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RESEARCH ARTICLE

Comparative analysis of the economic potential of dragon fruit cultivation in the central and northern dry zones of Karnataka, India

Pavan P R[1], Mallikarjun G Kerutagi[2], D P Prakasha[3], Anil Ishwar Sabarad[4], Sateesh Pattepur[1], Prashantha A[5], Mahantesha B N Naika[6] & Yallesh Kumar H S[1]

[1]Department of Fruit Science, Kittur Rani Channamma College of Horticulture (University of Horticultural Sciences), Arabhavi 591 218, Karnataka, India

[2]Department of Agricultural Economics, Kittur Rani Channamma College of Horticulture (University of Horticultural Sciences), Arabhavi 591 218, Karnataka, India

[3]Department of Fruit Science, College of Horticulture (University of Horticultural Sciences), Sirsi 581 401, Karnataka, India

[4]Department of Fruit Science, College of Horticulture (University of Horticultural Sciences), Bagalkot 587 104, Karnataka, India

[5]Department of Plant Pathology, Kittur Rani Channamma College of Horticulture (University of Horticultural Sciences), Arabhavi 591 218, Karnataka, India

[6]Centre for Biotechnology Research, Department of Biotechnology and Crop Improvement, College of Horticulture (University of Horticultural Sciences), Bagalkot 587 104, Karnataka, India

*Correspondence email - Pavanputtu.pr@gmail.com

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Abstract

India is the second-largest producer of fruits globally, has seen a rising demand for exotic fruits, particularly dragon fruit (*Hylocereus* sp.), due to its high nutritional value and commercial potential. Introduced in India in the late 1990s, dragon fruit cultivation has expanded across various agro-climatic regions, with Karnataka being a major contributor. The study conducted on the economics of dragon fruit farming through a comparative benefit cost analysis of two genotypes - *Hylocereus undatus* (white-fleshed) and *Hylocereus costaricensis* (pink-fleshed) – in experimental field at KRCCH, Arabhavi, MHREC, UHS, Bagalkot and farmer-managed fields in Karnataka, India. The total establishment cost was Rs. 143681 in the experimental field and Rs. 154562 in farmer-managed fields, with borewell and irrigation infrastructure being the primary cost components in both the systems. First-year maintenance costs were Rs. 50841 and Rs. 53396 per acre in experimental and farmer fields, respectively. From the second year onwards, the cost reduced to Rs. 33935 in the experimental field and Rs. 40169 in farmer-managed fields. The total yield per acre was 1293 kg in the experimental field and 1248 kg in the farmer's field, with market price of Rs. 140/kg. The net income per acre was Rs. 147085 and Rs. 134551, respectively, achieving a higher Benefit-Cost (B:C) ratio of 5.33 was compared to 4.34 in farmer-managed conditions. These findings highlighted the profitability and sustainability of dragon fruit cultivation, emphasizing efficient resource utilization and strategies for enhanced productivity.

Keywords: cost analysis; exotic fruit; farm economics; *Hylocereus* genotypes; profitability

Introduction

India is the second-largest producer of fruits globally and the standard of living of its population can be assessed through per capita fruit production and consumption. The Indian Council of Medical Research (ICMR) recommends a daily fruit consumption of 100 grams per person (1). Among the diverse fruit crops cultivated in India, both indigenous and exotic species have gained significant commercial value. Exotic fruits, often perceived as "mysteriously different" due to their unique characteristics and purported medicinal benefits, have seen an increase in cultivation. One such fruit is the dragon fruit (*Hylocereus* sp.), also known as pitaya or strawberry pear, which has witnessed growing popularity due to its high nutritional value and market demand (2).

Dragon fruit, a member of the Cactaceae family, originated in the tropical regions of Mexico and Central America and has been extensively cultivated in Vietnam and other Southeast Asian countries. In India, it was introduced in the late 1990s and its cultivation has expanded steadily, particularly in the dry, frost-free agro-climatic regions of Southern, Western and North-Eastern India. Presently, dragon fruit is cultivated across an estimated area of 5.30 thousand hectares, producing 21.22 thousand metric tons annually, with Karnataka contributing significantly to this production (3). States such as Mizoram, Nagaland, Gujarat, Andhra Pradesh, Maharashtra, West Bengal, Telangana, Kerala, Uttar Pradesh, Odisha, Tamil Nadu and the Andaman & Nicobar Islands have also embraced its cultivation (4).

