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Comparative Analysis of Profitability, Water and Energy Productivity in Curry Leaf Cultivation: Drip vs. Conventional Production Systems in Coimbatore district, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The aim is to analyze the cost and returns of curry leaf production under different irrigation methods, assess water and energy productivity and draw conclusions regarding the sustainability and profitability of drip irrigation. The study utilizes a sample of 60 respondents from two blocks in

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Coimbatore district, employing a multi-stage random sampling technique. Primary data was collected through structured questionnaires administered via personal interviews between June and September 2023. Cost concepts were employed to calculate cultivation costs, while water and energy consumption were assessed to determine productivity. This study investigates the economic and environmental implications of adopting drip irrigation over conventional furrow irrigation for curry leaf cultivation in the Coimbatore district of Tamil Nadu, India. The results demonstrate that drip irrigation significantly reduces operational costs and improves yields compared to furrow irrigation. Gross and net incomes are substantially higher with drip irrigation, highlighting its economic advantages. Moreover, drip irrigation shows higher water and energy productivity, indicating its potential for resource conservation and sustainability. The results emphasize the importance of governmental support in promoting drip irrigation adoption to enhance water efficiency and facilitate value-added product export. In conclusion, this study highlights the significance of drip irrigation in enhancing profitability, conserving resources and promoting agricultural sustainability in curry leaf cultivation within the Coimbatore region.

Keywords: Cost and returns; curry leaf; water productivity; energy productivity; drip vs conventional method.

1. INTRODUCTION

Curry leaf (*Murraya koenigii* (L.) Spreng) holds significant cultural, culinary and medicinal importance in India [1]. Curry leaf is an integral component of Indian cuisine, enhancing the taste and aroma of various dishes due to its renowned aromatic leaves and distinct flavour [2,3]. Beyond its culinary uses, curry leaf boasts nutraceutical, medicinal, and therapeutic properties, contributing to its widespread cultivation and consumption [4,5]. Due to increasing demand in both domestic and international markets, the commercial cultivation of curry leaf as a leafy vegetable has expanded to various districts across Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, and Kerala (Mohan, 2012). Also Tamil Nadu government has been trying to improve the adoption of curry leaf area and production due to its low investment cost and higher returns and higher export opportunity. Spice board (2012) found that export of curry powders/paste surged by 11 per cent in quantity and 20 per cent in 2011-12 year, with 17,000 metric tonnes worth Rs. 252.08 crores exported, compared to 15,250 metric tonnes worth Rs. 210.50 crores previous year. Additionally, Ravikumar and Subathra [3] observed that 1.2 lakh kilograms (or 120,000 kilograms) of curry leaves were exported from India during the fiscal year 2014-15.

The Sengambu variety of curry leaves is particularly popular and extensively cultivated in regions like Annur, Karamadai, PN Palayam and SS Kulam, covering approximately 1270 hectares of agricultural land. This variety is favoured by farmers for its desirable attributes and adaptability to local growing conditions. The petioles exhibit a distinctive purplish-red hue, while the leaves boast a rich aroma and flavor attributed to their high essential oil content. Additionally, farmers in these regions are actively pursuing Geographical Indication (GI) tag certification for their curry leaf produce. Obtaining a GI tag would not only recognize the unique qualities and characteristics of curry leaves grown in these specific regions. Villages in and around Mettupalayam serve as the primary producers of Senkaambu curry leaves in Tamil Nadu. These regions serve as major suppliers, exporting leaves to countries like Singapore, Dubai and Malaysia, while also meeting the demand within various states across India [6].

Overall, the cultivation of curry leaves, especially the Sengambu variety, plays a vital role in the agricultural landscape of these regions, contributing to both local economies and cultural heritage. The study highlights the advantages of drip irrigation in improving profitability and sustainability in the area by using it in curry leaf farming to save costs, water and energy productivity. The main objective of the study is to find the cost and returns of curry leaf under drip vs conventional irrigation method in Coimbatore district. Also, the study tries to estimate the water and energy productivity by adopting drip over conventional method.

