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PRODUCTION ECONOMICS OF DRAGON FRUIT (*Hylocereus* SPP.) FARMING ACROSS DIFFERENT FARM SIZES IN MAHARASHTRA: COSTS, RETURNS AND PROFITABILITY

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ABSTRACT

The study evaluated the cost of cultivation and profitability of dragon fruit production across different farm sizes in Maharashtra. Per hectare total cost of cultivation (Cost C) ranged from Rs.683,451.9 for small farmers to Rs.831,791.8 for large farmers, with an average of Rs.749,264.6. Hired male and female labour averaged 75.68 and 56.81 mandays, costing Rs.37,841.67 (4.97%) and Rs.14,201.67 (1.82%), respectively. Machine power use averaged 29.91 h costing Rs.26,919 (3.42%), while manure application averaged 176 qtl costing Rs.44,000 (5.75%). Fixed costs dominated the cost structure, particularly rental value of land Rs.426,964.1 (57.01%) and amortization Rs.101,325.2 (13.64%). The average yield was 26.272 t ha⁻¹ and at an APMC price of Rs.1,00,000 t⁻¹, gross returns were Rs.26.33 lakh ha⁻¹. The benefit–cost ratio ranged from 3.36 to 3.73, with an average of 3.49, indicating high economic viability and economies of scale in dragon fruit cultivation.

Key words: Dragon fruit, cost of cultivation, Profitability analysis, Benefit–cost ratio, Farm size, Maharashtra.

Introduction

Dragon fruit (*Hylocereus* spp.), a member of the family Cactaceae, has emerged as an important high-value horticultural crop owing to its nutritional, medicinal and economic significance. It is known by various names such as pitaya, pitahaya, strawberry pear, queen of the night and night-blooming cereus. Although its exact origin remains uncertain, the crop is widely believed to have originated in the rainforests of Mexico and Central America, particularly along the Pacific coasts of Guatemala, Costa Rica and El Salvador, with Southeast Asia regarded as a secondary centre of diversification (Britton and Rose, 1963; Wu *et al.*, 2010; Ibrahim *et al.*, 2018). The plant bears trailing cladode stems with modified areoles producing attractive fruits of varying colours, which are valued for their pleasant flavour and visual appeal. Dragon fruit is nutritionally rich in antioxidants (betalains), prebiotics, vitamins and minerals,

and offers health benefits such as reduced risk of diabetes, cardiovascular disorders, colon cancer and lowered blood pressure and cholesterol levels (Le Bellec *et al.*, 2006; Villalobos-Gutierrez *et al.*, 2012; Wichienchot *et al.*, 2010; Tenore *et al.*, 2012; Garcia-Cruz *et al.*, 2013; Rahimi *et al.*, 2019; Lima *et al.*, 2020; Poolsup *et al.*, 2017).

Commercial cultivation is mainly carried out through stem cuttings, which establish rapidly and begin flowering within 8–18 months after planting. The crop produces large, hermaphrodite, nocturnal flowers, with fruit maturity attained within 30–40 days after anthesis. With appropriate training, pruning and nutrient management, dragon fruit plants remain economically productive for 20–25 years (Mizrahi *et al.*, 1997; Nerd and Mizrahi, 1997; Le Bellec *et al.*, 2006).

Dragon fruit is a climate-resilient crop, tolerant to high light intensity, elevated temperatures and drought

conditions due to its succulent stems, waxy epidermis and Crassulacean Acid Metabolism (CAM) pathway (Nobel, 1994; Nerd *et al.*, 2002; Nobel and Barrera, 2004; Yadav *et al.*, 2023). Although it performs well in saline and degraded soils, the crop is sensitive to prolonged waterlogging (Luders and McMahon, 2004; Liaotrakoon, 2013; Yang *et al.*, 2015). Plants generally begin fruiting from the second year, reach peak production by the fifth year and yield between 16 and 80 t ha⁻¹ depending on agro-climatic conditions and management practices (FAO, 2004; Duangtaweesub *et al.*, 2011).