The rising domestic and international demand for dragon fruit presents an economically viable opportunity for growers, ranging from backyard gardeners to large-scale enterprises. Major global producers of dragon fruit include Vietnam, Colombia, Mexico, Costa Rica and Nicaragua, with significant import markets in the European Union and China (5). In India, the increasing consumer preference for this fruit due to its rich vitamin C content, antioxidant properties and multiple health benefits has further boosted its market potential. Apart from its nutritional value, dragon fruit has applications as a food coloring agent and in traditional medicinal practices (6).

Furthermore, the economic viability of dragon fruit cultivation remains underexplored, particularly in terms of benefit cost analysis and market dynamics. While the crop is gaining popularity, comprehensive studies evaluating its production cost, profitability and scalability are scarce. Understanding the economic implications of different propagation methods and cultivation practices is crucial for farmers and investors looking to capitalize on this emerging industry (7). Therefore, this study aims to assess the economic potential of dragon fruit cultivation through a comparative analysis, providing valuable insights into its sustainability.

Materials and Methods

Study area and experimental design

The study was conducted over a period of two years (2022-2024) to assess the economic performance of two dragon fruit (*Hylocereus* spp.) genotypes under varying agro-climatic conditions in Karnataka, India. The experiment was carried out at three key locations: (i) a farmer's field in Kadur, Chikkamagaluru district, comes under the Central Dry Zone; (ii) the College Orchard, Department of Fruit Science (FSC), Kittur Rani Channamma College of Horticulture (KRCCH), Arabhavi, located in Mudalagi Taluk, Belagavi district; and (iii) the Main Horticultural Research and Extension Centre (MHREC), University of Horticultural Sciences (UHS), Bagalkot-both of which are situated in the Northern Dry Zone of Karnataka.

Two dragon fruit genotypes were evaluated: *Hylocereus undatus* (white-fleshed variety) and *Hylocereus costaricensis* (pink-fleshed variety). The experimental layout followed a 2 × 2 factorial randomized complete block design (FRCBD) with five replications. The treatments comprised two factors - genotype (G) and propagation method (P) - to analyse both individual and interactive effects on growth, yield and economic traits. Each experimental unit consisted of a single concrete pole supporting four plants and five such poles were maintained per genotype (20 plants per treatment).

Observations were recorded during the second- and third-years post-planting to capture consistent yield across seasons. Data collection focused on parameters related to profitability, cost structure and sustainability of cultivation. This comprehensive approach enabled a structured and statistically robust comparison of economic performance of genotypes across agro-climatic zones.

Economic analysis of dragon fruit cultivation

To determine the economic viability of dragon fruit cultivation, the per-acre cost of establishment and maintenance was analysed. The cost was categorized into investment cost and maintenance cost, covering both pre-bearing and post-bearing stages.

Cost of establishment

The cost involved in establishing a dragon fruit orchard up to the bearing stage were classified into two key components (Fig. 1):

1. Investment cost: These include initial capital expenditures required for orchard setup.

a. Irrigation system installation (drip irrigation setup)

