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Research article

Optimizing cowpea (*Vigna unguiculata* (L.) Walp) for economic prosperity: A strategic approach to amplify agricultural revenue in Karnataka

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Abstract

Cowpea, a versatile crop, serves as both a nutritious vegetable and valuable fodder, excels in water-limited and soil-deficient environments, and aligns with 'Sustainable Development Goals' (SDGs) 2, 3, and 13. Despite Karnataka's renowned output, cowpea production encounters obstacles and is deemed non-profitable. This study analyzes its growth, forecasts seed demand and resource-use-efficiency and evaluates economics in the region. Primary data was gathered from 125 farmers from five key districts through a field survey conducted in 2022. The study utilized the compound annual growth rate, cost-returns method, and Cobb-Douglass production function for data analysis. Findings reveal an annual declining trend of 3.26% in cowpea cultivation in Karnataka. The projected cultivated area for cowpeas in 2023-24 is 59,271 hectares, requiring a supply of 14,818 quintals of seeds over the specified period. The total cost of cultivation was estimated at Rs 39,510 per hectare. The study demonstrates that cowpea production yields promising net and gross returns per hectare (Rs 1,16,245 and Rs 1,55,755, respectively) with a benefit-cost ratio of 3.94, indicating a potential for doubling farm income. The investigation also demonstrated a noteworthy positive effect on cowpea income resulting from the utilization of resources during the production process, including chemicals, manures, fertilizers, and machinery. The main barriers to the cowpea industry are high labor costs and input expenses.

Keywords: Area, Cowpea, Fodder, Profit, Vegetable

Introduction

The global population is projected to increase by 70% by 2050, posing significant challenges in ensuring an adequate supply of food and fodder (Omomowo and Babalola, 2021). Legumes including cowpea [*Vigna unguiculata* (L.) Walp], plays a crucial role in achieving sustainable nutrition goals by providing essential nutrients, particularly affordable protein (Padhi *et al*., 2022; Mohare, 2022). Cowpea is a versatile crop cultivated for its dual purpose as a nutritious vegetable and a valuable fodder crop, making it significant in both the culinary and fodder sectors. This resilient legume thrives in water-limited and soil-deficient environments, with its high protein content, low carbon footprint, short growth period, and productivity in marginal areas aligning with Sustainable Development Goals, namely SDGs 2, 3, and 13. In India, cowpea is a minor pulse crop grown primarily in arid and semi-arid plains, covering approximately 3.9 million hectares and yielding 2.21 million tonnes annually (Giridhar *et al*., 2020). The tender pods of the cowpea plant, commonly known as 'cowpea beans' or 'black-eyed peas,' are consumed as a vegetable, while the crop is extensively cultivated as fodder due to its excellent forage quality. Cowpea's rapid growth ensures a consistent supply of fodder, and its leaves, stems, and pods are rich in protein and other essential nutrients, making it an ideal choice for livestock feed (Birla *et al*., 2018). Additionally, cowpea exhibits the unique ability to fix atmospheric nitrogen, converting it into a form usable by the plant and neighboring crops (Agyeman *et al*., 2015). Despite being one of the leading global producers of cowpea, India has witnessed a significant decline in its cultivation across various states (Vaibhav, 2022). Cowpea cultivation offers an economical alternative to costly commercial feed options, reducing dependence on expensive feed supplements and concentrate feeds and thereby lowering production costs. This cost minimization gives an opportunity to double farm income. Karnataka, with its diverse agro-climatic conditions, holds a prominent position in cowpea cultivation. Farmers in the state embrace cowpea as both a *kharif* and *rabi* crop due to its adaptability to arid and semi-arid regions with minimal water requirements.

As input costs rise and arable land becomes scarce (Ayana *et al.,* 2013), enhancing crop productivity on the available land is essential to meet the increasing demand for food and animal feed resources (Manjunatha *et al*., 2016). An understanding of the area growth pattern and seed demand is crucial, along with considering cost-return structures and constraints. Therefore, this study aims to analyze the growth of cowpea cultivation, predict seed demand, evaluate profitability and resource use efficiency and identify challenges in cowpea production in Karnataka. The findings of this research will assist growers in making informed decisions regarding the management of issues specific to the study region. Moreover, the study will provide timely, valuable facts and data to planners, policymakers, and extension workers for better management decision-making toward enhancing the farmer's income, thereby providing timely and beneficial inputs to various stakeholders.

