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Sachin Kumar
 Subject Matter Specialist
 (Plant Protection -
 Entomology), Krishi Vigyan
 Kendra, Veer Chandra Singh
 Garhwali Uttarakhand
 University of Horticulture and
 Forestry, Ranichauri, Tehri
 Garhwal, Uttarakhand, India

Vikas Singh Sengar
 Assistant Professor,
 Agricultural Economics,
 College of Hill Agriculture,
 Veer Chandra Singh Garhwali
 Uttarakhand University of
 Horticulture and Forestry,
 Ranichauri, Tehri Garhwal,
 Uttarakhand, India

Corresponding Author:
Vikas Singh Sengar
 Assistant Professor,
 Agricultural Economics,
 College of Hill Agriculture,
 Veer Chandra Singh Garhwali
 Uttarakhand University of
 Horticulture and Forestry,
 Ranichauri, Tehri Garhwal,
 Uttarakhand, India

Economic analysis of potato cultivation in ballia district of Uttar Pradesh, India

Sachin Kumar and Vikas Singh Sengar

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Abstract

Potato (*Solanum tuberosum* L.) is an essential commercial vegetable crop and contributes significantly in farm income, employment generation and diversification of agricultural production. The present study was conducted to estimate the cost of cultivation, returns and economic efficiency of potato production across different farm-size categories in Ballia district of Uttar Pradesh. A four-stage multistage sampling technique was adopted for the selection of the district, blocks, villages and sample farmers. Two blocks, namely Murlichhapra and Bairia, and eight villages were selected for the study. A total of 160 potato-growing farmers, comprising 40 each from marginal, small, medium and large farm-size groups, were selected through simple random sampling. Primary data were collected through personal interviews using a pre-tested interview schedule for the agricultural year 2024-25. Tabular analysis averages and percentages were used for estimation and interpretation. The standard cost concepts of the Commission for Agricultural Costs and Prices (CACP) were used for estimating Cost A1/A2, Cost B1, Cost B2, Cost C1, Cost C2 and Cost C3. The results revealed that the overall average cost of cultivation at Cost C3 was ₹109,425.81/ha, increasing from ₹97,852.80 on marginal farms to ₹122,148.02/ha on large farms. Potato seed constituted the largest individual cost component (22.72%), followed by rental value of land (20.56%) and human labour (18.73%). The overall average potato yield was 236.51 q/ha, with yield increasing from 225.35 q/ha on marginal farms to 248.30 q/ha on large farms. The overall gross income was ₹248,335.50/ha, while net return over Cost C3 was ₹138,909.69/ha. The overall input-output ratio on Cost C3 was 1:2.27, indicating that potato cultivation generated positive returns over the comprehensive cost of cultivation. The findings suggest that efficient management of seed, labour, irrigation, fertilizer and machinery costs, together with improved productivity and market access, can further strengthen the economic performance of potato cultivation in the study area.

Keywords: Potato cost of cultivation, Cost C3, gross income, net return, input-output ratio, farm size, Ballia, Uttar Pradesh

Introduction

Potato (*Solanum tuberosum* L.) is one of the most important food and commercial crops cultivated in India. Besides contributing to food and nutritional security, potato provides cash income and employment opportunities to farm households because of its relatively intensive input use and short production cycle. The crop has an important place in the agricultural economy of northern and eastern India, where favourable agro-climatic conditions and established marketing systems support commercial production. The economics of potato cultivation is strongly influenced by the prices of seed, labour, fertilizers, irrigation, machinery and plant-protection inputs. Since potato production requires substantial expenditure on seed and other variable inputs, estimation of cost and returns is essential for assessing the economic performance of the crop. Recent studies have reported substantial variation in potato production costs and profitability across regions and farm-size groups. Kumar *et al.* (2022) ^[4, 8], reported an overall cost of cultivation of ₹82,560.79/ha and a net income of ₹88,993.96/ha in Sultanpur district of Uttar Pradesh, with an input-output ratio of 1:2.08. Similarly, Yadav *et al.* (2024) ^[15], reported a Cost C3 of ₹78,154.62/ha and positive net income in Azamgarh district of eastern Uttar Pradesh. Studies from other potato-growing