Globally, dragon fruit cultivation spans more than 22 countries, with Vietnam, China and Indonesia together accounting for over 93 per cent of total production (Choo and Yong, 2011; Chen and Paull, 2018; Wakchaure *et al.*, 2020; Mercado-Silva, 2018; Yadav *et al.*, 2023). Among cultivated species, *H. undatus* dominates global acreage, followed by *H. polyrhizus*/*H. monacanthus* and *H. megalanthus* (Choo and Yong, 2011). In India, dragon fruit was introduced in the late 1990s and has expanded rapidly, particularly in Gujarat, Maharashtra and Karnataka (Karunakaran *et al.*, 2019; Singh and Singh, 2017). During 2023–24, Andhra Pradesh emerged as the leading producer, followed by Telangana and Maharashtra, with major production belts in Solapur, Sangli, Ahmednagar, Pune and Nashik districts of Maharashtra (Sathe *et al.*, 2024; Desikheti, 2025). Increasing consumer demand, adaptability to water-scarce regions and high market value have positioned dragon fruit as a promising crop for domestic consumption, export markets and value-added processing industries.

Materials and Methods

The study was conducted in major dragon fruit-growing regions of Maharashtra using a farm-level survey approach. Primary data were collected from randomly selected small, medium, and large dragon fruit growers through personal interviews using a pre-tested structured schedule. Information on input use, labour employment (hired and family), machinery use, irrigation, fertilizers, plant protection measures, and other operational expenses was collected on a per hectare basis.

Costs were estimated following standard cost concepts used in farm management studies. Working capital was computed as the sum of variable cost items, and interest on working capital was charged at 10 per cent. Cost A included working capital, interest on working capital, depreciation on implements, and land revenue and taxes. Cost B was derived by adding rental value of land, interest on fixed capital (12%), and amortization cost to Cost A. Cost C was obtained by adding the imputed value of family labour to Cost B. Gross returns were calculated

using observed yield and prevailing APMC prices, and profitability was assessed using the benefit–cost ratio.

Results

Table 1 and Fig. 1 to 4 presents a detailed breakdown of the cost of cultivation of dragon fruit on a per-hectare basis across small, medium and large farm categories, along with overall averages. The table comprehensively accounts for hired and family labour, material inputs, fixed and variable costs, and profitability indicators.

Small farms incurred a total cost of cultivation (Cost C) of Rs.6,83,451.9 per hectare. Hired human labour constituted a significant component, with 76.28 mandays of male labour costing Rs.38,140 (5.58%) and 51.66 mandays of female labour costing Rs.12,915 (1.89%). Machine power usage amounted to 25.26 hours, incurring Rs.22,734 (3.33%). Expenditure on manure was 152 qtl costing Rs.38,000 (5.56%), while fertilizer use included 126 kg nitrogen (Rs.1,012.16; 0.15%), 117.15 kg phosphorous (Rs.1,406.76; 0.21%) and 95.4 kg potassium (Rs.3,434.40; 0.50%). Irrigation charges were Rs.4,266.28 (0.62%), plant protection Rs.14,450 (2.11%), incidental charges Rs.1,220 (0.18%) and repairs Rs.2,442.68 (0.36%). The working capital amounted to Rs.1,40,021.3 (20.49%), with interest on working capital at Rs.14,002.13 (2.05%), depreciation Rs.2,161.28 (0.32%) and land revenue and taxes Rs.512.55 (0.07%), resulting in Cost A of Rs.1,56,697.2 (22.93%). Adding the rental value of land (Rs.3,81,213; 55.78%), interest on fixed capital (Rs.7,715.42; 1.13%) and amortization cost (Rs.93,111.26; 13.62%), Cost B was Rs.6,38,736.9 (93.46%). Family labour costs comprised 68.25 mandays of male labour costing Rs.34,125 (4.99%) and 42.36 mandays of female labour costing Rs.10,590 (1.55%), leading to Cost C of Rs.6,83,451.9. With an output of