b. Pit digging and planting

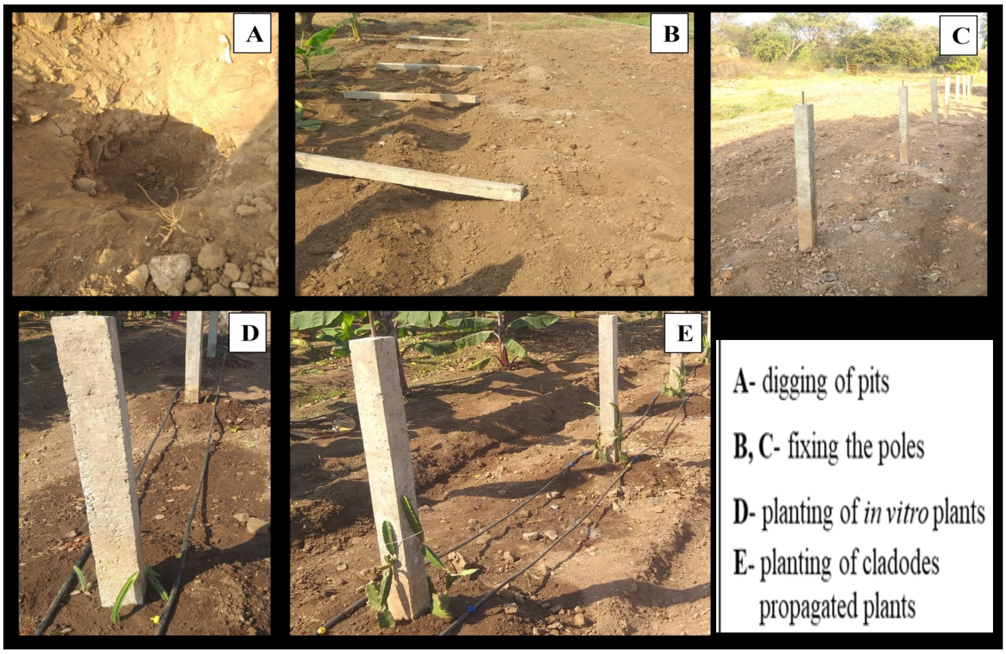


Fig. 1. Field preparation and planting of dragon fruit propagules.

c. Procurement of planting materials
d. Borewell and pumpset installation
e. Farm equipment and tools (sprayers, fertilizers and other essentials).

2. Maintenance cost: These represent recurring operational expenses necessary for orchard upkeep:

a. Inter-cultivation activities (soil loosening, aeration and weed control)
b. Pruning and gap filling (replacing missing plants)
c. Fertilization and manuring (organic and inorganic applications)
d. Irrigation and plant protection measures (pest and disease management).

Cost of cultivation (per acre)

The cost of cultivation was classified into three primary components: variable cost, fixed cost and marketing cost.

1. Variable cost: These are cost that fluctuate based on production levels:

a. Seedlings: Based on actual procurement prices from suppliers or agencies
b. Farm Yard Manure (FYM): Cost evaluated as per local market rates
c. Fertilizers and plant protection chemicals: Computed from actual expenses incurred by farmers
d. Labour: Wages calculated at prevailing rates for an 8-hr workday (including male, female and machine labour)
e. Interest on working capital: Estimated at 7.5 % per annum on expenses for seedlings, fertilizers, manure, plant protection and labour.

2. Fixed cost: These remain constant regardless of production levels:

a. Depreciation on machinery and farm implements: Calculated using the straight-line method
b. Land revenue: Based on government-imposed rates
c. Rental value of land: Assessed based on prevailing annual rental rates, prorated according to the crop's duration.

3. Marketing cost: This cost is associated with post-harvest handling and selling:

a. Packing, loading and unloading charges
b. Transportation to market centres
c. Spoilage losses during storage or transit
d. Miscellaneous expenses (market fees, personal expenses and other incidental cost).

Benefit-cost ratio (B:C ratio) analysis

The profitability of dragon fruit cultivation was assessed using the benefit-cost ratio (B:C ratio), which measures the relationship between total benefits (cash inflows) and total cost (cash outflows).

$$\text{B:C ratio} = \frac{\text{Sum of discounted cash inflows}}{\text{Sum of discounted cash outflows}}$$

Results and Discussion

The study presented a comprehensive comparison of the economic performance of dragon fruit cultivation under controlled experimental field and farmer field. Key economic factors including production costs, yield, profitability and return on investment were analysed across both conditions to highlight differences and practical implications.

Investment pattern

The cost of borewells was Rs 40000 in the experimental field, which accounted for 27.84 per cent of the total investment. In comparison, the farmer's field incurred a slightly higher expense of Rs. 44500, representing 28.79 per cent of their total investment. Similarly, the pump set cost were Rs. 32000 (22.27 %) in the experimental field and Rs. 35418 (22.92 %) in the farmer's field. Both fields incurred the same cost of Rs. 5000 for concrete poles and rings, representing 3.48 % and 3.48 % in the experimental field and 3.23 per cent each in the farmer's field, respectively.

The cost for sprayers was Rs. 1560 (1.09 %) in the experimental field and Rs. 1628 (1.05 %) in the farmer's field, showing minimal variation. The cost for plant material was Rs. 4000 (2.78 %) in the experimental field compared to Rs. 4600 (2.98 %) in the farmer's field, indicating a higher investment in quality planting material by farmers. The cost was Rs. 780 (0.54 %) in the experimental field and Rs. 760 (0.49 %) in the farmer's field, reflecting similar expenditure on tying materials. The cost for planting, including cuttings and drip system installation, was Rs. 4500 (3.13 %) in the experimental field and Rs. 4260 (2.76 %) in the farmer's field (Table 1).

