Asian Journal of Agricultural Extension, Economics & Sociology

Volume 42, Issue 12, Page 81-89, 2024; Article no.AJAEES.126870
ISSN: 2320-7027

Economic Assessment of Soybean Production in Amravati District: Costs, Returns, and Farm Size Dynamics

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Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/ajaees/2024/v42i122633

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/126870

Original Research Article

Received: 16/09/2024
Accepted: 19/11/2024
Published: 25/11/2024

ABSTRACT

The research estimated the cost and returns of soybean production in the Amravati district of Maharashtra, a key region for soybean cultivation in India. Primary data was collected from 120 farmers across different farm sizes (small, medium, and large) through personal interviews and structured questionnaires. The study assessed the economic dynamics of soybean farming by examining inputs such as human labour, bullock labour, seeds, fertilizers, mechanization, and plant protection costs, and analyzed the output in terms of yields and profitability. The findings revealed significant variations in resource allocation and profitability across farm sizes. Small farmers incurred higher costs, particularly in labour due to limited mechanization, compared to medium and large farmers. The per quintal cost of production for overall farmers was Rs. 4002.20. In contrast, large farms benefited from economies of scale, with lower production cost (Cost C_3: Rs. 60,878.89/ha) compared to small (Rs. 62,755.14/ha) and medium farms (Rs. 63,009.94/ha).

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Cite as: *Joharapurkar, S. M., S. S. Thakare, and S. N. Ingle. 2024. "Economic Assessment of Soybean Production in Amravati District: Costs, Returns, and Farm Size Dynamics". Asian Journal of Agricultural Extension, Economics & Sociology 42 (12):81-89. https://doi.org/10.9734/ajaees/2024/v42i122633.*

Medium-sized farmers emerged as the most profitable, showing the best balance between input costs and returns, with a gross return of Rs. 72,597.99/ha. The overall input-output ratio for soybean cultivation indicates profitability, with a ratio of 1.14 at Cost C_3. The study emphasized the potential for improving efficiency in farms through strategic investments in mechanization and better resource management. By enhancing productivity, such measures can help bridge the gap between local and global soybean productivity levels and give economic stability to soybean farmers in the region.

Keywords: Soybean; cost and returns; input-output ratio.

1. INTRODUCTION

Agriculture plays a pivotal role in the Indian economy, contributing significantly to both GDP and employment. As of 2023-24, agriculture provides livelihoods for 42.3% of the population and accounts for 18.2% of the national GDP (Nageswaran 2024). Compared to leading agricultural countries, India lags in crop productivity, with structural issues like fragmented land holdings, insufficient mechanization, and inadequate access to quality inputs contributing to this gap. The oilseed crops are the second most important determinant of agricultural economy (*NFSM* 2017), India is fortunate in having a verity of oilseed crops grown in its distinctive rich agro climatic zones. India ranks fourth in the world vegetable oil economy, next to China, Brazil and Argentina (Patel et al. 2023). There are nine important oilseed crops grown in India, out of which seven are edible and two are non-edible oils. The edible oils are soybean, groundnut, rapeseed mustard, sunflower, sesame, and safflower In terms of acreage, production, and economic value, oilseeds are second only to food grains (Kumar et al. 2023). India is heavily dependent on imports to meet its domestic edible oil demand importing nearly 70% of its edible oil from countries such as Indonesia, Malaysia, Russia, and Argentina (Prashnani et al. 2024). The soybean provides the majority of domestic edible oil production and in the past few decades has proven to be a reliable source of oilseed for India.

1.1 Importance of Soybean

Soybean (*Glycine max*), a key oilseed crop, is vital for food security and nutritional balance, especially in developing nations like India. Soybean is also known as the “gold of the soil” due to its easy cultivation, nitrogen-fixing ability, less requirement of nitrogenous fertilizer, etc (Mohod et al. 2018). It is a highly remunerative crop with comparatively less input demands (Bhopale & Shende 2021). It is grown under diverse agro-climatic conditions and contributes 25% of the world’s edible oil production while providing an essential source of protein for livestock. In India, where over 40% of the population suffers from energy and protein malnutrition (Anonymous 2024), soybean’s natural source of high protein with a number of essential amino acids and nutrient content makes it an essential crop for maintaining good health (Perke et al. 2017). Its seeds contain 20% oil and 40% protein, along with healthy fats like omega-3 and omega-6, making it highly valuable for human consumption, livestock feed, and various industrial uses. The soybean processing industry in India is estimated to be worth around $10 billion, and is growing at a rate of approximately 7% per year (Ravichandran & Dixit 2023), The processing industry creates a range of soybean products, like soybean oil, soy meal, and other derivative products. This has made the soybean crop a leading biotech crop and modification of the fatty acid profile of soy oil, improvement in protein content, and nutritional quality have established it as one of the most viable commercial crop (Tiwari & Ramchandra 2022).