2. MATERIALS AND METHODS

2.1 Sample Design

Coimbatore district was chosen due to its higher cultivation area and production of curry leaves in Tamil Nadu. Coimbatore district is in the western part of state Tamil Nadu and lies between the latitude of 10°10' N and 11°30'N and longitude of 76°40'E and 77°30'E at an elevation of 460.60m from mean sea level. The sample selected for the study area comes under two blocks namely Karamadai and Annur. From the study area, 30 respondents were selected at random from each irrigation method namely Electric + Drip and Electric + Furrow irrigation adopters. Totally 60 respondents were selected from the study area. Thus multi stage random sampling was adopted for the study.

2.2 Duration of Study

Primary data was gathered from sample respondents between June and September 2023 via well-structured, pre-tested questionnaires administered through personal interviews. The survey details covered demographic details, farming characteristics and cost analysis, followed by data processing, tabulation and statistical analysis.

2.3 Methodology

2.3.1 Cost concept

Cost concepts will be used to understand the cost incurred for the cultivation of crops on farms. Cost of cultivation was calculated using cost concepts and the terms of costs included under each concept are given below:

1. Fixed Cost (FC)

i. Rental value of owned land
ii. Interest on value of owned fixed capital assets (excluding land)
iii. Depreciation
iv. Land revenue paid, cess and other taxes

2. Variable Cost (VC)

i. Value of hired human labour
ii. Imputed value of family labour
iii. Cost of hired bullock labour
iv. Cost of owned bullock labour
v. Value of owned machinery labour
vi. Value of hired machinery labour
vii. Value of seed (both farm produced and purchased)
viii. Price of insecticides and pesticides
ix. Value of manure
x. Value of fertilizer
xi. Irrigation charges
xii. Interest on working capital
xiii. Miscellaneous expenses.

3. Total cost (TC) = Fixed Cost +Variable Cost

4. Gross income (GI)

$GI = (Q_{MP} * P_{MP}) + (Q_{BP} + Q_{BP})$

Where

Q_{MP} = Total quantity of main output
P_{MP} = Price of main product
Q_{BP} = Total quantity of by-product
P_{BP} = Price of by-product

5. Net Income = Gross Income – Total Cost

6. Cost of Production = $\frac{\text{Total cost} - \text{value of by product}}{\text{Total quantity (output)of main product}}$

2.4 Energy Consumption in Groundwater Extraction

Hourly operation cost of electric wells with metered connection is worked out easily by using the energy charges per kilowatt hour (kwh) [7]. In case of wells with a flat rate and no meter connection, the implicit cost per hour of irrigation is worked out using capacity of pump, number of hours of irrigation and economic value of electricity for agriculture.

The energy consumption (electricity) for groundwater pumping (irrigation) was estimated based on the capacity of the electric motor's submersible pump set and the duration of operation (Adopted from Suresh and Palanisami [8].

$$\text{Electricity Consumption (KWh for each crop)} = (\text{HP of pump}) \times (\text{no. hours of irrigation}) \times (\text{no. irrigations}) \times 0.746^{1}$$

2.5 Volume of Water Applied to Crop

A volumetric measure is an indicator for the volume of freshwater used to cultivate a crop, the water footprint (WF) of crop production makes a distinction between the green WF (rainwater consumption), blue WF (irrigation water consumption) and grey WF (water pollution). The major crops selected in the

[1] 1 HP = 746 watts (or) 0.746 kwh, A one HP pump running for one hour consumes 0.746 kwh of power. (1 unit is also known as 1 kwh)

study area are all completely irrigated so that the green water applied (Green WF) to the crop is not taken into account. Volumetric water use for each crop was estimated using the given formula [9,10,11]. The data was acquired during the survey for the current crop to measure the volume of groundwater water extracted (Q) at the farm level. The total amount of pumping hours in a year was computed using crop-wise pumping hours. The formula to calculate the quantity of groundwater extracted or pumped (Q) for each crop is,

$$Q = \frac{q * 3600 * p}{1000}$$

Where,

Q: Volume of groundwater pumped or extracted (in m^3)
q: discharge rate (liters per second)
p: pumping hours