The subtotal for the initial investment (A) was Rs. 92840 (64.62 %) in the experimental field and Rs. 101166 (65.45 %) in the farmer's field. The first-year operational cost (B) were Rs 50841 (35.38 %) for the experimental field and Rs. 53396 (34.55 %) for the farmer's field.

The investment analysis of dragon fruit orchard establishment shows a consistent cost structure with minor variations between experimental and farmer-managed fields. The total establishment cost was Rs. 154562 in the farmer's field, 7.57 per cent higher than the Rs. 143681 in the experimental field, mainly due to higher irrigation and land preparation expenses. Water infrastructure accounted for nearly 50 per cent of the total investment, with borewell and pump set cost being crucial for irrigation. Structural support (concrete poles and rings) made up 7 per cent, while plant materials and installation contributed around 3 per cent. First-year maintenance cost comprised 35 % of the total investment, reflecting the importance of orchard care.

The higher per acre investment in farmer's fields was due to land levelling, deeper borewell requirements

Table 1. Investment pattern of dragon fruit orchard (Rs/acre)

Sl. No.	Particulars	Experimental field		Farmer's field	
		Value	%	Value	%
1.	Bore	40000	27.84	44500	28.79
2.	Pumpset	32000	22.27	35418	22.92
3.	Concrete pole	5000	3.48	5000	3.23
4.	Concrete ring	5000	3.48	5000	3.23
5.	Sprayer	1560	1.09	1628	1.05
6.	Plant material	4000	2.78	4600	2.98
7.	Material for tying	780	0.54	760	0.49
8.	Planting (cutting and drip system installation)	4500	3.13	4260	2.76
A	**Sub Total**	**92840**	**64.62**	**101166**	**65.45**
B					
	I[st] year	50841	35.38	53396	34.55
	Total establishment cost (A+B)	**143681**	**100.00**	**154562**	**100.00**

and higher planting material cost, influenced by terrain and resource availability. These findings provide valuable financial insights for prospective farmers (4). Despite high initial cost, dragon fruit farming offers strong profitability within 4-5 years, driven by its climate adaptability and market demand domestically and internationally. The studies examine the economics of various fruit orchards, highlighting investment patterns and cost structures. In banana cultivation, drip irrigation showed higher yields and profits compared to conventional methods, with increasing returns to scale (8). For kinnow orchards, initial costs were dominated by planting materials and charges, while operational costs increased with orchard age. Direct selling by farmers yielded higher returns than using pre-harvest contractors (9). Pomegranate orchards demonstrated high profitability, with establishment costs primarily comprising material and maintenance expenses. Financial analysis revealed quick investment recovery and high internal rates of return (10).

Maintenance cost of dragon fruit cultivation of 1st year

The maintenance cost associated with dragon fruit cultivation during the first year were analysed by comparing expenses in experimental fields and farmer's fields. The total maintenance cost per acre was Rs. 50841 in the experimental field and Rs. 53396 in the farmer's field, highlighting variations in cultivation practices. Labour expenses constituted the largest component, accounting for 46.04 per cent (Rs. 23405) in the experimental field and 47.69 per cent (Rs. 25467) in the farmer's field. Key labour activities included land preparation, which cost Rs. 3800 (7.47 %) in the experimental field and Rs. 4600 (8.61 %) in the farmer's field and the application of farmyard manure (FYM), which was Rs. 2380 (4.68 %) in the experimental field compared to Rs. 3300 (6.18 %) in the farmer's field.

Material cost also significantly impacted overall expenses, with the experimental field spending Rs. 16117 (31.70 %) and the farmer's field Rs. 17429 (32.64 %). Farmers allocated more to FYM (Rs. 8640 or 16.18 %) than the experimental field (Rs. 7571 or 14.89 %), indicating a greater reliance on organic amendments. Fertilizer cost was higher in the experimental setup (Rs. 5785 or 11.38 %) compared to the farmer's field (Rs. 4584 or 8.58 %). Managerial cost was consistent across both setups, amounting to Rs. 4622 (9.09 %) in the experimental field and Rs. 4854 (9.09 %) in the farmer's field (Table 2).

Fixed cost was slightly higher in the experimental field at Rs. 6697.3 (13.17 %) compared to Rs. 5646 (10.57 %) in the farmer's field, primarily due to greater investments in crop insurance and infrastructure depreciation. Overall, the findings suggest that while the total maintenance cost is lower in the experimental field, the farmer's field incurs higher labour and material cost, reflecting differences in cultivation practices and resource management.