1.2 Soybean’s Area, Production and Productivity

The contribution of India in the world soybean area is around 9-10% but the contribution to world soybean production is only around 3-4% indicating relatively lower levels of productivity (1150 kg/ha) as compared to the world average (2730 kg/ha), which is a major cause of concern (Anonymous 2024). According to the Final Estimates of Production of Food Grains for 2023-24, soybean crop is estimated at 130.62 lakh tonnes as compared to 149.85 lakh tonnes in 2022-23 (DA&FW 2024). Among the states, Maharashtra is leading in soybean production followed by Madhya Pradesh, Rajasthan, Karnataka, and Gujarat.

Maharashtra accounts for around 40 percent of India's soybean production area. According to the Department of Agriculture, Government of Maharashtra, soybean is cultivated across a 5.08 million ha area with production of 6.60 million tonnes and productivity of 1299.18 kg/ha. The Latur and Amravati divisions in the state have significant acreage devoted to the cultivation of soybean both these divisions together contribute 68.39 per cent area and 74.33 per cent production of total soybean cultivation in the state. The maximum productivity is recorded by the Kolhapur division with 1602.86 kg/ha. In particular, the Amravati division emerges as a major hub for soybean cultivation. The division contributes around 30 percent of the area and 33 percent of soybean production. In the Amravati division, Buldhana district has the maximum area (418128 ha) and production (617914 tonnes). In contrast, the Amravati district has the highest productivity (1629.20 kg/ha) with an area of 252551 ha and production of 411456 tonnes (Department of Agriculture, Government of Maharashtra. 2024).

The region’s favourable climatic conditions and extensive agricultural infrastructure make it an important area for studying soybean productivity. However, despite its leading role, the productivity levels in Amravati remain inconsistent and below the global average. This research was focused on understanding the cost and returns associated with soybean production in the Amravati district, assessing various factors such as human labor, machine use, seed quality, fertilizers, and pest control methods.

2. METHODOLOGY

2.1 Study Area

The study was conducted in the Amravati district of Maharashtra, a key soybean-producing region in India in *Kharif* season of 2023-24. The district's agro-climatic conditions make it suitable for soybean cultivation.

2.2 Data Collection

Primary data was collected from 120 randomly selected soybean farmers across six villages in the Dhamangaon Rly. and Nandgaon Kh. tehsils of Amravati district. Data was gathered through personal interviews and structured questionnaires covering specific information related to cost of cultivation, inputs used, and yields obtained.

2.3 Cost and Returns of Soybean Cultivation

The cost and returns of soybean cultivation were calculated using standard cost concepts: Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, Cost C_2, and Cost C_3.

Cost A_1 is the sum of all items which include

- Cost of hired human labour
- Cost of hired bullock labour
- Cost of owned bullock labour
- Cost of hired machine labour
- Cost of owned machine labour
- Cost of seed (both farm-produced and purchased)
- Cost of seed treatment (fungicides and biofertilizers)
- Cost of manure (owned and purchased)
- Cost of fertilizers
- Cost of micronutrients
- Cost of herbicides
- Cost of plant protection (insecticides and pesticides)
- Repairing charges
- Interest on working capital at the rate of 6% per annum
- Depreciation of implements and farm buildings
- Land revenue cesses and other taxes

Cost A_2 = Cost A_1 + Rent paid for leased-in land

No correction: Just eliminate the space

Cost B_1 = Cost A_1 + Interest on fixed capital at the rate of 10% per annum (excluding land)

Cost B_2 = Cost B_1 + Rental value of owned land

No correction: Just eliminate the space

Cost C_1 = Cost B_1 + Imputed value of family labour

Cost C_2 = Cost B_2 + Imputed value of family labour

Cost C_3 = Cost C_2 + 10% of Cost C_2 on account of managerial function performed by farmer

2.4 Gross and Net Return

2.4.1 Gross return

The gross return was estimated from the sale of the crop output i.e. main produce and by produce.

2.4.2 Net return

The net return was computed at different standard cost concepts i.e. Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, Cost C_2, and Cost C_3 by deducting the respective costs from the gross return.

2.5 Input-output Ratio

The input-output ratio represents returns obtained per rupee of investment. The input-output ratio was worked out based on standard cost concepts i.e. by dividing the gross income by respective Cost A_1, Cost A_2, Cost B_1, Cost B_2, Cost C_1, Cost C_2, and Cost C_3.