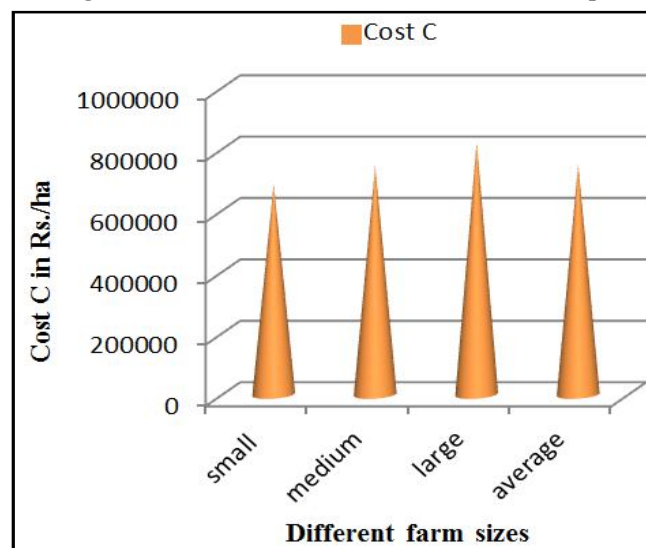


Fig. 1: Cost C across different farm sizes.

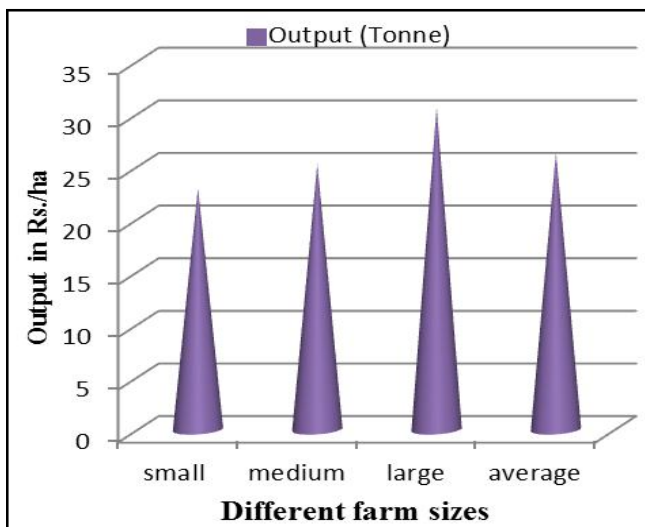


Fig. 2: Output across different farm sizes.

229.52 qtl (22.95 tonnes) and an APMC price of Rs.1,00,000 per tonne, gross returns were Rs.22,45,000, yielding a B:C ratio of 3.36.

Medium farms recorded a total cultivation cost (Cost C) of Rs.7,51,728 per hectare. Hired male labour usage was 74.22 mandays, costing Rs.37,110 (4.89%), while female labour amounted to 58.56 mandays with an expenditure of Rs.14,640 (1.82%). Machine power use increased to 30.25 hours, costing Rs.27,225 (3.43%). Manure application was 178 qtl, incurring Rs.44,500 (5.84%). Fertilizer consumption included 136.25 kg nitrogen (Rs.1,090; 0.14%), 128.1 kg phosphorous (Rs.1,537.20; 0.20%) and 95.6 kg potassium (Rs.3,441.60; 0.45%). Irrigation charges were Rs.4,616.44 (0.61%), plant protection Rs.14,932.13 (2.03%), incidental charges Rs.1,328.32 (0.19%) and repairs Rs.2,662.25 (0.34%). Working capital stood at