The analysis of first-year maintenance cost highlights notable differences between experimental and farmer-managed fields, particularly in input utilization and cost distribution. Farmer-managed fields incurred higher cost, primarily due to increased spending on labour, organic fertilizers (FYM) and micronutrients. This aligns with sustainable farming practices aimed at enhancing soil health and long-term productivity (11, 12). While this approach increases initial cost, it promotes soil fertility and sustainable orchard management.

In contrast, experimental fields allocated a larger share of expenses to chemical fertilizers, indicating a strategic focus on precision fertility management to optimize yield (13). This approach resulted in controlled input cost and efficient resource utilization, reducing overall expenditures compared to the labour-intensive strategies adopted in farmer-managed fields. The contrasting cost structures underscore how different management strategies impact economic efficiency, with experimental fields demonstrating a more resource-efficient and cost-effective approach to dragon fruit cultivation.

Material cost was also higher in farmer-managed fields, totalling Rs. 13746, due to increased application of FYM and micronutrients. This aligns with integrated nutrient management practices, which have been shown to enhance soil fertility, yield and overall crop health. Studies in Mizoram indicate that combining organic amendments with biofertilizers and inorganic fertilizers significantly improves crop productivity. Additionally, higher fertilizer and pesticide cost in farmer fields suggest an aggressive fertility and pest control strategy, which, while increasing expenses, aims to maximize yield and ensure long-term orchard sustainability. Research indicates that such integrated management strategies can enhance vine growth and yield by 18.50 per cent (11).

Table 2. Maintenance cost of dragon fruit (1st year) in the study area (Rs/acre)

Sl. No	Particulars	Experimental field		Farmer's field	
		I	%	I	%
I	**Variable cost**				
A	**Labour cost**				
2.	Land preparation	3800	7.47	4600	8.61
3.	Cost of fixing poles	2125	4.18	2250	4.21
4.	Planting	1250	2.46	1400	2.62
5.	Application of FYM	2380	4.68	3300	6.18
6.	Application of chemical fertilizers	2600	5.11	1720	3.22
7.	Application of PPC/Spraying	2450	4.82	2250	4.21
8.	Cleaning/Weeding	5800	11.41	6147	11.51
9.	Irrigation	1600	3.15	2400	4.49
10.	Miscellaneous	1400	2.75	1400	2.62
	Total labour cost (A)	**23405**	**46.04**	**25467**	**47.69**
B	**Material cost**				
i.	FYM	7571	14.89	8640	16.18
ii.	Fertilizer (kg)	5785	11.38	4584	8.58
iii.	Liquid fertilizer (L)	1037	2.04	1734	3.25
iv.	Pesticides (L)	942	1.85	976	1.83
v.	Weedicides (kg/L)	0	0.00	550	1.03
vi.	Micronutrients (kg/L)	782	1.54	945	1.77
	Total material cost (B)	**16117**	**31.70**	**17429**	**32.64**
	Managerial cost (10 % of TC)	4622	9.09	4854	9.09
	Total variable cost (A+B)	**44144**	**86.83**	**47750**	**89.43**
II	**Fixed cost**				
	Crop insurance/risk premium (2 % of sum insured)	3478	6.84	2948	5.52
	Land and water tax	35	0.07	25	0.05
	Depreciation	2577	5.07	2160	4.05
	Interest on fixed capital (10 %)	607.3	1.19	513	0.96
	Total fixed cost	**6697.3**	**13.17**	**5646**	**10.57**
	Total cost (I+II)	**50841**	**100**	**53396**	**100.00**

Economic analysis revealed that dragon fruit farming is profitable in southern Indian states, with Andhra Pradesh and Karnataka showing better financial outcomes than Tamil Nadu (7). However, challenges such as high installation costs, insufficient technical support and inadequate cold storage facilities persist. Micropropagation has emerged as a potential solution to meet the increasing demand for planting materials, offering clonal fidelity and year-round availability (14).

Maintenance cost and economic performance of dragon fruit cultivation from the 2nd year onwards

The maintenance cost of dragon fruit cultivation from the second year onwards (first fruiting) was analysed by comparing the expenses incurred in experimental fields and farmer's fields. The findings indicate that the total maintenance cost per acre was Rs. 33935 in the experimental field and Rs. 40169 in the farmer's field. This cost variation can be attributed to differences in labour, material and fixed cost, which influence the overall economic viability of dragon fruit cultivation (Table 3).