3. RESULTS AND DISCUSSION

3.1 Cost of Cultivation of Soybean Farmers

The per hectare cost of soybean cultivation for small, medium, large, and overall farmers was worked out and presented in Table 1. The analysis of costs and returns across small, medium, and large farming categories reveals significant differences in resource allocation and associated costs. Small farmers tend to have higher costs in certain areas, such as hired labour, while larger farmers benefit from economies of scale. Specifically, the total costs for hired human labour (male and female) are highest for large farmers at Rs. 8005.26/ha, while small and medium farmers incur Rs. 6886.06/ha and Rs. 6405.12/ha respectively. This suggests that large farmers rely more on hired labour due to less family labour. As farm size increases, there is a noticeable shift towards using machine labour, with large farmers spending Rs. 8601.47/ha on hired and owned machine labour combined compared to small and medium farmers, highlighting the capital intensity of larger farming operations. It was also observed that machine labour has the maximum share in Cost A_1 and a similar result was observed by (Ghule et al. 2024).

Seed, fertilizer, and manure costs also vary by farm size. Medium farmers have the highest expenditure on seeds at Rs. 8175.25/ha, while small and large farmers spend Rs. 7586.34/ha and Rs. 7923.30/ha, respectively, suggesting differences in seed varieties or planting densities. Fertilizer costs are slightly lower for large farmers (Rs. 3206.92/ha) compared to small (Rs. 3441.85/ha) and medium farmers (Rs. 3431.69/ha), reflecting mechanization of fertilizer application. Cost A_1 is highest for large farmers (Rs. 40371.51/ha), followed by small (Rs. 38657.33/ha) and medium farmers (Rs. 38277.91/ha), which aligns with the larger scale of operations and greater input requirements for larger farmers.

The family labour (male and female) was lowest for large farmers Rs. 1458.18 as compared to small and medium farmers indicating higher land holding and more management work. The overall cost structure indicates that total costs (Cost C_3) is lowest for large farmers (Rs. 60788.89/ha) compared to small (Rs. 62755.14/ha) and medium farmers (Rs. 63009.94/ha), indicating that larger farmers achieve better economies of scale. For overall farmers the Cost C_3 was Rs. 62539.26/ha.

3.2 Cost and Returns from Soybean Cultivation

The data on cost and returns from soybean is presented in Table 2. The data reveals that the gross return from soybean production generates Rs. 71,506.26/ha on average, with small and medium-sizwd farmers showing slightly higher returns (Rs. 71,729.98/ha and Rs. 72,597.99/ha, respectively) compared to large-sized farmers (Rs. 68,695.39/ha). The average price received by overall farmer for their produce was Rs. 4590.20/q which was extremely close to the Minimum Support Price (MSP) for Soybean (yellow) Rs. 4600/q for Kharif Marketing Season 2023-24 which was similarly observed by(Chawla & Singh 2024). It was also evident from the data that the small-sized farmers received price below MSP while medium and large-sizwd farmers received higher price than MSP indicating immediate need of money for next sowing season. The per quintal cost of production also increases with increase in farm size, from Rs. 3968.29 for small farmers to Rs. 4162.33 for large farmers, suggesting that large farmers incur higher production cost. The profit margins, when considering various cost categories (Cost A_1 to Cost C_3), shows that while basic returns remain positive (Rs. 32,692.97 at Cost A_1), they decrease significantly as more costs are accounted for, dropping to Rs. 8,967.00 at Cost C_3 for overall farmers. Small-sized farmers appear to manage costs more effectively, while medium-sized farmers received higher profit margin at Cost C_3, while large-sized farmers face greater cost pressures and diminishing returns to scale.

Table 1. Cost of cultivation of soybean farmers (Rs./ha)