Pumping hours were estimated by multiplying the number of hours required to irrigate the crop by the frequency of irrigation (per month) and the number of months the crop is irrigated. Volumetric (bucket) method was used to estimate the discharge rate from groundwater structures (wells). A bucket with known capacity and a stopwatch were used to measure the wells' discharge at the farm level [12]. The well output was allowed to fill the bucket directly, and the time taken to fill the bucket was recorded. Before recording, the motor pump was turned on for ten minutes to prevent early pump yield bias.

$$\mathrm{q} = \frac{\text{Volume of water collected in bucket}}{\text{Time required to fill the bucket}}$$

where, q is the discharge rate of well (liters per second)

2.6 Physical Water and Energy Productivity

Physical water productivity was employed to evaluate the efficiency and productivity of water use in agriculture. Agricultural output per unit volume of water is a measure of water productivity. The physical water productivity PWP (kg/m^3) for irrigated crop is estimated as

$$\mathrm{PWP}(\mathrm{kg/m^3}) = \frac{\mathrm{Y}}{\mathrm{VOL_W}}$$

Physical energy productivity in agricultural crops measures the quantity of output produced per unit of electricity consumed. The energy mass productivity or energy productivity for major crops cultivated is estimated as

$$\mathrm{PEP}(\mathrm{kg/kwh}) = \frac{\mathrm{Y}}{\mathrm{Ec_W}}$$

$\mathrm{VOL_W}$ and Y are the volume of irrigation water used (m^3/ha) and yield of the crop (Kg/ha). Ec_W is the energy consumption (electricity) for groundwater pumping of the crop (Kg/kwh).

3. RESULTS AND DISCUSSION

3.1 Cost and Returns of Curry Leaves

Curry leaf is an aromatic perennial shrub, predominantly grown by the sample respondents in critical + semi-critical region. Curry leaf harvesting begins a year after the seedlings are planted. Cost and returns on curry leaf cultivation in Coimbatore district is presented in Table 1. The table outlines various cost components and their differences between the two irrigation methods.

The result indicates the cost of cultivating curry leaves under drip irrigation compared to conventional furrow irrigation in Coimbatore, represented in rupees per hectare (Rs/ha). Across various expense categories, drip irrigation consistently demonstrates cost savings over furrow irrigation. Notably, expenses such as human labour, machine labour, seed procurement, fertilizers, plant protection chemicals, irrigation, and interest on working capital are all notably lower with drip irrigation. The operational cost under drip irrigation is significantly reduced, Rs 1,69,441 in drip irrigation method compared to Rs 1,93,906 for furrow irrigation, resulting in a substantial difference of Rs 24,466. Moreover, fixed costs are also lower under drip irrigation, amounting to Rs 59,806, as opposed to Rs 48,976 under furrow irrigation. Additionally, drip irrigation outperforms furrow irrigation in terms of yield, with a difference of 5.12 tons per hectare. Consequently, the gross income derived from drip irrigation is substantially higher at Rs 7,25,200, compared to Rs 5,81,840 generated by furrow irrigation, resulting in a significant surplus of Rs 1,43,360. This disparity in gross income translates into a substantial difference in net income, with drip irrigation yielding Rs 4,95,953 and furrow irrigation yielding Rs 3,38,958, signifying a noteworthy surplus of Rs 1,56,996 with drip irrigation. Therefore, the data

Table 1. Cost of cultivation of curry leaves under drip vs conventional method of irrigation in Coimbatore

(Rs/ha)