Variable cost analysis

Variable cost accounted for a significant portion of the total expenditure, comprising 80.32 per cent (Rs. 27255) in the experimental field and 85.94 per cent (Rs. 34523) in the farmer's field. Within variable cost, labour expenses were substantial, amounting to Rs. 13210 (38.93 %) in the experimental field and Rs. 17125 (42.63 %) in the farmer's field. Notably, cleaning and weeding cost were Rs. 2460 (7.25 %) in the experimental field and Rs. 3800 (9.46 %) in the farmer's field, highlighting the increased manual labour required in farmer's fields. Similarly, the application of farmyard manure (FYM), chemical fertilizers and plant protection chemicals (PPC/spraying) were higher in the farmer's field, leading to increased labour cost. Irrigation expenses were also marginally higher in the farmer's field (Rs. 1400 or 3.49 %) compared to the experimental field (Rs. 1200 or 3.54 %).

Material cost was another significant component of variable cost, totalling Rs. 10960 (32.30 %) in the experimental field and Rs. 13746 (34.22 %) in the farmer's field. The major cost contributors were FYM, fertilizers, liquid fertilizers and micronutrients. Farmer's fields had higher expenditures on FYM (Rs. 5700 or 14.19 %) compared to Rs. 4500 (13.26 %) in the experimental field, indicating a greater reliance on organic inputs. Similarly, the cost of fertilizers was Rs. 4800 (11.95 %) in the farmer's field, slightly higher than Rs. 3950 (11.64 %) in the experimental field. The expenses for micronutrients and pesticides were also greater in farmer's fields, reflecting differences in nutrient and pest management strategies.

Fixed cost analysis

Fixed cost, which included crop insurance, land and water tax, depreciation and interest on fixed capital, accounted for 19.68 per cent (Rs. 6680) of the total cost in the experimental field and 14.06 per cent (Rs. 5646) in the farmer's field. Crop insurance or risk premium was a major contributor, amounting to Rs. 3478 (10.25 %) in the experimental field, whereas farmers allocated Rs. 2948 (7.34 %), indicating a higher risk mitigation strategy in experimental conditions. Depreciation cost was also higher in the experimental field (Rs. 2577 or 7.59 %) compared to the farmer's field (Rs. 2160 or 5.38 %), likely due to better-maintained infrastructure and equipment usage. The managerial cost, which was 10 % of the total cost, remained

Table 3. Maintenance cost of dragon fruit 2nd year onwards (first fruiting) in the study area (Rs/acre)

Sl. No	Particulars	Experimental field		Farmer's field	
		II	%	II	%
I	**Variable cost**				
A	**Labour cost**				
2.	Interculture operation	2900	8.55	3875	9.65
3.	Cost of fixing poles	0	0.00	0	0.00
4.	Planting	0	0.00	0	0.00
5.	Application of FYM	2250	6.63	2450	6.10
6.	Application of chemical fertilizers	1950	5.75	2450	6.10
7.	Application of PPC/spraying	1650	4.86	2450	6.10
8.	cleaning/Weeding	2460	7.25	3800	9.46
9.	Irrigation	1200	3.54	1400	3.49
10.	Miscellaneous	800	2.36	700	1.74
	Total labour cost (A)	**13210**	**38.93**	**17125**	**42.63**
B	**Material cost**				
i.	FYM	4500	13.26	5700	14.19
ii.	Fertilizer (kg)	3950	11.64	4800	11.95
iii.	Liquid fertilizer (L)	1100	3.24	1250	3.11
iv.	Pesticides (L)	760	2.24	976	2.43
v.	Weedicides (kg/L)	0	0.00	0	0.00
vi.	Micronutrients (kg/L)	650	1.92	1020	2.54
	Total material cost (B)	**10960**	**32.30**	**13746**	**34.22**
	Managerial cost (10 % of TC)	3085	9.09	3652	9.09
	Total variable cost (A+B)	**27255**	**80.32**	**34523**	**85.94**
II	**Fixed cost**				
	Crop insurance/Risk premium (2 % of sum insured	3478	10.25	2948	7.34
	Land and water tax	18	0.05	25	0.06
	Depreciation	2577	7.59	2160	5.38
	Interest on fixed capital (10 %)	607	1.79	513	1.28
	Total fixed cost	**6680**	**19.68**	**5646**	**14.06**
	Total cost (I+II)	**33935**	**100**	**40169**	**100.00**