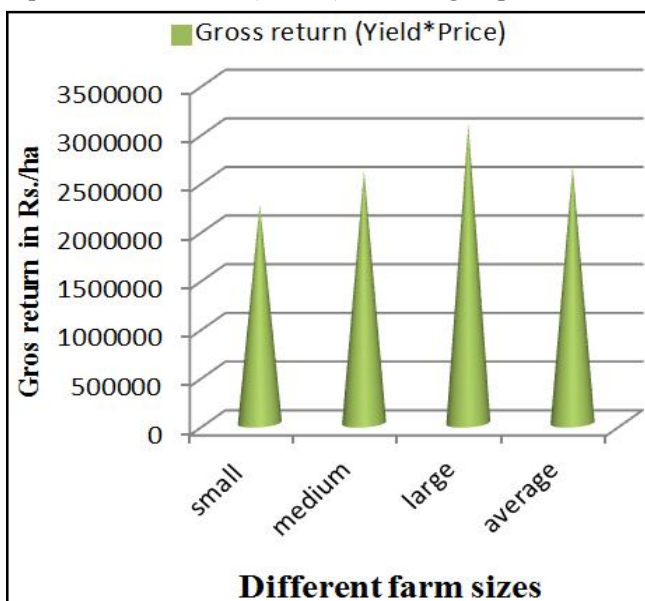


Fig. 3: Gross return across different farm sizes.

Rs.1,53,082.9 (19.95%), with interest on working capital of Rs.15,308.29 (2.00%), depreciation Rs.2,438.12 (0.30%) and land revenue and taxes Rs.551.26 (0.06%), resulting in Cost A of Rs.1,71,380.6 (22.31%). The rental value of land (Rs.4,12,365.2; 56.19%), interest on fixed capital (Rs.7,895.20; 1.02%) and amortization cost (Rs.1,06,192.4; 14.39%) raised Cost B to Rs.7,05,940.5 (93.91%). Family labour consisted of 70.23 mandays of male labour costing Rs.35,115 (4.67%) and 42.69 mandays of female labour costing Rs.10,672.5 (1.42%), leading to Cost C of Rs.7,51,728. Output was 252.44 qtl (25.244 tonnes), generating gross returns of Rs.25,94,000 at the prevailing price, and a B:C ratio of 3.39.

Large farms incurred the highest total cost of cultivation (Cost C) at Rs.8,31,791.8 per hectare. Hired male labour use was 76.55 mandays, costing Rs.38,275 (4.43%), while female labour accounted for 60.20 mandays at a cost of Rs.15,050 (1.75%). Machine power utilization was 34.22 hours, costing Rs.30,798 (3.49%). Manure application reached 198 qtl, with an expenditure of Rs.49,500 (5.85%). Fertilizer use comprised 141.26 kg nitrogen (Rs.1,130.08; 0.13%), 134.20 kg phosphorous (Rs.1,610.40; 0.19%) and 90.33 kg potassium (Rs.3,251.88; 0.39%). Irrigation charges were Rs.5,028.66 (0.62%), plant protection Rs.15,390 (1.94%), incidental charges Rs.1,536.12 (0.18%) and repairs Rs.2,798.25 (0.31%). Working capital amounted to Rs.1,64,368.4 (19.28%), with interest on working capital of Rs.16,436.84 (1.93%), depreciation Rs.2,539.30 (0.27%) and land revenue and taxes Rs.622.34 (0.05%), resulting in Cost A of Rs.1,83,966.9 (21.53%). The rental value of land was Rs.4,87,314.1 (59.06%), interest on fixed capital Rs.7,915.44 (0.91%) and amortization cost

