value of land occupied major share in both rainfed (13.07%) and irrigated (11.68%) finger millet cultivation. The average fixed cost was found to be Rs. 18798.11 per ha and Rs. 7344.44 per ha under irrigated and rainfed finger millet cultivation; The average cost of cultivation of irrigated and rainfed Finger millet was found to be Rs. 59419 and Rs. 32888.46 per hectare, respectively. Cost of cultivation was found to be higher in irrigated situation compared to rainfed situation, due to the use of higher labour, FYM and fertilizer.

Returns from finger millet cultivation

The gross return includes returns from main product (grain) as well as by-product (straw) and the details are presented in the Table. The average grain yield obtained per hectare under rainfed and irrigated situation was 20.83 quintals and 29.43 quintals, respectively. Per hectare gross return was Rs.51341.9 and Rs. 85991.5 in rainfed and irrigated finger millet cultivation, respectively. The results indicated that, yield was higher in irrigated situation compared to the rainfed situation which was mainly because of the adoption of management practices like maintaining optimum plant spacing, use of fertilizer, FYM and timely irrigation. The irrigated finger millet also fetched higher price (Rs. 2800/Quintal) compared to the rainfed finger millet (Rs. 2300/Quintal) because of the reason that the off season production from irrigated condition was lesser resulting in poor market arrivals during February to March and higher price for the produce.

The analysis of net return from finger millet cultivation revealed that the net return per hectare was Rs. 10819.2 under rainfed cultivation, whereas, the net return was Rs.20284.7 per hectare under irrigated cultivation. Rainfed farmers realized low net returns because of higher cost of cultivation and also lower yield. In spite of lower net returns, farmers continue to persist with finger millet cultivation mainly for the purpose of consumption and the quantity and quality of the fodder that it provides for rearing livestock. The cost of production under rainfed finger millet environment was Rs. 1635.51 per quintal compared to that of irrigated environment was Rs. 1714.53 per quintal.

Estimation of technical efficiency under in irrigated and rainfed Finger millet Production Environment

To assess the technical efficacy of finger millet production in irrigated and rainfed farms, data envelope analysis was used. An approach to non-parametric mathematical programming is called Data Envelopment Analysis (DEA).

The technical efficiency and scale efficiency of irrigated and rainfed production system calculated using the DEA approach are presented in Table 2.

Technical and scale efficiencies of irrigated and rainfed agro-ecological systems are provided as a result of DEA in Table 2.

Table 2: Technical and Scale efficiency under irrigated and rainfed finger millet production Environment

S. No.	Parameters	Irrigated Finger millet		Rainfed Finger millet	
		Technical efficiency	Scale efficiency	Technical efficiency	Scale efficiency
1.	Mean	0.80	0.87	0.87	0.874
2.	Standard Deviation	0.16	0.14	0.13	0.13
3.	Minimum	0.18	0.20	0.65	0.65
4.	Maximum	1.00	1.00	1.00	1.00

In production of irrigated finger millet and rainfed finger millet, the average technical efficiency score was determined to be 0.80 and 0.87, respectively. It implied that the irrigated finger millet production system was less technically efficient than the rainfed finger millet production system in Dharmapuri district. The results indicated that there is the potential to raise the output levels on irrigated farms by 0.20% and on rainfed farms by 0.13%.

In order to achieve the optimum output, there is possibility to increase yield on both types of farms the average Scale efficiency score was 0.87 and 0.874 respectively.

Table 3: Frequency Distribution of technical efficiency of Finger millet production among the sample farms

Frequency	Technical efficiency		Scale efficiency	
	Irrigated	Rainfed	Irrigated	Rainfed
<0.50	2 (3.33)	0 (0.00)	1 (1.67)	0 (0.00)
0.50-0.60	3 (5.0)	0 (0.00)	1 (1.67)	0 (0.00)
0.60-0.70	7 (11.7)	9 (15)	2 (3.33)	9 (15)
0.70-0.80	21 (35)	15 (25)	15 (25)	15 (25)
0.80-0.90	8 (13.3)	4 (6.7)	8 (13.33)	4 (6.67)
0.90-1.00	3 (5.0)	13 (21.67)	17 (28.33)	13 (21.67)
1.00	16 (26.7)	19 (31.7)	16 (26.67)	19 (31.67)
Total	60 (100)	60 (100)	60 (100)	60 (100)

From the table 3, it could be inferred that a greater proportion of the TE scores (35%) fells within the 0.70-0.80 range in irrigated and 31.70% fells within the range of 1.00 in rainfed environment. Results showed that out of 60 DMUs irrigated finger millet, 16 (26.70% of the total) and out of 60 DMUs rainfed finger millet 19 (31.70%) were technically efficient with TTE score equal to one. The agricultural production of these units was very efficient and they were the benchmarks for the other technically inefficient DMUs. These statistics presented a true reflection of the level of improvements needed by the farmers so as to reach the various optimum efficiency levels desired. With respect to scale efficiency, 26.60% of irrigated farms and 31.60% of rain-fed farms were in the most efficient size group (100%) whereas 1.66% of irrigated farms were in the least efficient scale group (0.50-0.60).

Conclusion

In comparison to the cultivation of finger millet under rainfed condition, irrigated condition resulted in higher level of profit primarily due to increased yield in Dharmapuri district. Under irrigated condition, the operational and management practices such as manuring, timely weeding and irrigation, application of appropriate dosage of fertilizers were properly adopted. The major constraint in rainfed condition was erratic rainfall followed by negative impact of climate. The results of Data Envelopment analysis indicated that the mean technical efficiency of irrigated and rainfed system farms was 0.80 per cent, and 0.87 per cent respectively. The mean scale efficiency of both irrigated and rainfed system was 0.87 per cent. Analysis of the technical efficiency showed that there occurred inefficiency in finger millet production and subsequent shortage of attaining the frontier yield.

Policy and Recommendation

This study analyzed the production efficiency of finger millet under irrigated and rainfed condition of Dharmapuri district of Tamil Nadu using primary data collected from 120 farmers. Econometric analysis was carried out using the DEA methodology to estimate the technical and scale efficiencies. The findings of the study revealed that about, 26.70% of irrigated farms and 31.70% of rain-fed farms were operating at full TE in terms of input use. Substantial levels of inefficiency exist in farmers' operations (technical, allocative and economic) with improvement potentials, given the current resources at the disposal of farmers. Finger millet production in both the environment required proper targeting of policies to improve the performance of Finger millet producers in Dharmapuri district.

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