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Profitability and resource use efficiency in soybean-based cropping systems: evidence from North-Eastern Karnataka

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Abstract

The present study was conducted in Bidar and Kalaburagi districts of Karnataka with the objective of analysing the comparative economics of major soybean-based cropping systems practiced in North-Eastern Karnataka. A sample of 160 farmers was selected through a multistage random sampling technique. Primary data were collected from the selected respondents for the study using the personal interview method. The study identified four predominant soybean-based cropping systems in the region, namely Soybean + Redgram (CS-I), Soybean + Jowar (CS-II), Soybean + Bajra (CS-III), and Sole Soybean (CS-IV). The socio-economic profile of the respondents indicated that the average age of farmers was 43, 45, 41, and 44 years in CS-I, CS-II, CS-III, and CS-IV, respectively, with an overall average age of 43 years, reflecting a relatively experienced farming population. The literacy level among farmers was found to be highest in CS-I, followed by CS-IV, CS-II, and CS-III, suggesting relatively better educational attainment among farmers practicing the soybean + redgram system. The economic analysis revealed notable variations in profitability across cropping systems. The net returns per hectare were estimated at ₹54,443.20 in CS-I (Soybean + Redgram), ₹34,108.18 in CS-II (Soybean + Jowar), ₹21,047.27 in CS-III (Soybean + Bajra), and ₹13,503.06 in CS-IV (Sole Soybean). Among these, CS-I (Soybean + Redgram) recorded the highest net returns and returns per rupee of expenditure, indicating its superior economic viability compared to other soybean-based cropping systems in the study area. The findings suggest that the soybean + redgram intercropping system offers greater profitability and resource-use efficiency, making it a more economically sustainable option for farmers in North-Eastern Karnataka.

Keywords: Costs and returns, soybean, cropping systems, comparative economics, North-Eastern Karnataka.

Introduction

Agriculture remains a cornerstone of the Indian economy, contributing significantly to national income, food security, rural livelihoods, and employment generation. Despite rapid industrialization and expansion of the service sector, agriculture continues to support nearly half of the country's workforce and contributes substantially to the Gross Domestic Product (GDP) ^[1]. The sector plays a pivotal role in ensuring economic stability, reducing rural poverty, and sustaining the livelihoods of millions of small and marginal farmers. In recent decades, increasing pressure on land resources, climate variability, and the need for higher agricultural productivity have emphasized the importance of efficient and sustainable farming systems ^[2].

Cropping systems constitute a fundamental component of agricultural production systems and are defined as the sequence and arrangement of crops grown on a particular piece of land over a specified period. The selection of an appropriate cropping system is influenced by agro-climatic conditions, resource availability, technological advancements, market demand, and farmers' socio-economic circumstances ^[3]. Efficient cropping systems facilitate optimum utilization of land, water, labor, and capital resources while enhancing productivity, profitability, and environmental sustainability. Diversified and

scientifically planned cropping systems have become increasingly important for maintaining soil health, minimizing production risks, and ensuring long-term agricultural sustainability ^[4].

Among various crops cultivated in India, soybean (*Glycine max* L. Merrill) has emerged as one of the most important oilseed and pulse crops due to its high nutritional value, versatility, and economic significance. Soybean is often referred to as the "Golden Bean" because of its rich protein and oil content. It contains approximately 40 percent protein and 20 percent oil, making it an important source of edible oil and livestock feed ^[5]. The economic value of soybean primarily depends on its two major by-products, namely soybean meal and soybean oil, which account for nearly two-thirds and one-third of its market value, respectively ^[6]. Owing to its high demand in domestic and international markets, soybean has become a profitable crop for farmers and a valuable contributor to India's agricultural economy. Soybean-based cropping systems have gained considerable importance in several regions of India due to their potential to improve farm income, enhance soil fertility through biological nitrogen fixation, and increase overall resource-use efficiency ^[7]. The inclusion of soybean in crop rotations and intercropping systems contributes to better nutrient cycling, reduced pest and disease incidence, and improved

soil physical properties. Moreover, soybean serves as an excellent component in diversified cropping systems because of its relatively short duration and compatibility with a wide range of companion crops [8].

In Karnataka, particularly in the North-Eastern districts of Bidar and Kalaburagi, soybean cultivation has expanded significantly over the past few decades. The region possesses favorable agro-climatic conditions, including suitable rainfall patterns, temperature regimes, soil characteristics, and sunshine duration, which support successful soybean production [9]. Farmers in these districts have increasingly adopted soybean-based cropping systems due to their economic viability and adaptability to rainfed conditions. Common soybean-based systems include soybean–chickpea, soybean–safflower, soybean–wheat, soybean–sorghum, and soybean + redgram intercropping systems, each offering varying levels of productivity and profitability [10].