Sr. No.	Item		Unit	Small		Medium		Large		Overall	
				Inputs/ha	Total Cost/ha	Inputs/ha	Total Cost/ha	Inputs/ha	Total Cost/ha	Inputs/ha	Total Cost/ha
1	Hired Human Labour	Male	Days	6.69	2620.86 (4.18)	4.71	1828.97 (2.90)	5.82	2203.66 (3.62)	6.03	2347.11 (3.75)
		Female	Days	10.93	4265.20 (6.80)	11.74	4576.15 (7.26)	14.30	5801.60 (9.53)	11.65	4578.58 (7.32)
2	Bullock Labour	Hired	Days	1.84	1398.84 (2.23)	1.33	1027.56 (1.63)	1.12	844.23 (1.39)	1.60	1216.64 (1.95)
		Owned	Days	1.54	1041.66 (1.66)	1.58	1057.82 (1.68)	1.36	929.11 (1.53)	1.52	1029.09 (1.65)
3	Machine Labour	Hired	Hrs	11.38	7812.13 (12.45)	10.06	7160.65 (11.37)	8.56	6819.57 (11.20)	10.60	7489.52 (11.98)
		Owned	Hrs	0.00	0.00 (0.00)	1.11	656.28 (1.04)	2.49	1781.90 (2.93)	0.67	442.29 (0.71)
4	Seed		Kgs.	73.40	7586.34 (12.09)	72.9	8175.25 (12.98)	75.30	7923.30 (13.01)	73.6	7793.93 (12.46)
5	Seed Treatment		Rs.	-	589.07 (0.94)	-	711.66 (1.13)	-	705.87 (1.16)	-	639.28 (1.02)
6	Manure		Tonnes	0.33	832.74 (1.33)	0.18	455.83 (0.72)	0.34	797.67 (1.31)	0.29	726.97 (1.16)
7	Fertilizer		Kgs.	179.40	3441.85 (5.48)	171.7	3431.69 (5.45)	158.80	3206.92 (5.27)	174.2	3403.90 (5.44)
8	Micronutrient		Rs.	-	687.07 (1.09)	-	811.87 (1.29)	-	664.47 (1.09)	-	716.96 (1.15)
9	Herbicide		Rs.	-	2223.44 (3.54)	-	2062.46 (3.27)	-	1968.39 (3.23)	-	2142.26 (3.43)
10	Plant protection		Rs.	-	3292.84 (5.25)	-	3271.20 (5.19)	-	3022.24 (4.96)	-	3246.48 (5.19)
11	Repairing Charge		Rs.	-	315.57 (0.50)	-	296.09 (0.47)	-	297.67 (0.49)	-	307.70 (0.49)
12	Working Capital		Rs.	-	36107.61 (57.54)	-	35523.48 (56.39)	-	36966.60 (60.72)	-	36080.71 (57.69)

Sr. No.	Item		Unit	Small		Medium		Large		Overall	
				Inputs/ha	Total Cost/ha	Inputs/ha	Total Cost/ha	Inputs/ha	Total Cost/ha	Inputs/ha	Total Cost/ha
13	Interest on Working Capital		Rs.	-	2166.46 (3.45)	-	2131.41 (3.38)	-	2218.00 (3.64)	-	2164.84 (3.46)
14	Depreciation		Rs.	-	315.21 (0.50)	-	565.06 (0.90)	-	1129.13 (1.85)	-	503.93 (0.81)
15	Land Revenue		Rs.	-	68.05 (0.11)	-	57.96 (0.09)	-	57.78 (0.09)	-	63.81 (0.10)
16	Cost A_1		Rs.		38657.33 (61.60)		38277.91 (60.76)		40371.51 (66.31)		38813.29 (62.06)
17	Rent Paid for Leased Land		Rs.	-	0.00 (0.00)	-	0.00 (0.00)	-	0.00 (0.00)	-	0.00 (0.00)
18	Cost A_2		Rs.		38657.33 (61.60)		38277.91 (60.76)		40371.51 (66.31)		38813.29 (62.06)
19	Interest on Fixed Capital		Rs.	-	1519.00 (2.42)	-	2404.85 (3.82)	-	2123.31 (3.49)	-	1845.87 (2.95)
20	Cost B_1		Rs.		40176.33 (64.02)		40682.76 (64.57)		42494.82 (69.80)		40659.16 (65.01)
21	Rental Value of Land		Rs.	-	11886.95 (18.94)	-	12041.71 (19.11)	-	11391.45 (18.71)	-	11853.90 (18.95)
22	Cost B_2		Rs.		52063.28 (82.96)		52724.47 (83.69)		53886.27 (88.51)		52513.06 (83.97)
23.	Family Labour	Male	Days	8.02	2833.83 (4.52)	7.03	2618.52 (4.16)	3.06	1049.10 (1.72)	7.02	2508.70 (4.01)
		Female	Days	6.80	2153.02 (3.43)	6.04	1930.59 (3.06)	1.35	409.08 (0.67)	5.78	1832.11 (2.93)
24.	Cost C_1		Rs.		45163.18 (71.97)		45231.87 (71.80)		43953.00 (72.20)		44999.97 (71.95)
25.	Cost C_2		Rs.		57050.13 (90.91)		57273.58 (90.91)		55344.45 (90.91)		56853.87 (90.91)
26.	Managerial Cost		Rs.	-	5705.01 (9.09)	-	5727.36 (9.09)	-	5534.44 (9.09)	-	5685.39 (9.09)
27.	Cost C_3		Rs.		62755.14 (100.00)		63000.94 (100.00)		60878.89 (100.00)		62539.26 (100.00)

