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Research Article

Profitability and sustainability of Assam lemon for border cropping in tea plantations of Assam: A cash-flow analysis of grower enterprises

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Abstract

Assam lemon (*Citrus limon* (L.) Burm. f.), locally known as Kaji Nemu, is an important perennial horticultural crop of Assam and is also documented as a border crop in diversified tea plantations. The present study evaluates the profitability and financial sustainability of the Assam lemon enterprise using primary data collected from 197 commercial growers in Tinsukia district during 2022–2024. Establishment cost, maintenance cost, yield, cash inflow and cash outflow were organized over a 13-year economic horizon. Financial feasibility was assessed through payback period, net present value, internal rate of return and benefit-cost ratio at a 12 per cent discount rate. Based on the cash-flow series reported in the study, the net present value was Rs. 11,06,861.43 per acre, the internal rate of return was 42.83 per cent, the benefit-cost ratio was 1.93 and the simple payback period was approximately 5.87 years. Positive annual cash flow commenced in the fifth year and strengthened as the plantation reached mature production. The results indicate that the lemon component can provide a financially attractive diversification option for tea-based plantation systems where it is established along garden borders. The original field schedule, however, did not separately quantify the costs and returns of the tea component; the results therefore represent the economics of Assam lemon rather than a comparative tea-plus-lemon system.

Keywords: Assam Lemon, Border Crop, Cash Flow, Profitability, Sustainability, Tea Plantation

Introduction

Assam lemon, locally known as Kaji Nemu (*Citrus limon* (L.) Burm. f.), is a distinctive citrus type cultivated throughout Assam and valued for its aroma, culinary use and commercial potential. The Government of Assam formally declared Kaji Nemu the State Fruit in 2024, reflecting its economic and cultural importance. Assam lemon is marketed both as fresh fruit and as a raw material for value-added products, while its commercialization continues to depend on reliable production practices, market access and post-harvest handling (Barua & Bharadwaj, 2017; Kashyap *et al.,* 2024).

The relevance of Assam lemon to plantation-crop research arises from its documented role in diversified tea systems. Sonowal *et al.* (2024) describe a tea + Assam lemon model in which tea remains the principal plantation crop and Assam lemon is planted along tea-garden borders, contributing additional farm output and functioning as a biological boundary. Such diversification is particularly relevant to small tea holdings where supplementary perennial or horticultural components can improve land-use efficiency and broaden farm income. Evidence from Assam also shows that the non-estate tea sector is an important source of farm income and employment, but is exposed to production and price constraints (Das & Mishra, 2019; Gam & Deka, 2020).

Profitability of a perennial crop depends on establishment cost, recurring maintenance expenditure, the gestation period and the pattern of returns over the productive life of the planting. In Assam lemon, fertigation and nutrient-management studies have demonstrated that management practices can materially influence yield and economic return (Barua & Hazarika, 2014; Hazarika & Aheibam, 2019). At the marketing stage, growers face constraints associated with intermediary-dominated channels, transport, storage and price realization. In a study of Assam lemon marketing in Nalbari district, 55 per cent of marketed surplus moved through the longest identified channel and producer share in the consumer rupee was lowest in that channel (Baruah *et al.,* 2023). More generally, citrus growers' channel choices are shaped by price, payment conditions and harvesting arrangements (Siddique *et al.,* 2018), while appropriate post-harvest handling and cold-chain practices are important for maintaining fruit quality (Strano *et al.,* 2017).

Despite the agronomic and market potential of Assam lemon, farm-level evidence on its long-term cash-flow performance remains limited. The objective of the present study was therefore to estimate the cost and return structure of commercial Assam lemon cultivation and to assess its financial viability over a 13-year horizon. In the context of the Journal of Plantation Crops, the results are interpreted for the Assam lemon component that can be integrated as a border crop in tea plantations. The study does not estimate the combined profitability of tea and lemon because the original survey instrument did not separately record tea-enterprise costs or returns.

Material and methods

The study was carried out in Tinsukia district of Assam. Primary information was collected during 2022–

2024 through structured personal interviews with 197 respondents selected purposively from farmers extensively engaged in commercial Assam lemon cultivation. Secondary literature was used to place the enterprise within the wider context of Assam horticulture and tea-based diversification. Because the field schedule focused on the lemon enterprise, respondents were not stratified by whether the lemon planting occurred inside a tea holding, along a tea-garden border or as a standalone orchard. Accordingly, the economic estimates below represent the Assam lemon component and should be interpreted as evidence relevant to its documented use in tea-based border-cropping systems rather than as a comparative trial of tea monoculture versus tea + lemon.

Costs were organized into (i) initial establishment investment, (ii) maintenance cost during the first three years, and (iii) maintenance cost during the bearing period. Initial investment included rental value of land, planting material, pit preparation, bamboo fencing, irrigation installation, tillage, planting and miscellaneous establishment expenditure (Table 1). Maintenance during the first three years included labour, farmyard manure, fertilizer, pesticides, interest on working capital and fixed costs (Table 2). The bearing-period cost used in the cash-flow model is summarized in Table 3.