The sustainability of agricultural production depends largely on the efficient utilization of natural resources while maintaining environmental quality and farm profitability. Soybean-based cropping systems contribute to sustainable agriculture by improving soil fertility, enhancing water-use efficiency, reducing dependence on synthetic nitrogen fertilizers, and providing diversified income sources to farming households [11]. Furthermore, diversified cropping systems help mitigate production risks associated with climate variability, market fluctuations, and pest outbreaks, thereby improving the resilience of farming systems [12].

Given the increasing need for sustainable intensification of agriculture, evaluating the economic performance and resource-use efficiency of soybean-based cropping systems has become essential. Understanding the profitability and sustainability of different cropping combinations can provide valuable insights for policymakers, researchers, and farmers seeking to optimize agricultural production and improve rural livelihoods. Therefore, the present study focuses on soybean-based cropping systems in North-Eastern Karnataka, with particular emphasis on their economic viability, resource-use efficiency, and contribution to sustainable agricultural development. The findings are expected to support informed decision-making and promote the adoption of economically efficient and environmentally sustainable cropping systems in the region [13].

Comparative Economics of Soybean-Based Cropping Systems

The comparative economics of different soybean-based cropping systems practiced in the study area were evaluated in terms of total cost of cultivation, gross returns, net returns, and returns per rupee of expenditure. The results are presented in Table 2 and Figure 1.

The analysis revealed substantial variations in the cost and profitability of the selected cropping systems. Among all the cropping systems, the highest total cost of cultivation was incurred in Cropping System-I (Soybean + Redgram), amounting to ₹45,177.65 per hectare, whereas the lowest

total cost was recorded in Cropping System-IV (Sole Soybean) at ₹26,513.30 per hectare. The higher cost in the soybean + redgram system was mainly attributed to increased expenditure on labor, seed, fertilizers, intercultural operations, and crop management practices required for intercropping.

The share of variable costs in total cultivation costs was highest in CS-I (65.54%), followed by CS-IV (58.01%), CS-III (57.31%), and CS-II (57.05%). In contrast, the proportion of fixed costs was relatively higher in CS-II (38.46%) compared to the other cropping systems. Family labor also contributed significantly to cultivation expenses, with the highest family labor cost observed in CS-I (₹1,624.75 per hectare) and the lowest in CS-IV (₹1,161.60 per hectare).

Gross returns varied considerably across the cropping systems. The soybean + redgram intercropping system (CS-I) generated the highest gross returns of ₹99,620.80 per hectare, followed by soybean + jowar (CS-II) with ₹67,673.60 per hectare, soybean + bajra (CS-III) with ₹49,345.10 per hectare, and sole soybean cultivation (CS-IV) with ₹40,016.40 per hectare. The superior gross returns obtained from CS-I may be attributed to higher overall productivity and better market value of redgram combined with soybean.

Net returns over total cost followed a similar trend. The highest net return was realized from CS-I (₹54,443.20 per hectare), followed by CS-II (₹34,108.27 per hectare), CS-III (₹21,047.30 per hectare), and CS-IV (₹13,503.10 per hectare). These findings indicate that soybean-based intercropping systems generated significantly higher profits than sole soybean cultivation. The additional income obtained from companion crops enhanced overall farm profitability and reduced the risks associated with dependence on a single crop.

The return per rupee of expenditure was also highest in CS-I, with a benefit-cost ratio of 2.21, indicating that every rupee invested generated a return of ₹2.21. Conversely, the lowest return per rupee invested was observed in CS-IV. The superior economic performance of the soybean + redgram system can be attributed to the complementary utilization of available resources, improved land-use efficiency, and favorable agro-climatic conditions for both component crops.

Overall, the results clearly demonstrate that the soybean + redgram cropping system was the most economically viable and profitable among the systems studied. The prevailing climatic conditions, soil characteristics, and market opportunities in the study area were highly conducive to the cultivation of both soybean and redgram. Therefore, farmers may be encouraged to allocate a larger proportion of their cultivated area to this cropping combination to enhance farm income and improve economic sustainability. Similar findings were reported by Kumara *et al.* (2012), who observed higher profitability and resource-use efficiency in diversified cropping systems compared with monocropping systems in the Northern Transition Zone of Karnataka.