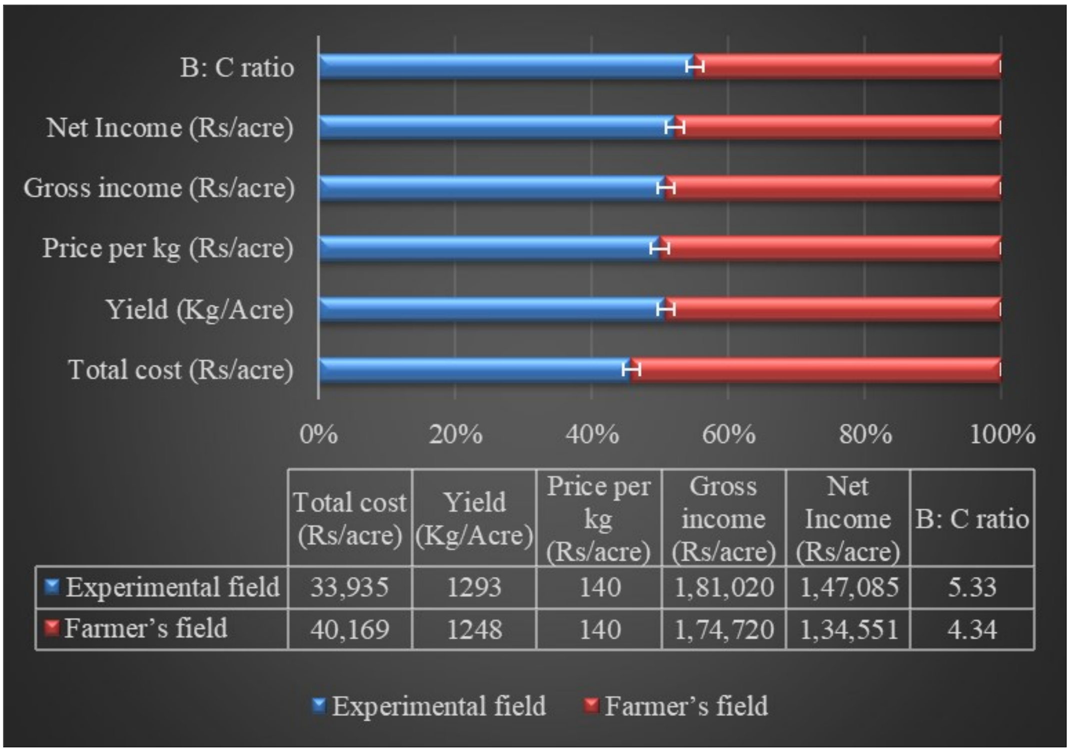
consistent across both fields, amounting to Rs. 3085 (9.09 %) in the experimental field and Rs. 3652 (9.09 %) in the farmer's field. Similarly, the studies examine the economics of various crop productions in India. Variable costs constitute a significant portion of total expenditure, ranging from 85-98 % across different crops (15, 16). Labor expenses are substantial, with weeding costs being particularly high in manually weeded farms compared to herbicide-applied ones (17). Material costs, including fertilizers and manures, also contribute significantly to variable costs (18).

Economic performance: yield, income and profitability

The analysis of economic performance in the second year of cultivation revealed that the total yield per acre was 1293 kg in the experimental field and 1248 kg in the farmer's field. Despite a slightly lower yield in farmer's fields, the price per kilogram of dragon fruit remained constant at Rs. 140/kg across both setups. Consequently, the gross income from dragon fruit cultivation was Rs. 181020 in the experimental field and Rs. 174720 in the farmer's field. When subtracting the total cost from the gross income, the net income stood at Rs. 147085 for the experimental field and Rs. 134551 for the farmer's field. This indicates that experimental field conditions resulted in a higher net income, likely due to cost optimization and efficient resource utilization.

The benefit-cost ratio (BCR), which measures the profitability of cultivation, was 5.33 in the experimental field and 4.34 in the farmer's field (Fig. 2). This suggests that for every Rs. 1 invested in cultivation, farmers in experimental conditions earned Rs. 5.33, whereas in traditional farmer-managed fields, the return was Rs. 4.34. The higher B:C ratio in the experimental field indicates a more cost-efficient approach to dragon fruit farming, with better resource allocation and management strategies.