regions also demonstrate the economic importance of the crop. Raj Kumar et al. (2020) [1]. reported a total cost of ₹179,449/ha, gross return of ₹274,944/ha and net return of ₹95,495/ha in Kurukshetra, Haryana. Studies on potato production have further shown that seed, labour, fertilizers and land-related costs constitute major components of total cultivation expenditure (Yadav *et al.*, 2020; Kumar *et al.*, 2022; Shakya *et al.*, 2024) [2, 4, 8, 16]. Farm size can also influence input-use intensity, productivity and profitability. Recent research from Uttar Pradesh has reported increasing cultivation costs with farm size in some locations, while productivity and economic efficiency may vary according to input management and access to resources (Kumar *et al.*, 2024; Kumar *et al.*, 2025) [17, 21]. Similarly, studies on potato production in other parts of India have demonstrated the importance of production technology, irrigation, planting geometry and nutrient management in determining yield and economic returns (Kumar *et al.*, 2023; Singh *et al.*, 2024) [10, 19]. In view above facts in mind, the present study was conducted entitled, “Economic Analysis of Potato Cultivation in Ballia District of Uttar Pradesh, India”.

Research Methodology Sampling procedure

A four-stage multistage sampling technique was employed for the selection of the study area and sample respondents. In the first stage, Ballia district of Uttar Pradesh was selected for the study. In the second stage, two blocks, namely Murlichhapra and Bairia, were selected. In the third stage, eight villages—Sonbarsa, Bhojpur, Lakshimpur, Dalan Chhapara, Upadhyapur, Chakiya Jamalpur, Madhubani and Karmanpur—were selected randomly from the selected blocks (table-1). In fourth stage, a comprehensive list of vegetable-growing farmers was prepared for each selected village. The farmers were classified into four groups according to operational landholding size: marginal farmers (<1 ha), small farmers (1-2 ha), medium farmers (2-4 ha) and large farmers (>4 ha). Five farmers from each farm-size category were selected randomly from each village, resulting in a total sample of 160 farmers, with 40 respondents in each farm-size category (table-2).

Table 1: Selection of District, blocks and villages in the study area

S. No.	Particulars	Selection of study area	Technique
1.	District	Ballia	Purposive
2.	Blocks	Murlichhapra and Bairia	Purposive
3.	Villages	Sonbarsa, Bhojpur, Lakshimpur, Dalan chhapara, Upadhyapur, Chakiya Jamalpur, Madhubani, and Karmanpur	Random

Table 2: Selection of Farmers

Sl. No.	Village	Size of Holding								Total	
		Marginal farmers (< 1 ha)		Small farmers (1-2 ha)		Medium farmers (2-4 ha)		Large farmers (> 4 ha)			
		T	S	T	S	T	S	T	S	T	S
1	Sonbarsa	216	5	187	5	168	5	79	5	650	20
2	Bhojpur	115	5	93	5	75	5	39	5	322	20
3	Lakshimpur	55	5	49	5	30	5	22	5	156	20
4	Dalan chhapara	184	5	169	5	155	5	84	5	592	20
5	Upadhyapur	116	5	119	5	92	5	52	5	379	20
6	Chakiya Jamalpur	35	5	47	5	38	5	25	5	145	20
7	Madhubani	76	5	64	5	48	5	43	5	231	20
8	Karmanpur	127	5	125	5	113	5	72	5	437	20
Total		924	40	853	40	719	40	416	40	2912	160

Note: T= Total Farmers, S= Selected Farmers

Data collection

Primary data were collected directly from the selected farmers through personal interviews using a pre-structured and pre-tested interview schedule. The data pertained to the agricultural year 2024-25. Secondary information was collected from government publications, agricultural reports, research journals, books, research papers and other relevant official sources.

Analytical tools

For estimating the cost and returns of potato cultivation, tabular analysis, simple averages and percentages were employed. The standard cost concepts used in agricultural economics were adopted for systematic estimation of different levels of cost. The Government of India's Directorate of Economics and Statistics conducts comprehensive cost-of-cultivation studies, and CACP uses such cost estimates in its agricultural price-policy framework. Simple Average (Arithmetic Mean)

$$\text{Arithmetic Mean} = \frac{\sum X}{N}$$

Where,

$\sum X$ = Sum of all observations

N = Number of observations

Percentage

$$\text{Percentage} = \frac{\text{Part}}{\text{Total}} \times 100$$

Where,

Part = Value of a specific item

Total = Overall total value

CACP cost concepts

The following cost concepts were used:

Cost A1/A2: Actual paid-out costs incurred in potato cultivation, including hired labour, machinery charges, seed, manure and fertilizers, irrigation, plant protection and interest on working capital. Where applicable, rent paid for leased-in land is incorporated in Cost A2.

