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Economic Evaluation of Papaya Cultivation under Drip and Flood Irrigation Systems in Bellary District, Karnataka

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Abstract

Papaya (*Carica papaya*) is a high-value horticultural crop cultivated extensively in tropical and subtropical regions due to its rapid growth, high productivity, and nutritional significance. Efficient water management is critical for maximizing yield and profitability, especially in water-scarce regions like the Bellary district of Karnataka. The present study evaluates the economic performance of papaya cultivation under drip and flood irrigation systems, focusing on establishment cost, operational cost, yield, water usage, and net returns. Primary data were collected from 80 randomly selected farmers (40 under drip irrigation and 40 under flood irrigation), and partial budgeting was employed for economic comparison. Results indicate that although drip irrigation involves higher initial costs, it leads to significantly higher yields (42.32 t/acre vs. 30.26 t/acre) and net returns (₹2,21,198.96 vs. ₹1,38,399.93 per acre) compared to flood irrigation. The benefit-cost ratio was higher under drip irrigation (1.48) than under flood irrigation (1.10). The analysis highlights the economic viability of drip irrigation in papaya cultivation under semi-arid conditions, supporting its promotion for improving water productivity and farm profitability.

Keywords: Drip irrigation, flood irrigation, economic analysis, water-use efficiency, partial budgeting

Introduction

Papaya (*Carica papaya*) holds significant commercial importance in Karnataka, a leading state in papaya production in India (NHB, 2020) ^[5]. Bellary district, characterized by its semi-arid climate, well-drained soils, and irrigation infrastructure, is a key contributor to the state's papaya output, with 552 hectares under cultivation and an annual yield of 67.84 MT/ha (GoK, 2022) ^[7].

Agriculture in semi-arid regions faces challenges including water scarcity and rising input costs, necessitating efficient resource management to sustain profitability (Kumar *et al.*, 2017) ^[10]. While flood irrigation has been the traditional practice, it often results in water wastage and lower water-use efficiency (INCID, 1994) ^[4]. Drip irrigation, as a micro-irrigation system, delivers water directly to the root zone, reducing evaporation losses, enhancing fertilizer-use efficiency, and improving yields (Narayanamoorthy, 1997; Patel & Rajput, 2007) ^[1, 2].

Despite these benefits, the adoption of drip irrigation remains limited due to perceived high investment costs and lack of clear economic evidence, particularly for small and marginal farmers (Kumar *et al.*, 2008) ^[3]. The present study undertakes a comparative economic evaluation of papaya cultivation under drip and flood irrigation systems in Bellary district, assessing cost of cultivation, yield performance, net returns, and benefit-cost ratios to guide farmers and policymakers toward sustainable and profitable practices.

Materials and Methods

Study Area

The study was conducted in Bellary district, Karnataka, a semi-arid region with notable papaya cultivation.

Data Collection

- Primary data were collected from 80 farmers (40 under drip irrigation and 40 under flood irrigation) using pre-tested structured schedules through random sampling.
- Secondary data on area, production, and productivity were obtained from the Directorate of Horticulture, Lalbagh, Bengaluru (GoK, 2022) ^[7].

Analytical Tools

1. Cost and Returns Analysis

Cost and returns analysis was used to assess the profitability of papaya cultivation under drip and flood irrigation systems.

A. Total Cost of Cultivation (TCC)

$TCC = \text{Total Variable Cost (TVC)} + \text{Total Fixed Cost (TFC)}$

Where:

- TVC = costs of seeds, fertilizers, FYM, plant protection chemicals, hired labor, irrigation charges, etc.

- TFC = depreciation, rental value of land, interest on fixed capital, amortized establishment cost, etc.

B. Gross Returns (GR)

GR = Yield (tonnes/acre) × Price per tonne (₹)

C. Net Returns (NR)

NR = Gross Returns – Total Cost of Cultivation

D. Benefit-Cost Ratio (BCR)

BCR = Gross Returns/Total Cost of Cultivation

BCR > 1 indicates profitable cultivation.

2. Partial Budgeting

Partial budgeting was employed to analyze the economic viability of drip irrigation over flood irrigation in papaya cultivation, estimating additional costs, reduced costs, additional returns, and net gain.

The partial budgeting formula used is:

Net Gain = (Additional Returns + Reduced Costs) – Additional Costs

Where:

- Additional Returns (AR): Increased income due to higher yield under drip irrigation.
- Reduced Costs (RC): Savings under drip irrigation (e.g., reduced plant protection and irrigation costs).
- Additional Costs (AC): Extra expenses incurred under drip irrigation (e.g., system installation, additional fertilizers, additional labor). (Samra & Singh, 2000)^[6].