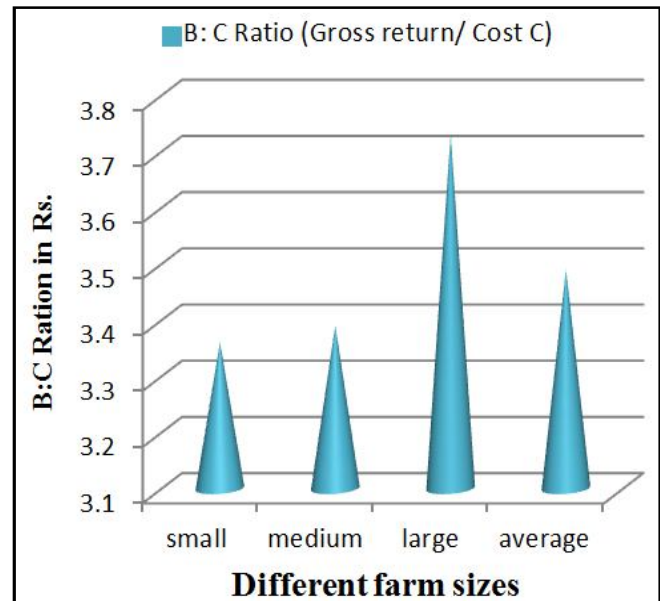


Fig. 4: B: C Ratio across different farm sizes.

Table 1: Cost of Cultivation for Dragon Fruit Production per hectare (Rs. /ha).

Particulars	Small Farmer			Medium Farmer			Large Farmer			Average		
	No./Qty.	Rs.	%	No./Qty.	Rs.	%	No./Qty.	Rs.	%	No./Qty.	Rs.	%
Hired Human Labour												
1.	76.28	38140	5.58	74.22	37110	4.89	76.55	38275	4.43	75.68333	37841.67	4.97
2.	51.66	12915	1.89	58.56	14640	1.82	60.2	15050	1.75	56.80667	14201.67	1.82
3.	25.26	22734	3.33	30.25	27225	3.43	34.22	30798	3.49	29.91	26919	3.42
4.	152	38000	5.56	178	44500	5.84	198	49500	5.85	176	44000	5.75
4A			0.00									
5.	126	1012.16	0.15	136.25	1090	0.14	141.26	1130.08	0.13	134.5033	1077.413	0.14
6.	117.15	1406.76	0.21	128.1	1537.2	0.2	134.2	1610.4	0.19	126.4833	1518.12	0.20
7.	95.4	3434.4	0.50	95.6	3441.6	0.45	90.33	3251.88	0.39	93.77667	3375.96	0.45
8.		4266.28	0.62		4616.44	0.61		5028.66	0.62	0	4637.127	0.62
9.		14450	2.11		14932.13	2.03		15390	1.94	0	14924.04	2.03
10.		1220	0.18		1328.32	0.19		1536.12	0.18	0	1361.48	0.18
11.		2442.68	0.36		2662.25	0.34		2798.25	0.31	0	2634.393	0.34
12.	137883.9	140021.3	20.49	149997.4	153082.9	19.95	162386.5	164368.4	19.28		152490.9	19.91
13.		14002.13	2.05		15308.29	2		16436.84	1.93	0	15249.09	1.99
14.		2161.28	0.32		2438.12	0.3		2539.3	0.27	0	2379.567	0.30
15.		512.55	0.07		551.26	0.06		622.34	0.05	0	562.05	0.06
Cost A	154362.2	156697.2	22.93	168295.1	171380.6	22.31	181315	183966.9	21.53		170681.6	22.26
16.		381213	55.78		412365.2	56.19		487314.1	59.06	0	426964.1	57.01
17.		7715.42	1.13		7895.2	1.02		7915.44	0.91	0	7842.02	1.02
18.		93111.26	13.62		106192.4	14.39		104672	12.9	0	101325.2	13.64
Cost B		638736.9	93.46	705940.5	697833.4	93.91	794939.3	783868.4	94.4		706812.9	93.92
Family Labour												
19.	68.25	34125	4.99	70.23	35115	4.67	71.36	35680	4.24	69.94667	34973.33	4.63
20.	42.36	10590	1.55	42.69	10672.5	1.42	45.89	1172.5	1.36	43.64667	7478.333	1.44
Cost C		683451.9	100	751728	743620.9	100	831791.8	820720.9	100	42451.67	749264.6	100
OQ		229.52			252.44			306.2		0	262.72	0
OT		22.95			25.244			30.62		0	26.272	
APMC		1,00,000			1,00,000			1,00,000			1,00,000	
GR		22,45,000			25,94,000			30,62,000			2633000	
BC		3.36			3.39			3.73			3.49	
1: Male (mandays); 2: Female (mandays); 3: Machine power (hr); 4: Manure (qtl); 4A: Fertilizers (kg); 5: Nitrogen; 6: Phosphorous; 7: Potassium; 8: Irrigation charges; 9: Plant protection; 10: Incidental charges; 11: Repairs; 12: Working capital (WC); 13: Interest on WC @10 %; 14: Depreciation on implements; 15: Land revenue and taxes; 16: Rental value of land; 17: Interest on fixed capital @12 %; 18: Amortization cost; 19: Male; 20: Female; OQ: Output (Qtl); OT: Output (Tonne); APMC: APMC Price/tonne; GR: Gross return (Yield*Price); BC: B: C Ratio (Gross return/ Cost C) Note: Working capital (W.C.) = Sum of 1 to 11; Cost A= W.C. +13+14+15; Cost B= Cost A+16+17+18; Cost C= Cost B +19+20												