Particulars	Electric + Drip	Electric + Furrow	Difference between drip over furrow
Human labour	48900 (21.33)	57680 (23.75)	-8780
Machine labour	10982 (4.79)	12350 (5.08)	-1368
Seed (Sapling material)	7510 (3.28)	7587 (3.12)	-77
Fertilizer and manures	36783 (16.05)	36538 (15.04)	245
Plant protection chemical	50531 (22.04)	58116 (23.93)	-7585
Irrigation	2800 (1.22)	8100 (3.33)	-5300
Miscellaneous	850 (0.37)	850 (0.35)	0
Interest on working capital	11085 (4.84)	12685 (5.22)	-1601
Operational cost	169441 (73.91)	193906 (79.84)	-24466
Fixed cost	59806 (26.09)	48976 (20.16)	-10830
Total cost	229247 (100.00)	242882 (100.00)	-13636
Yield (ton/ha)	25.90	20.78	5.12
Gross income	725200	581840	143360
Net income	495953	338958	156996

Source: Primary data collection (2023)
Note: Figures in the parentheses indicate the percentage of the total cost

underscores the economic advantages and potential profitability of adopting drip irrigation practices for curry leaf cultivation in the Coimbatore region. Similarly, Aishwarya et al., [13] investigated the cost of cultivation for coconut crop across different irrigation water management technology including solar + drip, electric + drip and electric + furrow methods.

3.2 Water and Energy Mass Productivity of Curry Leaves

The pumping hours and number of irrigation days per hectare per year for curry leaves in Coimbatore district is presented in Fig. 1. Under the Electric + Furrow method, the pumping hours required per hectare are 2283.05 hours, with an average of 77 irrigations per hectare. But in Electric + Drip method, the pumping hours reduce significantly to 726.35 hours per hectare, with an increased frequency of 182.50 irrigations per hectare. Similarly, Aishwarya et al., [14] estimate water productivity for major crops cultivated under three different regions namely head, middle and tail of Krishnagiri reservoir irrigation project.

The water and energy productivity of curry leaves in Coimbatore district is presented in Table 2. Electric + Drip irrigation method utilizes 6615.60 m^3/ha of volume of water applied for curry leaf cultivation, which is 65.00 per cent lower than electric + furrow's consumption of water 18903.65 m^3/ha. Additionally, Electric + Drip irrigation method requires 4692.48 kWh/ha of electricity, marking a reduction of 62.51 per cent compared to electric + furrow's consumption of 12518.19 kWh /ha. These findings highlight the significantly lower water and energy requirements of Electric + Drip irrigation, making it a more efficient and sustainable choice for curry leaf cultivation.

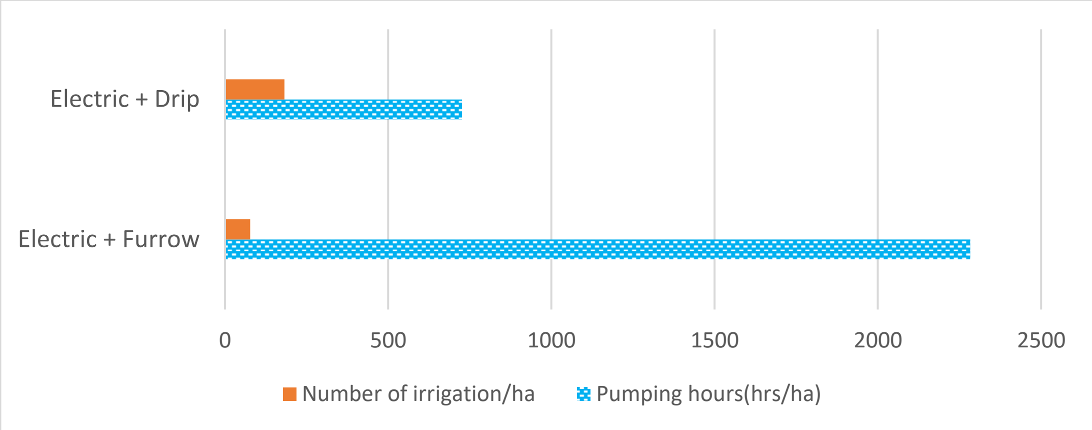

Fig. 1. Pumping hours and Number of irrigations per hectare for Curry leaves in Coimbatore district
Source: Primary data collection (2023)