Table 1: Socio-economic characteristics of sample respondents in the study area (N=160)

Sl. no.	Particulars	Units	Cropping Systems				
			CS-I	CS-II	CS-III	CS-IV	Overall
1	Average age	Yrs	43	45	41	44	43
2	Family size						
	i. Male	Nos	1.75 (22.79)	1.62 (23.34)	1.58 (23.69)	1.72 (26.83)	1.67 (24.10)
	ii. Female	Nos	1.68 (21.88)	1.64 (23.63)	1.55 (23.24)	1.67 (26.05)	1.64 (23.67)
	iii. Children	Nos	4.25 (55.34)	3.68 (53.03)	3.54 (53.07)	3.02 (47.11)	3.62 (53.23)
	Total	Nos	7.68	6.94	6.67	6.41	6.93
3	Engaged in agriculture						
	a. Male	Nos	1.67 (53.35)	1.20 (48.97)	1.35 (50.75)	1.02 (49.75)	1.31 (50.97)
	b. Female	Nos	1.46 (46.65)	1.25 (51.02)	1.31 (49.24)	1.03 (50.24)	1.26 (49.02)
	Total	Nos	3.13	2.45	2.66	2.05	2.57
4	Education level						
	a. Illiterate	Nos	10 (25.00)	12 (30.00)	10 (25.00)	12 (30.00)	44 (27.50)
	b. Primary	Nos	09 (22.50)	10 (25.00)	08 (20.00)	10 (25.00)	37 (23.12)
	c. High school	Nos	10 (25.00)	08 (20.00)	12 (30.00)	07 (17.50)	37 (23.12)
	d. PUC and above	Nos	11 (27.50)	10 (25.00)	10 (25.00)	11 (27.50)	42 (26.25)
	Total		40	40	40	40	160
5	Average size of holding						
	i. Rainfed	Ha	6.65 (83.75)	6.15 (85.42)	4.85 (75.20)	5.55 (92.04)	5.80 (84.06)
	ii. Irrigated	Ha	1.29 (16.25)	1.05 (14.58)	1.60 (24.80)	0.48 (7.96)	1.10 (15.94)
	Total	Ha	7.94	7.20	6.45	6.03	6.90

Note: Figures in parentheses indicate percentage to respective total

CS-I = Soybean + Redgram

CS-II = Soybean + Jowar

CS-III = Soybean + Bajra

CS-IV = Soybean sole crop

3.2 Comparative Economics of Soybean-Based Cropping Systems

The economic performance of the soybean-based cropping systems practiced in the study area was assessed by estimating the total cost of cultivation, gross returns, net returns, and returns per rupee of expenditure. The results are presented in Table 2 and Figure 1.

Among the different cropping systems, the highest total cost of cultivation was incurred in Cropping System-I (Soybean + Redgram), amounting to ₹45,177.65 per hectare, while the lowest cost was observed in Cropping System-IV (Sole Soybean) at ₹26,513.30 per hectare. The higher cultivation cost in the soybean + redgram system was primarily due to greater expenditure on labor, seed, fertilizers, plant protection measures, and intercultural operations. Variable costs constituted the major share of total costs across all cropping systems. The proportion of variable costs was highest in CS-I (65.54%), followed by CS-IV (58.01%), CS-III (57.31%), and CS-II (57.05%). In contrast, the share of fixed costs was relatively higher in CS-II (38.46%), indicating a greater contribution of fixed resources to the total production cost.

The gross returns realized from different soybean-based cropping systems showed considerable variation. The

highest gross returns were obtained from CS-I (₹99,620.80 per hectare), followed by CS-II (₹67,673.60 per hectare), CS-III (₹49,345.10 per hectare), and CS-IV (₹40,016.40 per hectare). The superior performance of the soybean + redgram intercropping system may be attributed to higher biological productivity and better market value of the component crops. Family labor cost was also highest in CS-I (₹1,624.75 per hectare) and lowest in CS-IV (₹1,161.60 per hectare), reflecting the relatively higher labor requirements of diversified cropping systems.

Net returns provide a more realistic measure of profitability by accounting for production costs. The results indicated that CS-I generated the highest net returns over total cost, amounting to ₹54,443.20 per hectare. This was followed by CS-II (₹34,108.27 per hectare), CS-III (₹21,047.30 per hectare), and CS-IV (₹13,503.10 per hectare). The substantially higher net income from CS-I highlights the economic advantage of soybean-redgram intercropping over sole cropping and other cropping combinations.

Similarly, the return per rupee invested was highest in CS-I, with a benefit-cost ratio of 2.21, indicating that every rupee spent on cultivation generated a return of ₹2.21. The lowest return per rupee of expenditure was recorded in CS-IV, suggesting comparatively lower profitability of sole soybean

cultivation. The higher profitability of CS-I may be attributed to efficient utilization of available resources, complementary interactions between soybean and redgram, and favorable agro-climatic conditions prevailing in the study area.

Overall, the findings clearly indicate that the soybean + redgram cropping system was the most profitable and economically viable among the soybean-based cropping systems evaluated. The climatic conditions, rainfall pattern, and soil characteristics of North-Eastern Karnataka are

highly suitable for the cultivation of both soybean and redgram, resulting in higher productivity and profitability. Therefore, farmers may be encouraged to expand the area under soybean + redgram intercropping to enhance farm income, improve resource-use efficiency, and achieve greater economic sustainability. Similar observations were reported by Kumara *et al.* (2012), who found that diversified cropping systems generated higher returns and improved economic efficiency compared to monocropping systems in the Northern Transition Zone of Karnataka.