Materials and Methods

The study initiates with the design phase, outlining the methodological framework for site selection, data acquisition, and analytical procedures to fulfill the research objectives.

Study design and sampling: The study was conducted in Karnataka, a prominent state for cowpea cultivation for both food and fodder purposes. Five major cowpea-producing districts- Mysuru, Haasana, Mandya, Ballari, and Chamarajanagara were purposively selected based on their high production and area under cultivation. A total of 125 cowpea farmers (25 from each district) were randomly selected as respondents. Primary data were collected through structured interviews conducted during 2022, focusing on investment patterns and return structures. Secondary data on the area under cowpea cultivation from 2011-12 to 2022-23 were sourced from the Directorate of Economics and Statistics, Government of Karnataka.

Analytical techniques

Compound annual growth rate (CAGR): The study examined the expansion of cowpea cultivation area in Karnataka using an exponential model and calculating the Compound Annual Growth Rate (CAGR) (Ashoka *et al*., 2022a). The model was represented as:

$$Y_t = \beta_0 \beta_1 t U_t$$

where: Y_t = area under cowpea during the time period 't'; β_0 = Intercept; β_1 = Slope coefficient; t = Time in years (2010-11 to 2022-23); U_t = Stochastic term

The model parameters were estimated using ordinary least squares after applying a natural logarithmic transformation to the model:

$$Ln = LnY_t = ln\beta_0 + t ln\beta_1 + U_t$$

The CAGR was calculated using the expression:

$$CAGR = (antilog(ln\beta_1) - 1) \times 100$$

The rise in area under cowpea for the following year, 2023-24, was approximated by adding the previous year's actual area to the actual area times CAGR, i.e., the area under the crop in 2023-24 equals the area under the crop in 2022-23 + CAGR (area under cowpea in 2022-23). For example, the CAGR in the cowpea area was -3.26% each year, while the area of cowpea in Karnataka in the last year was 61,269 ha. The incremental area expansion for the following year (2023-24) will be 61,269 ha X -3.26 = -1997 ha (Ashoka *et al.,* 2019). As a result, the total area under cowpea in the next year is expected to be 61,269-1,997=59,271 hectares.

Seed demand estimation: The anticipated seed demand for cowpea in Karnataka's major districts was calculated using the estimated area under cowpea for 2023-24 and the per-hectare seed requirement of 25 kg/ha (Anonymous, 2014) as specified in the package of practices.

Cost-returns analysis: The cost of cowpea cultivation was estimated using the cost concepts prescribed by the Commission for Agricultural Costs and Prices (CACP) (Ashoka et al., 2022c). Gross returns were computed based on the market value of the main product and by-products. Net income was derived by subtracting Cost C3 from the gross returns. The benefit-cost ratio (B:C) was calculated by dividing gross returns by Cost C3. Return on Investment (ROI), representing the profitability of invested capital, was expressed as a percentage by dividing net returns by the total cost of cultivation. The CACP cost concepts employed are outlined below:

Cost A_1=Value of hired human labor + Value of machine power + Value of bullock power (hired + owned) + Value of seed (hired + owned) + Value of pesticides power (hired + owned) + Fertilizers + Manures (Hired + owned) + Depreciation on implements and farm building + Irrigation charges + Land revenue and taxes + Miscellaneous expenses + Interest on working capital

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

Cost B_1= Cost A_1+ Interest on value on owned capital (excluding land)
Cost B_2 = Cost B_1 + Rental value of owned land (less land revenue)
Cost C_1 = Cost B_1 + Imputed value of family labor
Cost C_2 = Cost B_2 + Imputed value of family labor
Cost C_3= Cost C_2 + 10% of cost C_2 (as managerial cost)

Resource use efficiency:

Cowpea crop resource usage efficiency was examined using a nonlinear Cobb-Douglas production model (Kumar et al. 2018). Below is a list of the variables and production function used:

$$Y = a.X_1b_1.X_2b_2.X_3b_3X_4b_4.X_5b_5.X_6b_6X_7b_7.X_8.U$$

With the aid of Microsoft Excel, this model was solved by taking the logarithm on both sides and converting the non-linear form to the linear form.

$$LogY = Loga + b_1LogX_1 + b_2LogX_2 + b_3LogX_3 + b_4LogX_4 + b_5LogX_5 + b_6LogX_6 + b_7LogX_7$$

where, Y= Income (Rs/ha), X_1 =Seeds used (kg/ha), X_2 =Chemicals used (lit/ha), X_3= Manures used (tons/ha), X_4=Fertilizers used (kg/ ha), X_5=Human labor used (mandays), X_6= Farm size (Ha), X_7=Machinery (Hours)

Results and Discussion

Growth in the area of cowpea in Karnataka: The CAGR of the cowpea area in Karnataka was calculated for the period from 2010-11 to 2022-23 (Table 1). Karnataka, known as one of the major cowpea-growing states, experienced a negative annual growth rate of 3.26%. Among the major districts, only Mandya and Ballari showed positive growth rates of 3.48 and 3.46% per year, respectively. The remaining districts, including Mysuru, Haasana, Chamarajanagara, and others, witnessed a decline in growth rate during the study period, with negative growth rates ranging from 3.15 to 5.86%. The findings indicate that farmers in these districts reduced cowpea cultivation area and shifted to other field crops due to lower prices in previous years, aligning with the results of a study by Ashoka *et al*. (2021a) on cluster bean cultivation in Karnataka. The projected incremental area for the following year (2023-24) varied across districts, with Mandya and Ballari showing an increase of 320 and 85 hectares, respectively. In contrast, Mysuru, Haasana, Chamarajanagara, and other districts experienced a decrease in the incremental area by 764, 413, 114, and 820 hectares, respectively. Overall, due to the negative growth rates, the total cowpea cultivation area in Karnataka is expected to decrease by 1,997 hectares. This trend aligns with the findings of Ashoka *et al*. (2021b) on black pepper cultivation. The projected area for cowpea cultivation in 2023-24 was estimated to be 59,271 hectares, fulfilling the seed requirement for the entire state.

Based on the expected seed demand for the 2023-24 period, Mysuru district was projected to have the highest demand for seeds, estimated at 5,866 quintals. Mandya followed it with a demand of 2,379 quintals, Haasana with 2,251 quintals, Ballari with 633 quintals, and Chamarajanagara with 469 quintals. The remaining districts would require a total of 3,294 quintals of seed. The higher anticipated cultivation area for cowpeas in Mysuru district in the subsequent year contributed to this increased seed demand. This finding aligns with the conclusions of Sindhuja (2020) and Ashoka et al. (2022b). The study emphasizes the importance of expanding the cowpea enterprise in the study area to meet the substantial demand, necessitating adequate seed production.

Input use pattern and cost of cultivation: Cowpea is primarily cultivated during the *Kharif* season in Karnataka, especially under rainfed conditions. Therefore, understanding the expenditure pattern and economic viability is crucial. A financial analysis of cowpea cultivation in the study area was conducted, and the cost and input utilization trends were examined

Table 1. Growth, area and seed demand estimation of cowpea in Karnataka, India

Districts	Area under cowpea in 2022-23 (ha)	CAGR (per cent) in area from 2011-12 to 2022-23	Increase / Decrease in area during 2023-24 (ha)	Estimated area in 2023-24 (ha)	Estimated demand for cowpea seed (quintal) during 2023-24
Mysuru	24,227	-3.15	-764	23,464	5,866
Haasana	9,418	-4.38	-413	9,005	2,251
Mandya	9,195	3.48	320	9,515	2379
Ballari	2,446	3.46	85	2,531	633
Chamarajanagara	19,88	-5.72	-114	1,874	469
Other districts	13995	-5.86	-820	13,175	3,294
Karnataka total	61,269	-3.26	-1,997	59,271	14,818