The yield and return series used in the financial model is presented in Table 4. Although Assam lemon may begin biological bearing earlier, the source cash-flow schedule records no commercial inflow during the first three years and begins marketable yield in the fourth year. The analysis therefore follows the observed economic series rather than assuming an earlier saleable yield.

Financial feasibility was evaluated from the annual cash-flow series in Table 5. Net Present Value (NPV) was calculated as the sum of discounted annual net cash flows at 12 per cent. The Benefit-Cost (B:C) ratio was calculated as the present value of cash inflows divided by the present value of cash outflows. The Internal Rate of Return (IRR) was the discount rate at which NPV equals zero. The simple payback period was calculated from cumulative undiscounted net cash flow as the last full year with a negative cumulative balance plus the unrecovered balance divided by the following year's net cash flow. These indicators were recalculated directly from the cash-flow values in Table 5 to ensure internal numerical consistency.

Results and discussion

Initial investment

The establishment investment for one acre of Assam lemon was Rs. 67,985 (Table 1). Bamboo fencing was the largest single component (Rs. 21,000; 30.89 per cent), followed by planting material (Rs. 17,760; 26.12 per cent) and irrigation installation (Rs. 10,150; 14.93 per cent). These costs show that protection of the planting and establishment infrastructure account for a substantial share of the first-year commitment.

Table 1: Initial investment in Assam lemon farming (per acre)

Particulars	Amount (Rs.)	Percentage
Rental value of land	5,250	7.72
Planting material	17,760	26.12
Pit preparation	5,125	7.54
Bamboo fencing	21,000	30.89
Installation of irrigation	10,150	14.93
Tillage cost	5,950	8.75
Cost of planting	1,750	2.57
Miscellaneous	1,000	1.47
Total	67,985	100.00

Source: Field survey. Note: Irrigation cost includes the initial tube-well and 0.75-hp single-phase self-priming water pump. Daily labour wage used in the source schedule was Rs. 250

Maintenance during the first three years

The combined maintenance cost during years 1–3 was Rs. 1,90,348.40 (Table 2). Across this period, variable costs were dominated by material inputs, particularly farmyard manure and pesticides, while labour included fertilizer application, weeding, chemical spraying and imputed farmer salary. This cost structure is consistent with the importance of nutrient and crop-management practices documented for Assam lemon (Barua & Hazarika, 2014; Hazarika & Aheibam, 2019).

Bearing-period cost

Total maintenance cost for the bearing period represented in Table 3 was Rs. 24,24,084, of which variable costs were Rs. 23,49,088 (96.91 per cent) and fixed costs were Rs. 74,996 (3.09 per cent). Labour was the largest major cost group within variable costs, followed by material costs. The dominance of recurring labour and material expenditure indicates that economic performance after establishment remains sensitive to input prices and management efficiency.

Yield and return structure

The economic model records no marketable yield in years 1–3, followed by 49,000 fruits per acre in year 4 and progressively higher yields thereafter (Table 4). Output reaches 2,94,000 fruits per acre annually in years 10–13. At the value used in the source schedule, total gross return over years 4–13 is Rs. 64,68,000. Because the study is based on a 13-year financial horizon, no return beyond year 13 is included in the feasibility indicators.

Cash-flow pattern

Annual net cash flow remained negative through year 4 and became positive in year 5 (Table 5). The cumulative undiscounted cash balance turned positive during year 6. From year 10 onward, annual net cash flow was Rs. 6,39,592 under the yield and price assumptions used in the source schedule. This delayed but subsequently strong return profile is characteristic of a perennial enterprise in which establishment and juvenile-period costs precede mature output.

Table 2: Maintenance cost during the first three years of Assam lemon farming (per acre)

Particulars	Year 1	Year 2	Year 3	Share (%)
Variable cost				
Labour cost				
Fertilizer application	1,500	1,500	1,500	2.36
Weeding	1,400	1,400	1,400	2.21
Chemical spraying	2,000	2,000	2,000	3.15
Farmer's salary	7,500	7,500	7,500	11.82
Total labour cost (A)	12,400	12,400	12,400	19.54
Material cost				
Fertilizer cost	1,211	2,599	3,638	3.91
Farmyard manure	8,575	17,150	25,725	27.03
Pesticides	16,217	17,486	18,755	27.56
Total material cost (B)	26,003	37,235	48,118	58.50
Interest on working capital @ 7%	2,163.21	2,949.45	3,711.00	5.46
Total variable cost (A+B+C)	40,566	52,584	64,229	83.51
Fixed cost				
Rental value of land	5,250	5,250	5,250	8.27
Land revenue	140	140	140	0.22
Interest on fixed cost @ 12%	646.80	646.80	646.80	1.02
Depreciation	4,428	4,428	4,428	6.98
Total fixed cost	10,464.80	10,464.80	10,464.80	16.49
Total cost	51,555.80	63,573.80	75,218.80	100.00

Source: Field survey

Table 3: Maintenance cost during the bearing period of Assam lemon farming (per acre)