Conversely, experimental fields adopted optimized strategies, including balanced fertilizer application, precision irrigation and effective pest management, leading to higher productivity (1293 kg/acre *vs.* 1248 kg/acre in farmer fields). This resulted in a gross income of Rs. 181020 in experimental fields, translating into a net income of Rs. 147085, significantly surpassing that of farmer-managed fields. The benefit-cost ratio (B:C) in experimental fields was 5.33, outperforming the 4.34 ratio in farmer-managed fields, demonstrating superior returns on investment. These findings align with broader research on dragon fruit economics. An investment feasibility analysis in Nagaland reported a positive Net Present Value (NPV) and a B:C ratio of 2.04, indicating a financially viable venture for dragon fruit cultivation (19). Similarly, research in Indonesia found that implementing Good Agricultural Practices (GAP) led to a 140.32 % increase in income compared to traditional methods (20). Dragon fruit cultivation has shown promising economic potential across various regions in India. Studies have demonstrated positive financial outcomes, with benefit-cost ratios ranging from 2.04 in Nagaland (19) to 56.77 in organic farming systems (21). Recent research in southern Indian states revealed profitable dragon fruit farming, with Andhra Pradesh and Karnataka outperforming Tamil Nadu (7). These results highlight that adopting modern, optimized farming techniques enhances profitability, ensuring economic sustainability in dragon fruit cultivation.



	Total cost (Rs/acre)	Yield (Kg/Acre)	Price per kg (Rs/acre)	Gross income (Rs/acre)	Net Income (Rs/acre)	B: C ratio
Experimental field	33,935	1293	140	1,81,020	1,47,085	5.33
Farmer's field	40,169	1248	140	1,74,720	1,34,551	4.34

Fig. 2. Comparison of economic performance in both experimental field and farmer's field.

Dragon fruit cultivation can be optimized through various practices that enhance cost efficiency and productivity. The adoption of drip irrigation systems, particularly those powered by renewable energy sources like solar and wind, can significantly reduce water and energy costs (22). Integrated nutrient management, including the use of organic inputs and bio-fertilizers, has been shown to improve yield and economic returns compared to conventional practices (11). Proper pruning, training and the application of plant hormones are important agronomic techniques for quality yield (23). Farmers' knowledge and skills play a crucial role in successful dragon fruit cultivation, with experienced growers achieving better outcomes (24). Additionally, dragon fruit is recognized for its low maintenance requirements and stress resistance, making it an attractive option for smallholder farmers (23, 24). These practices collectively contribute to improved economic efficiency and sustainability in dragon fruit production systems.

Conclusion

The present study provided a holistic economic evaluation of dragon fruit (*Hylocereus* sp.) cultivation under both controlled experimental conditions and real-world farmer-managed settings across the Central and Northern Dry Zones of Karnataka, India. Through detailed cost-benefit analyses spanning establishment, first-year maintenance and second-year fruiting phases, the research underscores the financial viability and profitability of dragon fruit as a high-value horticultural crop. Investment patterns revealed that water infrastructure accounted for nearly 50 per cent of total establishment costs in both systems, with slightly higher expenditures observed in farmer-managed fields due to land levelling, deeper borewell requirements and superior planting material. First-year maintenance costs were driven predominantly by labour and material inputs, with farmers allocating more toward organic amendments such as FYM, reflecting a sustainability-oriented cultivation approach. Conversely, experimental fields emphasized precision nutrient management, resulting in more efficient resource utilization and lower overall costs. From the second year onwards, both systems demonstrated positive economic returns, with the experimental fields yielding slightly higher yield and superior profitability (1293 kg/acre and B:C ratio of 5.33:1 per cent) compared to farmer field (1248 kg/acre and B:C ratio of 4.34:1 per cent). These differences were attributed to improved input efficiency and optimized agronomic practices under experimental conditions. The findings reaffirm that dragon fruit cultivation, despite its relatively high initial investment, offers strong financial returns within 4-5 years and can serve as a viable alternative for farmers in arid and semi-arid regions.

Overall, the study highlighted the economic potential of dragon fruit cultivation under diverse management practices and agro-climatic conditions, supporting for the adoption of precision farming techniques and integrated nutrient management to enhance resource-use efficiency and long-term profitability. These identifications are critical for policymakers, extension agencies and farmers seeking to promote sustainable horticultural diversification in arid and semi-arid zones.

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Authors' contributions

All authors were actively involved in the study's design, data collection and analysis. They have collectively contributed to the research and have reviewed and approved the final manuscript.

Compliance with ethical standards

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