Cost B1: Cost A1/A2 plus interest on owned fixed capital excluding land.

Cost B2: Cost B1 plus rental value of owned land.

Cost C1: Cost B1 plus imputed value of family labour.

Cost C2: Cost B2 plus imputed value of family labour.

Cost C3: Cost C2 plus 10 per cent of Cost C2 as managerial cost.

The CACP framework recognizes the importance of paid-out costs, family labour, rental value of owned land and interest on fixed capital in comprehensive cost estimation.

Income measures

The following income measures were estimated:

Gross income = Total value of potato output

Net return over Cost C3 = Gross income - Cost C3

Farm business income = Gross income - Cost A1/A2

Family labour income = Gross income - Cost B2

Cost of production = Total cost ÷ total physical output

Input-output ratio = Gross income ÷ corresponding cost

Results and Discussion

Per-hectare cost of different inputs used in potato cultivation

The per-hectare cost structure of potato cultivation is presented in Table 1. The results show that the overall average Cost C3 was ₹109,425.81/ha. The cost increased progressively with farm size, from ₹97,852.80/ha on marginal farms to ₹105,370.40/ha on small farms, ₹112,533.45/ha on medium farms and ₹122,148.02/ha on large farms (table-3). The increasing total cost with farm size indicates greater expenditure on purchased inputs, labour, machinery and other production resources on larger farms. Similar increases in cultivation expenditure with farm size have been reported in recent potato studies from Uttar Pradesh (Kumar *et al.*, 2024; Kumar *et al.*, 2025) [17, 21].

Among the individual cost components, potato seed constituted the largest expenditure, accounting for 22.72 per cent of the overall Cost C3. The average expenditure on seed was ₹24,862.50/ha. Seed expenditure increased from ₹21,250/ha on marginal farms to ₹29,750/ha on large farms (table-3). The importance of seed as a major cost component in potato cultivation has also been reported in other Indian studies (Raj Kumar *et al.*, 2020; Kumar *et al.*, 2022) [1, 4, 8].

The second major cost component was human labour, which accounted for 18.73 per cent of total Cost C3, with an overall expenditure of ₹20,497.56/ha. Human labour expenditure increased from ₹17,492.62/ha on marginal farms to ₹23,043.71/ha on large farms. Within human labour, family labour accounted for ₹6,642.90/ha, while hired labour accounted for ₹13,854.66/ha (table-3). The increasing share of hired labour with farm size indicates greater dependence of larger farms on purchased labour.

The rental value of land constituted 20.56 per cent of the total cost, amounting to ₹22,500/ha across all farm-size groups. This indicates that land-related opportunity cost represented a substantial component of the comprehensive cost of potato cultivation. Manure and fertilizer expenditure accounted for 11.58 per cent of the total cost, with an overall average of ₹12,670.15/ha. The expenditure increased from ₹11,750.90/ha on marginal farms to ₹13,970.45/ha on large farms (table-3). Recent studies have also identified fertilizers and manures as important contributors to potato production cost and productivity (Yadav *et al.*, 2020; Kumar *et al.*, 2024) [2, 17]. Machinery and tractor charges accounted

for 6.48 per cent, while irrigation accounted for 6.09 per cent of total Cost C3. Plant-protection expenditure was comparatively smaller, accounting for 3.39 per cent. The pattern indicates that seed, land, labour and nutrient management together represented the major components of potato production expenditure. The total working capital averaged ₹68,855.43/ha, representing 62.92 per cent of total Cost C3. The proportion of working capital increased from 57.39 per cent on marginal farms to 67.36 per cent on large farms. Interest on working capital was ₹1,377.11/ha at the overall level.

The findings broadly correspond with recent potato cost studies. For example, Kumar *et al.* (2022) [4, 8], reported seed and labour as major components of potato production expenditure in Sultanpur, while Shakya *et al.* (2024) [16], observed that cultivation costs increased with farm size in Farrukhabad.