Rs.1,04,672.0 (12.90%), leading to Cost B of Rs.7,83,868.4 (94.40%). Family labour comprised 71.36 mandays of male labour costing Rs.35,680 (4.24%) and 45.89 mandays of female labour costing Rs.11,272.5 (1.36%), culminating in Cost C of Rs.8,31,791.8. The yield was 306.20 qtl (30.62 tonnes), resulting in gross returns of Rs.30,62,000 and the highest B:C ratio of 3.73.

On an average across all farm sizes, the total cost of cultivation (Cost C) was Rs.7,49,264.6 per hectare. Average hired labour use included 75.68 mandays of male labour costing Rs.37,841.67 (4.97%) and 56.81 mandays

of female labour costing Rs.14,201.67 (1.82%). Machine power averaged 29.91 hours, costing Rs.26,919 (3.42%), while manure application was 176 qtl with an expenditure of Rs.44,000 (5.75%). Fertilizer use on average comprised 134.50 kg nitrogen (Rs.1,077.41; 0.14%), 126.48 kg phosphorous (Rs.1,518.12; 0.20%) and 93.78 kg potassium (Rs.3,375.96; 0.45%). Irrigation charges averaged Rs.4,637.13 (0.62%), plant protection Rs.14,924.04 (2.03%), incidental charges Rs.1,361.48 (0.18%) and repairs Rs.2,634.39 (0.34%). Average working capital was Rs.1,52,490.9 (19.91%), with interest

on working capital of Rs.15,249.09 (1.99%), depreciation Rs.2,379.57 (0.30%) and land revenue and taxes Rs.562.05 (0.06%), resulting in Cost A of Rs.1,70,681.6 (22.26%). The average rental value of land was Rs.4,26,964.1 (57.01%), interest on fixed capital Rs.7,842.02 (1.02%) and amortization cost Rs.1,01,325.2 (13.64%), yielding an average Cost B of Rs.7,06,812.9 (93.92%). Family labour on average involved 69.95 mandays of male labour costing Rs.34,973.33 (4.63%) and 43.65 mandays of female labour costing Rs.7,478.33 (1.44%). The average output was 262.72 qtl (26.272 tonnes), generating gross returns of Rs.26,33,000, and an overall B:C ratio of 3.49, indicating high economic viability of dragon fruit cultivation across all farm sizes.