Particulars	Amount (Rs.)	Percentage
Variable cost		
Labour cost		
Farmer's salary	9,00,000	37.13
Weeding	56,000	2.31
Cutting/pruning	73,500	3.03
Farmyard manure and fertilizer application	40,000	1.65
Chemical spraying	60,000	2.48
Total labour cost (A)	11,29,500	46.59
Material cost		
Farmyard manure	6,86,000	28.30
Fertilizer	48,510	2.00
Pesticides	1,60,190	6.61
Stand/support	73,200	3.02
Total material cost (B)	9,67,900	39.93
Interest on working capital @ 7%	2,51,688	10.38
Total variable cost	23,49,088	96.91
Fixed cost		
Land revenue	1,400	0.06
Rental value of agricultural land	52,500	2.17
Interest on fixed cost @ 12%	6,468	0.27
Depreciation	14,628	0.60
Total fixed cost	74,996	3.09
Total cost	24,24,084	100.00

Source: Field survey

Table 4: Yield and return structure of Assam lemon farming (per acre)

Age of planting (year)	Yield (number/acre)	Value (Rs.)
1	Nil	Nil
2	Nil	Nil
3	Nil	Nil
4	49,000	1,47,000
5	98,000	2,94,000
6	1,96,000	5,88,000
7	1,96,000	5,88,000
8	1,96,000	5,88,000
9	2,45,000	7,35,000
10	2,94,000	8,82,000
11	2,94,000	8,82,000
12	2,94,000	8,82,000
13	2,94,000	8,82,000
Total	21,56,000	64,68,000

Source: Field survey

Financial viability

Recalculation from the annual series in Table 5 gives a Net Present Value of Rs. 11,06,861.43 per acre at a 12 per cent discount rate, an Internal Rate of Return of 42.83 per cent and a Benefit-Cost ratio of 1.93 (Table 6). The simple payback period is approximately 5.87 years. These indicators show that, under the study's cost, yield and price assumptions, discounted benefits exceed discounted costs by a substantial margin. The positive NPV and an IRR well above the 12 per cent appraisal rate support the financial attractiveness of the lemon enterprise.

Implications for tea-based plantation systems

Assam lemon has been specifically proposed as a border component of diversified tea cultivation (Sonowal *et al.,* 2024). The financial results therefore provide an estimate of the economic potential of the lemon component that a tea grower may consider alongside the principal tea enterprise. Border integration may also diversify saleable output, but realized benefit will depend on available border area, compatibility with tea-field operations, market access and post-harvest management. Marketing evidence from Assam shows that intermediary-heavy channels can reduce the producer's share of the final consumer price (Baruah *et al.,* 2023), reinforcing the importance of direct marketing, aggregation, storage and value addition.

Table 5: Cash-flow analysis of Assam lemon (per acre)

Year	Cash outflow (Rs.)	Cash inflow (Rs.)	Net cash flow (Rs.)	Discount factor @ 12%	Discounted net cash flow (Rs.)
1	119,540	0	-119,540	0.8929	-106,732.14
2	63,574	0	-63,574	0.7972	-50,680.80
3	75,219	0	-75,219	0.7118	-53,539.40
4	242,408	147,000	-95,408	0.6355	-60,633.51
5	242,408	294,000	51,592	0.5674	29,274.69
6	242,408	588,000	345,592	0.5066	175,087.66
7	242,408	588,000	345,592	0.4523	156,328.27
8	242,408	588,000	345,592	0.4039	139,578.81
9	242,408	735,000	492,592	0.3606	177,633.61
10	242,408	882,000	639,592	0.3220	205,931.51
11	242,408	882,000	639,592	0.2875	183,867.42
12	242,408	882,000	639,592	0.2567	164,167.34
13	242,408	882,000	639,592	0.2292	146,577.98

Source: Field survey; discounting recalculated at 12 per cent from the source cash-flow series

Table 6: Financial viability indicators for Assam lemon farming

Indicator	Estimate	Basis
Simple payback period	5.87 years	Cumulative undiscounted cash flow
Net Present Value	Rs. 1,106,861.43	12% discount rate
Internal Rate of Return	42.83%	Rate at which NPV=0
Benefit-Cost ratio	1.93	PV inflows/PV outflows
Present value of cash inflows	Rs. 2,292,710.18	12% discount rate
Present value of cash outflows	Rs. 1,185,848.76	12% discount rate

Source: Recalculated from the annual cash-flow series reported in Table 5

Conclusion

The 13-year cash-flow series indicates that commercial Assam lemon cultivation is financially viable under the cost, yield and price assumptions reported in the study. Recalculated indicators show a Net Present Value of Rs. 11,06,861.43 per acre at 12 per cent, an Internal Rate of Return of 42.83 per cent, a Benefit-Cost ratio of 1.93 and a simple payback period of about 5.87 years. In plantation-crop terms, these results are relevant because Assam lemon is documented as a border crop in diversified tea systems in Assam. It can therefore serve as a supplementary perennial enterprise where tea-garden boundaries and local management conditions permit its integration. The present estimates, however, are for the lemon enterprise alone; future studies should collect paired cost and return data from tea-only and tea + Assam lemon holdings to quantify the incremental profitability of the complete plantation cropping system.

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