Cost concepts of potato cultivation

The different CACP cost concepts are presented in Table 2. The overall Cost A1/A2 was ₹70,232.54/ha, increasing from ₹57,281.16/ha on marginal farms to ₹83,926.13/ha on large farms. Cost B1 was ₹70,335.11/ha at the overall level, while Cost B2 increased to ₹92,835.11/ha due to the addition of rental value of owned land. Cost C1 was ₹76,978.01/ha and Cost C2 was ₹99,478.01/ha at the overall level. After adding 10 per cent managerial cost, Cost C3 increased to ₹109,425.81/ha (Table-4). The increase from Cost A1/A2 to Cost C3 demonstrates the effect of incorporating family labour, owned land and fixed-capital costs into the comprehensive economic cost of potato cultivation. This approach is consistent with the cost-estimation framework used in Indian agricultural economics and CACP cost studies. The increasing Cost C3 across farm-size groups—from ₹97,852.80/ha on marginal farms to ₹122,148.02/ha on large farms—suggests greater absolute expenditure on production resources on larger farms (table-4). However, the higher cost was accompanied by higher potato productivity, as discussed below.

Yield and gross income

The average potato yield was 236.51 q/ha. The yield increased consistently with farm size, from 225.35 q/ha on marginal farms to 232.50 q/ha on small farms, 239.87 q/ha on medium farms and 248.30 q/ha on large farms (table-4). The higher yield on larger farms may be associated with greater use of purchased inputs, machinery, hired labour and production resources. Similar relationships between input use and potato productivity have been reported in studies of potato production in Uttar Pradesh and other Indian regions (Yadav *et al.*, 2020; Kumar *et al.*, 2024) [17].

The overall gross income from potato cultivation was ₹248,335.50/ha. Gross income increased from ₹236,617.50/ha on marginal farms to ₹260,715.00/ha on large farms. The higher gross income on larger farms was primarily associated with higher physical productivity (table-4). Recent research has similarly reported positive gross returns from potato production under different production systems and regions (Raj Kumar *et al.*, 2020; Kumar *et al.*, 2025) [1, 21].

Net returns over Cost C3

The overall net return over Cost C3 was ₹138,909.69/ha. Farm-size-wise, net returns were ₹138,764.70/ha on

marginal farms, ₹138,754.60/ha on small farms, ₹139,330.05/ha on medium farms and ₹138,566.98/ha on large farms (table-4). Although the large farms incurred the highest total cost, their higher yield and gross income largely compensated for the higher expenditure. As a result, net returns remained relatively close across the four farm-size categories. The medium farm group recorded the highest net return in the present dataset. The positive net returns over Cost C3 indicate that potato cultivation generated returns above the comprehensive cost, including imputed family labour, rental value of land, interest on fixed capital and managerial cost. Comparable positive profitability has been reported for potato cultivation (Kumar *et al.*, 2022; Kumar *et al.*, 2025) ^[4, 8, 21].

Family income

The overall family income was ₹178,102.96/ha, based on the difference between gross income and Cost B2. The corresponding values were ₹156,555.81/ha for marginal farms, ₹155,791.38/ha for small farms, ₹177,818.16/ha for medium farms and ₹176,788.87/ha for large farms (table-4). The positive family income across all farm-size categories indicates that potato cultivation generated sufficient returns to cover paid-out costs, interest on owned fixed capital and rental value of land while also compensating family labour.

Farm business income

Farm business income represents the return available after deducting Cost A1/A2 from gross income. On the basis of the supplied Cost A1/A2 and gross-income figures, the farm business income was approximately ₹178,102.96/ha at the overall level (table-4). The positive farm business income indicates that potato cultivation generated substantial returns over the paid-out cost of production. This measure is particularly relevant for owner-operated farms because it reflects the return available to the farmer for management, family labour and owned resources after meeting actual cash and kind expenditure.

Farm investment income

Farm investment income represents the return remaining after accounting for Cost B1. Based on the supplied gross income and Cost B1 values, potato cultivation generated positive returns over Cost B1 in all farm-size categories (table-4). The positive investment return indicates that potato cultivation was capable of covering variable expenditure as well as interest on owned fixed capital. Similar positive economic performance has been reported in recent potato studies from Uttar Pradesh and other regions of India (Yadav *et al.*, 2024; Raina *et al.*, 2024) ^[15, 18].