Discussion

The analysis of dragon fruit cultivation in Maharashtra revealed that total cost per hectare (Cost C) ranged from Rs.6.83 lakh for small farmers to Rs.8.32 lakh for large farmers, with an average of Rs.7.49 lakh/ha. Hired and family labour, manure, and land rental value were the major cost components, while fertilizer and incidental charges contributed minimally. The average yield was 26.27/ t/ha, with gross returns of Rs.26.33/ lakh/ha and a benefit–cost (B:C) ratio of 3.49, indicating high profitability. Larger farms, although incurring higher costs, achieved greater returns due to economies of scale.

These findings are consistent with other regional studies. Anil Kumar *et al.*, (2025) reported that in Kerala, dragon fruit cultivation cost Rs.8.29/ lakh/ha, with an average yield of 21/ t/ha and gross returns of Rs.27.33/ lakh/ha; B:C ratios ranged from 3.04 to 4.29, reflecting strong profitability. Sathe *et al.* (2024) observed in Solapur, Maharashtra, that costs ranged from Rs.9.27/ lakh/ha (small farms) to Rs.10.86/ lakh/ha (large farms), with higher yields (~29.87/ t/ha) and gross returns (~Rs.29.87/ lakh/ha), and an average B:C ratio of 3.42. In Karnataka, Ramesh *et al.* (2024) reported establishment costs of Rs.1.44–1.55/ lakh/acre, yields of 1,248–1,293/ kg/acre, net incomes of Rs.1.35–1.47/ lakh/acre, and B:C ratios of 4.34–5.33 under both farmer and experimental conditions.

Additional studies further confirm dragon fruit's profitability under diverse agro-climatic conditions. Pavan *et al.*, (2025) in Karnataka reported yields of 1,603/ kg/ acre and net returns of Rs.2,24,479, with a B:C ratio of 3.98 and IRR of 102.91% when scientific management practices were applied. Sethunath *et al.*, (2025) in Kerala found similar cost structures and B:C ratios of 3.04–4.29. In Nagaland, Kikon *et al.*, (2021) reported a positive NPV of Rs.2.08 crore and a B:C ratio of 2.04, highlighting financial viability (researchjournal.co.in). In Bangladesh,

Ahmed *et al.*, (2025) observed that dragon fruit cultivation provided high profitability along with employment generation, supporting its potential as a high-value horticultural crop.

Overall, these comparative studies indicate that although costs vary by region and farm size, dragon fruit consistently demonstrates high economic viability, with B:C ratios typically above 2.0 and often exceeding 3.0. Adoption of scientific management practices, mechanization, and efficient use of inputs further enhance profitability. These results reinforce that dragon fruit is a profitable, high-value horticultural crop suitable for Maharashtra and other regions in India, as well as neighboring countries, providing both income and employment opportunities.

Conclusion

The study demonstrates that dragon fruit cultivation in Maharashtra is highly profitable across all farm sizes, with an average benefit–cost ratio of 3.49, indicating strong economic viability. Major cost components include land rental value, hired and family labour, and manure, while inputs like fertilizers contribute minimally. Larger farms benefit from economies of scale, achieving proportionally higher returns despite higher costs. The crop's adaptability to diverse agro-climatic conditions, drought tolerance, and long productive lifespan further enhance its appeal as a high-value horticultural crop.

Future Scope

With rising domestic and export demand, dragon fruit cultivation has significant potential for expansion in water-scarce and degraded regions of India. Adoption of improved management practices, mechanization, and integrated pest management can further increase yields and profitability. Additionally, value-added processing, branding, and export-oriented cultivation offer opportunities to enhance farmers' income, employment generation, and regional horticultural development.

AI Disclosure Statement

The authors declare that artificial intelligence (AI)–based tools were used solely for language editing, grammar correction, and improving the clarity and readability of the manuscript. The AI technology did not contribute to the study design, data collection, data analysis, interpretation of results, or the formulation of key arguments and conclusions. All AI-assisted content was carefully reviewed, verified, and edited by the authors to ensure accuracy, originality, and compliance with academic and ethical standards. The authors take full responsibility for the content of the manuscript.

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