(Table 2). The average total cost (C3) per hectare was Rs 39,510. Labor cost accounted for the highest operational expense at Rs 10,660, followed by machinery cost at Rs 4,875. Cowpea cultivation requires significant manual labor, especially during critical activities such as sowing, weeding, and harvesting, which occur approximately 50 to 60 days after sowing. Similar expenditure patterns in cowpea cultivation have been observed by Saad *et al*. (2016). The cost of manures and fertilizers ranked third at Rs 4,754, followed by seed cost (Rs 2,632) and bullock power cost (Rs 2,280).

The value of seed, with a seed rate of 25 kg per hectare, emerged as the most significant variable resource in cowpea production. Notably, the seed cost of Rs 2,632 was approximately equivalent to the bullock power cost of Rs 2,280. Other minor expenses included irrigation charges (Rs 1,033), depreciation costs (Rs 470), and 7% annual interest on working capital (Rs 674). A similar investment pattern in cowpea farming was observed in Karnataka by Manjunatha *et al*. (2016) and Ningoji *et al*. (2020). Based on the comparison of various incurred expenses, Cost A_1 was determined to be Rs 29,714. Since no farmers leased land, Cost A_2 was equal to Cost A_1, and Cost B_1 and B_2 were ₹ 29,760 and Rs 33,918, respectively. Costs C_1 and C_2 were estimated at Rs 31,760 and Rs 35,918, respectively. When considering the entire cost of cultivation (including the farmer's managerial expenses), Cost C_3 was determined to be Rs 39,510.

Cost and returns structure: The cost and return structure of cowpea cultivation in the study area demonstrated its profitability (Table 3). The average yield of vegetable cowpea was 74.80 quintals per hectare, with an average wholesale cost of Rs 1,780 per quintal, reflecting remunerative prices in the previous year. The total cost of cultivation was Rs 39,510. The significantly higher gross return of Rs 1,55,755 resulted in a substantial net return of Rs 1,16,245, leading to a high benefit-cost ratio of 3.94. These findings are consistent with studies by Anonymous (2022), Rohit *et al*. (2013), and Vanitha *et al*. (2022). The returns on investment (ROI) for cowpea farming were found to be quite high at 294%. However, most farmers in the study area continue to employ conventional techniques, resulting in higher cultivation costs. Therefore, it is important to educate cowpea producers about improving their agricultural practices to lower cultivation costs and enhance yield and profitability to double the income. This finding is similar to Sakpal et al (2021) investigation of cowpea farming profitability in Maharashtra, India.

Resource use efficiency: Several production models were tested to analyze resource usage efficiency, but the Cobb-Douglas model stood out as the best match, primarily due to its high R-squared (R^2) value when compared to other models (Goni *et al.* 2013). Table 4 illustrates the application of this production model to evaluate resource usage efficiency in cowpea cultivation, with a focus on the significant level. The coefficient of multiple determinations (R_2) was found to be 0.70,

Table 2. Cost of cultivation and expenditure pattern of cowpea in Karnataka, India (Per ha)

Costs	Particulars	Amount (in Rs)
Cost A_1=	Value of hired human labor	10,660
	Value of machine power	4,875
	Value of bullock power (hired + owned)	2,280
	Value of seed (hired + owned)	2,632
	Value of pesticides power (hired + owned)	1680
	Fertilizers + Manures (Hired + owned)	4,754
	Depreciation on implements and farm building	470
	Irrigation charges	1,033
	Land revenue and taxes	76
	Miscellaneous expenses	581
	Interest on working capital	674
Cost A_2=	Cost A_1 + Rent paid for leased-in-land	29714
Cost B_1=	Cost A_1+ Interest on value on owned capital (Excluding land)	29,760
Cost B_2 =	Cost B_1 + Rental value of owned land (less land revenue)	33,918
Cost C_1 =	Cost B_1 + Imputed value of family labor	31760
Cost C_2 =	Cost B_2 + Imputed value of family labor	35,918
Cost C_3=	Cost C_2 + 10% of cost C_2	39,510