Results and Discussion

Cost of Cultivation

Table 1 presents the cost structure of papaya cultivation per acre under drip and flood irrigation systems. Material input costs accounted for the largest share in both systems, while amortized establishment costs and fixed capital interest were higher under drip irrigation due to initial investment. The total cost of cultivation was ₹1,49,228 per acre under drip irrigation compared to ₹1,26,465.85 per acre under flood irrigation.

Table 1: Cost of Cultivation under Drip and Flood Irrigation (₹/acre)

Sl. No.	Component	Drip	% of TC	Flood	% of TC
a.	Material Input Cost	54,996.24	66.67	47,204.79	65.85
b.	Labour Input Cost	22,556.28	27.38	21,324.59	29.75
C.	Interest on WC @ 7%	4,802.88	5.83	3,146.43	4.38
A	Total Variable Cost (TVC)	82,355.40	55.18	71,675.81	58.05
a.	Depreciation	2,686.20	4.14	2,460.60	4.49
b.	Rental Value of Land	21,470.00	33.53	20,527.00	37.46
c.	Land Revenue	35.00	-	35.00	-
d.	Interest on FC @ 10%	2,419.12	3.77	2,302.26	4.20
e.	Amortized Establishment Cost	40,262.27	-	29,465.18	-
B	Total Fixed Cost (TFC)	66,872.59	44.81	54,790.04	43.32
A+B	Total Cost of Cultivation	1,49,228.00	-	1,26,465.85	-

Yield and Gross Returns

Table 2 compares the yield and gross returns per acre under drip and flood irrigation. Drip irrigation recorded a higher yield (42.32 t/acre) than flood irrigation (30.26 t/acre), resulting in higher gross returns under drip irrigation (₹3,70,426.96/acre) than under flood irrigation (₹2,64,865.78/acre).

Table 2: Yield and Gross Returns under Drip and Flood Irrigation

Sl. No.	Parameter	Drip	Flood
1.	Yield (t/acre)	42.32	30.26
2.	Price per tonne (₹)	8,753.00	8,753.00
3.	Gross Returns (₹/acre)	3,70,426.96	2,64,865.78

Net Returns and Benefit-Cost Ratio

Table 3 shows net returns and the benefit-cost ratio under the two irrigation systems. Drip irrigation resulted in higher

net returns (₹2,21,198.96/acre) and a higher BCR (1.48) compared to flood irrigation (₹1,38,399.93/acre and BCR of 1.10).

Table 3: Net Returns and Benefit-Cost Ratio under Drip and Flood Irrigation

Sl. No.	Metric	Drip	Flood
1.	Net Returns (₹/acre)	2,21,198.96	1,38,399.93
2.	Benefit-Cost Ratio	1.48	1.10

Partial Budgeting

Table 4 presents the partial budgeting analysis, illustrating the additional costs incurred, savings achieved, and additional returns obtained under drip irrigation. The net gain from drip irrigation adoption over flood irrigation was ₹77,838.40/acre, supporting its economic viability.

Table 4: Partial Budgeting Analysis for Drip Irrigation over Flood Irrigation in Papaya Cultivation (₹/acre)

Particulars	Amount (₹)
A. Additional Costs under Drip Irrigation	
Additional Fertilizer & FYM Cost	11,088.00
Additional Labour Requirement	1,232.00
Drip Irrigation System Installation (Amortized)	20,513.61
Total Additional Costs (A)	32,833.61

B. Reduced Costs under Drip Irrigation (Savings)	
Reduced Plant Protection Chemical Cost	2,620.00
Reduced Irrigation Cost	2,491.00
Total Reduced Costs (B)	5,111.00
C. Additional Returns under Drip Irrigation	
Increased Gross Returns due to Higher Yield	1,05,561.00
Total Additional Returns (C)	1,05,561.00
D. Net Gain Calculation	
(B + C) - A = Net Gain	(5,111 + 1,05,561) - 32,833.61
	77,838.40

Conclusion

The comparative economic analysis confirms that drip irrigation, despite higher initial investment, provides higher yield, net returns, and benefit-cost ratio compared to flood irrigation in papaya cultivation under semi-arid conditions in Bellary district. Drip irrigation also enhances water-use efficiency, supporting climate-resilient and sustainable farming practices. Wider adoption can be encouraged through government subsidy schemes and capacity-building initiatives, aiding farmers in achieving higher profitability and resource efficiency.

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