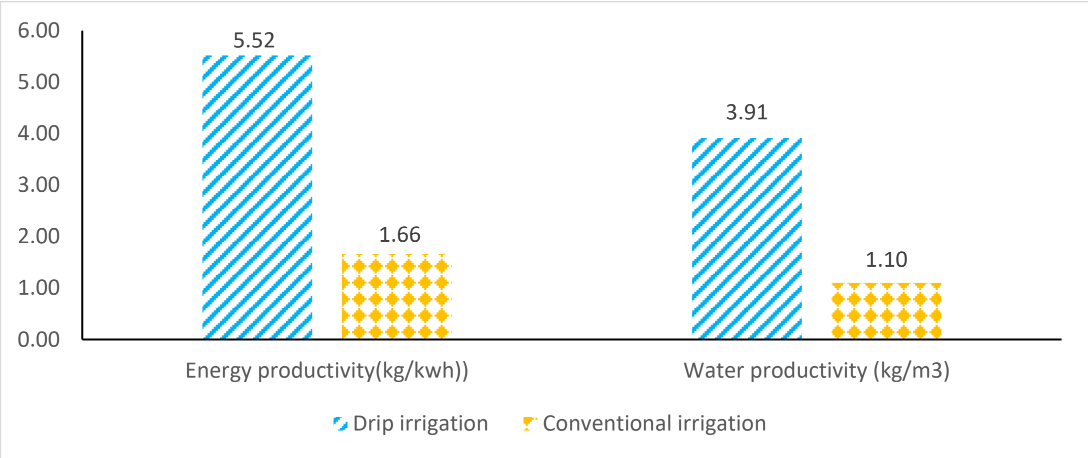

Fig. 2. Energy and Water mass productivity for Curry leaves in Coimbatore district
Source: Primary data collection (2023)

Table 2. Water and energy mass productivity for curry leaves in Coimbatore district

Category	Water consumption (m^3/ha)	Energy consumption(kWh/ha)	Water mass productivity(kg/m^3)	Energy mass productivity (kg/kWh)
Electric + Furrow	6615.6	4692.5	3.91	5.52
Electric + Drip	18904	12518	1.1	1.66

Source: Primary survey data collection (2023)

The water mass productivity for curry leaf is notably higher in Electric + Drip irrigation method at 3.91 kg/m^3, surpassing Electric + Furrow water mass productivity of 1.10 kg/m^3. Government support for farmers in adopting drip irrigation for curry leaf cultivation facilitates increased water efficiency and also aids in exporting the crop as a value-added product. Similarly, Electric + Drip irrigation method demonstrates superior energy productivity for curry leaf, indicating 5.52 kg/kWh compared to Electric + Furrow 1.66 kg/kWh. These findings highlight the significance of governmental assistance in promoting drip irrigation adoption, resulting in enhanced water and energy productivity for curry leaf cultivation.

4. CONCLUSION

The study concludes that there are significant economic and environmental advantages to using drip irrigation for curry leaf production in the Coimbatore area when compared to furrow irrigation. According to the data, drip irrigation drastically lowers operating costs by lowering expenditures for labour, fertilizers, seedling rate and irrigation, among other components. Furthermore, compared to furrow irrigation, drip irrigation produces larger yields, which increases gross and net income. Furthermore, curry leaves grown with drip irrigation have significantly greater water and energy productivity, proving the effectiveness and sustainability of this method of cultivation. Support from the government to encourage the use of drip irrigation emphasizes how crucial it is for increasing water efficiency and enabling the export of value-added products. All these findings highlighted, how important drip irrigation is to enhancing profitability, resource conservation and agricultural sustainability in curry leaf cultivation in the Coimbatore region.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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