Cost of production

The overall cost of production was ₹462.67/q. It increased from ₹434.23/q on marginal farms to ₹453.21/q on small farms, ₹469.14/q on medium farms and ₹491.94/q on large farms (table-4).

The increase in per-quintal cost with farm size indicates that the increase in production costs was proportionally greater than the increase in output. Therefore, although large farms recorded the highest yield, their per-unit production cost was also highest in the present study.

The importance of controlling per-unit production cost has been highlighted in recent potato economic studies, where variations in seed, labour and input expenditure have influenced profitability across farm categories (Kumar *et al.*, 2025; Darade *et al.*, 2025) ^[22].

Input-output ratio

The input-output ratio is an important indicator of the economic efficiency of potato cultivation. On the basis of Cost A1/A2, the overall input-output ratio was 1:3.54. It declined to 1:3.53 on Cost B1, 1:2.68 on Cost B2, 1:3.23 on Cost C1, 1:2.50 on Cost C2 and 1:2.27 on Cost C3. The Cost C3-based ratio of 1:2.27 means that an expenditure of ₹1 under the comprehensive cost of cultivation generated approximately ₹2.27 in gross income (table-4). The ratio remained above unity for all farm-size groups, indicating positive returns even after considering the comprehensive cost.

The Cost C3-based input-output ratios were 1:2.42, 1:2.32, 1:2.24 and 1:2.13 for marginal, small, medium and large farms, respectively. Thus, the ratio declined with increasing farm size, despite the increase in yield. This suggests that larger farms achieved greater physical productivity but incurred proportionately greater costs (table-4).

The overall profitability observed in the present study is comparable with recent findings from Uttar Pradesh. Kumar *et al.* (2022) ^[4], reported an input-output ratio of 1:2.08 in Sultanpur, while Kumar *et al.* (2025) ^[21], reported 1:1.96 in Kannauj. Positive economic returns have also been reported under improved potato production practices, nutrient management and planting configurations (Kumar *et al.*, 2023; Singh *et al.*, 2024; Chaurasiya *et al.*, 2023) ^[10, 14, 19].

Benefit-cost ratio

The B:C ratio under Cost C3 was 1:2.27 at the overall level. The corresponding ratios for marginal, small, medium and large farms were 1:2.42, 1:2.32, 1:2.24 and 1:2.13, respectively (table-4).

The ratio above unity across all farm-size groups indicates that potato cultivation generated gross returns greater than the comprehensive cost of production. The relatively higher ratio on marginal farms may be associated with their lower absolute cost of cultivation and substantial contribution of family labour, whereas the lower ratio on large farms reflects higher expenditure on hired labour, seed, machinery and other purchased inputs.

Comparable variations in profitability across farm sizes have been documented in potato studies. For example, Kumar *et al.* (2025) ^[21], reported an overall B:C ratio of 1:1.96 in Kannauj, whereas Darade *et al.* (2025) ^[22], reported a B:C ratio of 1.63 for chip-grade potato production in Pune.

Table 3: Per hectare costs of different inputs used in potato cultivation (Rs/ha)