Table 2: Comparative economics of Soybean based cropping system followed in the study area (₹/ha)

Sl. No.	Particulars	CS-I Soybean + Redgram	CS-II soybean + jowar	CS-III soybean+bajra	CS-IV sole soybean
1	Total Variable Cost	29607.50 (65.54)	19151.80 (57.05)	16219.7 (57.31)	15381.50 (58.01)
2	Total Fixed Cost	13945.40 (30.87)	12909.70 (38.46)	10767.8 (38.05)	9970.26 (37.60)
3	Family Labour Cost	1624.75 (3.60)	1504 (4.48)	1310.34 (4.64)	1161.60 (4.39)
4	Total Cost	45177.60 (100.00)	33565.40 (100.00)	28297.80 (100.00)	26513.30 (100.00)
5	Gross Returns	99620.80	67673.6	49345.1	40016.4
6	Net Returns	54443.20	34108.2	21047.3	13503.1
7	Returns per rupee spent	2.21	2.02	1.74	1.51

Note: CS-I= Soybean + Redgram

CS-II= Soybean + Jowar

CS-III= Soybean + Bajra

CS-IV= Soybean sole crop

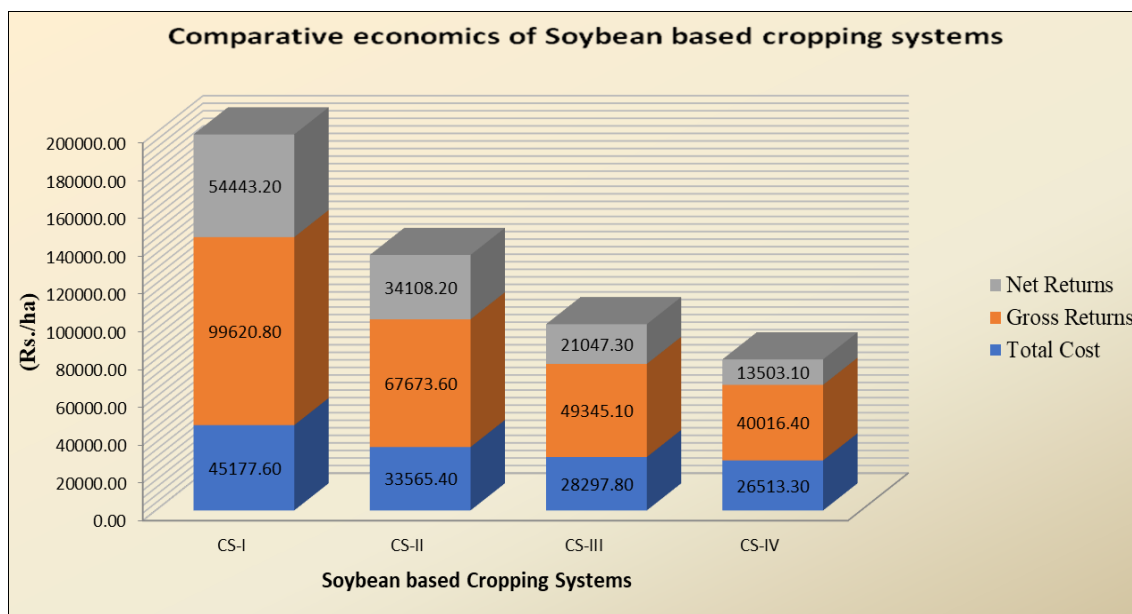


Fig 1: Comparative economics of Soybean based cropping system

Conclusion

Among the various soybean-based cropping systems practiced in the study area, CS-I (soybean + redgram) occupied the largest area, covering 142.80 ha, followed closely by CS-IV (sole soybean) with 140.00 ha. The other cropping systems included CS-II (soybean + jowar) with 57.20 ha and CS-III (soybean + bajra) with 15.20 ha. Thus, the predominant soybean-based cropping systems observed in the region were soybean + redgram, soybean + jowar, soybean + bajra, and sole soybean cultivation.

The economic analysis revealed that CS-I (soybean +

redgram) generated the highest gross returns compared to CS-II, CS-III, and CS-IV. A similar trend was observed in terms of net returns, where CS-I recorded the maximum profitability, followed by CS-II, CS-III, and CS-IV, respectively. Furthermore, the returns per rupee of investment were also highest under CS-I, indicating superior economic efficiency relative to the other cropping systems. These findings suggest that the soybean + redgram cropping system (CS-I) is economically more advantageous in the study area. Therefore, promoting and adopting this cropping system could enhance farmers' income and improve the

overall profitability of soybean-based farming systems in the region.

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