Table 3. Cost and returns structure of cowpea cultivation in Karnataka, India

Particulars	Units	Amount (in Rs)
Output of green cowpea	q/ha	74.8
Output of green fodder/ha	q/ha	133
Price of green cowpea	Rs /q	1,780
Price of green fodder per quintal	Rs /q	169
Gross returns	Rs /ha	1,55,755
Net Returns	Rs /ha	1,16,245
BC Ratio	-	3.94
Cost of production	Rs /q	425
Returns on investment	Per cent	294

Table 4. Regression coefficients of different production variables of cowpea

Input variable	Regression coefficients	Standard error	t-value
Seeds	-0.0235	0.1243	-0.1892
Chemicals	0.8877*	0.1355	6.5504
Manures	0.1156*	0.0393	2.9385
Fertilizers	0.7285*	0.1209	6.0223
Human Labor	0.0303	0.0884	0.3429
Farm size	-0.3710*	0.0378	-9.7953
Machinery	0.5377*	0.0845	6.3578
R^2	0.70		

* ($p < 0.05$)

indicating that 70% of the cowpea gross income was affected by the independent variables included in the model. The analysis revealed that the production process's utilization of resources, such as chemicals, manures, fertilizers, and machinery, had a substantial positive impact on cowpea income. On the other hand, the size of the farm had a significant negative impact on the income from cowpea production. This suggests that there is potential to expand the use of chemicals, manures, fertilizers, and machinery to double the farm's income from cowpea production.

Problems encountered by cowpea agripreneurs: Despite the profitability of cowpea cultivation for food and fodder, the industry faces various limitations, as indicated by the opinions of cowpea farmers surveyed (Table 5). Approximately 26.40% of agripreneurs identified paying higher labor wages due to labor scarcity during peak operations as a significant problem. Higher input costs due to rising prices were highlighted by 19.20% of respondents. Lack of technical instruction, especially regarding bio-agent seed treatment for pest and disease management, was identified as an important constraint by 15.83% of respondents. Market information deficiency, with price control by middlemen, was mentioned by 15% of farmers. The lack of resistant cultivars against pests, particularly *Helicoverpa armigera*, was reported as a severe problem by 12.50% of farmers. Furthermore, 8.80% of respondents emphasized the need for high-yielding cowpea varieties since it is grown for both vegetable and green fodder purposes. These findings are in line with Kaur *et al*. (2018), Gabriel *et al*. (2021), and Ashoka *et al*. (2020), who reported similar challenges in cowpea production.

Table 5. Constraints faced by the farmers in cowpea production in Karnataka, India

Particulars	No. of respondents	Percentage
Lack of availability of high-yielding varieties	11	8.80
Availability of irrigation water	5	4.00
Labor wages	33	26.40
High input cost	24	19.20
Less technical knowledge	19	15.83
Availability of market information	18	15.00
Lack of availability of pest resistant varieties	15	12.50
Total respondents	125	100

Conclusion

The CAGR of the cowpea cultivation area in Karnataka experienced a significant decline of -3.26% annually during the study period. To mitigate this decline and promote cowpea cultivation in the state, the Department of Animal Husbandry and Veterinary Services, Government of Karnataka, should consider providing input subsidies, including free high-quality seeds and fertilizers, as these inputs constitute a significant portion of the cultivation cost. Additionally, the announcement of a minimum support price (MSP) for cowpea would safeguard farmers from price fluctuations and incentivize them to expand their cowpea cultivation area. Increasing milk prices could further stimulate demand for fodder, indirectly contributing to the expansion of cowpea cultivation. Seed-producing companies in Karnataka would need to scale up their efforts to meet the demand for 14,818 quintals of cowpea seeds in the upcoming year (2023-24). Cowpea cultivation proves to be a lucrative venture, particularly in dryland areas, with a high net return of Rs 1,16,245 per hectare, making it a viable option for doubling farmer's income. For small farmers, cowpea cultivation during the Kharif season offers advantages, as it can be harvested as early as 55 days. According to the majority of respondents, lower input prices would incentivize farmers to expand their cultivation area.

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