Table 2. Cost and returns from soybean cultivation (Ra./ha)

Sr. No.	Particulars	Size of Holding			
		Small	Medium	Large	Overall
1	Main Produce (q/ha)	15.44	15.39	13.99	14.65
	Price (Rs./q)	4549.57	4614.04	4709.70	4590.20
	Value of Main Produce	70245.29	71010.03	67254.57	70000.61
2	By Produce (q/ha)	4.89	5.13	4.73	4.87
	Price (Rs./q)	303.62	309.54	302.69	305.41
	Value of By Produce	1484.69	1587.96	1440.82	1505.65
3	Value of Total Produce	71729.98	72597.99	68695.39	71506.26
4	Per Quintal Cost of Production	3968.29	3990.45	4162.33	4002.20
5	Total Cost				
	Cost A_1	38657.33	38277.91	40371.51	38813.29
	Cost A_2	38657.33	38277.91	40371.51	38813.29
	Cost B_1	40176.33	40682.76	42494.82	40659.16
	Cost B_2	52063.28	52724.47	53886.27	52513.06
	Cost C_1	45163.18	45231.87	43953.00	44999.97
	Cost C_2	57050.13	57273.58	55344.45	56853.87
	Cost C_3	62755.14	63000.94	60878.89	62539.26
6	Net Return Over				
	Cost A_1	33072.65	34320.08	28323.88	32692.97
	Cost A_2	33072.65	34320.08	28323.88	32692.97
	Cost B_1	31553.65	31915.23	26200.57	30847.10
	Cost B_2	19666.70	19873.52	14809.12	18993.20
	Cost C_1	26566.80	27366.12	24742.39	26506.29
	Cost C_2	14679.85	15324.41	13350.94	14652.39
	Cost C_3	8974.84	9597.05	7816.50	8967.00

3.3 Input-output Ratio of Soybean Cultivation

The Table 3 indicates the input-output ratio for soybean cultivation, where medium farmers yields highest profitability at all costs ranging from 1.90 at 'Cost A_1' to 1.15 at 'Cost C_3'. suggesting that medium-sized farmers are able to generate higher returns relative to all costs, maintaining a positive input-output ratio even as the cost increases. Small-sized farmers also show high profitability, with ratios of 1.86 at 'Cost A_1' and 1.14 at 'Cost C_3'. However, large-sized farmers have the lowest input-output ratios, starting at 1.70 at 'Cost A_1' to 1.13 at 'Cost C_3', suggesting that large-scale operations results in lower production efficiency and profitability. Overall, the data indicates that medium-sized farms are the most efficient in terms of returns on investment, followed by small farms, while large farms face diminishing returns to scale and lower profitability. At overall level the input-output ratio at 'Cost C_3' was 1.14 indicating soybean cultivation as a profitable venture for the farmers of Amravati district.

Table 3. Input-output ratio of soybean cultivation

Sr. No.	Particulars	Size of Holding			
		Small	Medium	Large	Overall
1	Cost A_1	1.86	1.90	1.70	1.84
2	Cost A_2	1.86	1.90	1.70	1.84
3	Cost B_1	1.79	1.78	1.62	1.76
4	Cost B_2	1.38	1.38	1.27	1.36
5	Cost C_1	1.59	1.61	1.56	1.59
6	Cost C_2	1.26	1.27	1.24	1.26
7	Cost C_3	1.14	1.15	1.13	1.14

4. CONCLUSION

The study on soybean production in the Amravati district highlights the critical role of efficient resource utilization in improving farmers' profitability. An analysis of cost and returns showed that large-sized farmers benefit from economies of scale, achieving a lower per-unit production 'Cost C_3' while small-sized farmers face higher labor costs due to limited mechanization. Medium-sized farmers demonstrated the best profitability margins, showcasing an optimal balance between input cost and yields. For overall farmers, the per quintal cost of production was Rs. 4002.20 and the price received per quintal was Rs. 4590.20. The overall input-output ratio at 'Cost C_3' stands at 1.14, indicating profitability across all farm sizes at lower levels. Investing in mechanization and improving resource management can help increase productivity, reduce costs for farmers, and ensure sustainable soybean cultivation in the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/126870