Sl. No	Particulars	Size group of farm				Overall average
		Marginal (40)	Small (40)	Medium (40)	Large (40)	
1	Human Labour	17492.62 (17.88)	20221.3(19.19)	21232.53(18.87)	23043.71(18.86)	20497.56(18.73)
a	Family labour	8895.40 (09.09)	7457.65(07.08)	5668.55(05.04)	4550.00(03.72)	6642.90(06.07)
b	Hired labour	8597.22 (08.79)	12763.72(12.11)	15563.98(13.83)	18493.71(15.14)	13854.66(12.66)
2	Tractor charges/ machinery charges	5849.90 (05.98)	6784.80(06.44)	7579.54(06.74)	8167.45(06.69)	7095.42(06.48)
3	Potato tubers(seeds)	21250.00 (21.72)	22950.00(21.78)	25500.00(22.66)	29750.00(24.36)	24862.50(22.72)
4	Manure & fertilizer	11750.90 (12.01)	12005.55(11.39)	12953.70(11.51)	13970.45(11.44)	12670.15(11.58)
5	Irrigation	5655.50 (05.78)	6478.05(06.15)	6990.50(06.21)	7540.40(06.17)	6666.11(06.09)
6	Plant protection	3054.48 (03.12)	3407.60(03.23)	4005.75(03.56)	4358.51 (03.57)	3706.59(03.39)
7	Total working capital	56158.00 (57.39)	64389.72(61.11)	72593.47(64.51)	82280.52(67.36)	68855.43(62.92)
8	Interest on working capital	1123.16 (01.15)	1287.78(01.22)	1451.87(01.29)	1645.61(01.35)	1377.11(12.58)
9	Rental value of land	22500.00 (22.99)	22500.00(21.35)	22500.00(19.99)	22500.00(18.42)	22500.00(20.56)
10	Interest on fixed capital	280.53 (0.29)	156.12(0.15)	89.25(0.08)	67.52(0.06)	102.57(0.09)
11	Sub total	88957.09 (90.91)	95791.27(90.91)	102303.14(90.91)	111043.65(90.91)	99478.01(90.91)
12	Managerial cost @10 of sub total	8895.71 (09.09)	9579.13(09.09)	10230.31(09.09)	11104.37(09.09)	9947.80(09.09)
	Grand total	97852.80 (100)	105370.40(100)	112533.45(100)	122148.02(100)	109425.81(100)

Table 4: Measures of per-hectare cost and profits of potato (Rs)

Sl. No	Particulars	Size group of farm				Overall average
		Marginal(40)	Small (40)	Medium (40)	Large (40)	
1	Cost A ₁ /A ₂	57281.16	65677.50	74045.34	83926.13	70232.54
a	Cost B ₁	57561.69	65833.62	74134.59	83993.65	70335.11
b	Cost B ₂	80061.69	88333.62	96634.59	106493.65	92835.11
2	Cost C ₁	66457.09	73291.27	79803.14	88543.65	76978.01
3	Cost C ₂	88957.09	95791.27	102303.14	111043.65	99478.01
4	Cost C ₃	97852.80	105370.40	112533.45	122148.02	109425.81
5	Yield (q/ha)	225.35	232.50	239.87	248.30	236.51
6	Gross Income	236617.50	244125.00	251863.50	260715.00	248335.50
7	Net return over cost C ₃	138764.70	138754.60	139330.05	138566.98	138909.69
8	Family Income	156555.81	155791.38	177818.16	176788.87	178102.96
9	Farm business income	179336.34	178447.50	155228.91	154221.35	155500.39
10	Farm investment income	170440.94	170989.85	172149.61	172238.87	171460.06
11	Cost of production (q/ha)	434.23	453.21	469.14	491.94	462.67
12	Input-Output ratio					
a.	On the basis of cost Cost A ₁ /A ₂	1:4.13	1:3.72	1:3.40	1:3.11	1:3.54
b.	On the basis of cost B ₁	1:4.11	1:3.70	1:3.39	1:3.10	1:3.53
c.	On the basis of cost B ₂	1:2.96	1:2.76	1:2.61	1:2.45	1:2.68
d.	On the basis of cost C ₁	1:3.56	1:3.33	1:3.16	1:2.94	1:3.23
e.	On the basis of cost C ₂	1:2.66	1:2.55	1:2.46	1:2.35	1:2.50
f.	On the basis of cost C ₃	1:2.42	1:2.32	1:2.24	1:2.13	1:2.27
13	B:C Ratio	1:2.42	1:2.32	1:2.24	1:2.13	1:2.27

Summary

The present study examined the economics of potato cultivation in Ballia district of Uttar Pradesh using primary data collected from 160 potato-growing farmers during the agricultural year 2024-25. The respondents were selected through a four-stage multistage sampling procedure and categorized into marginal, small, medium and large farm-size groups. The analysis showed that the overall Cost C₃ of potato cultivation was ₹109,425.81/ha, with the lowest cost on marginal farms (₹97,852.80/ha) and the highest on large farms (₹122,148.02/ha). Potato seed was the largest individual cost component, accounting for 22.72 per cent of total cost, followed by rental value of land (20.56%) and human labour (18.73%).

The average potato yield was 236.51 q/ha, increasing from 225.35 q/ha on marginal farms to 248.30 q/ha on large farms. Gross income averaged ₹248,335.50/ha, while net return over Cost C₃ was ₹138,909.69/ha.

The overall cost of production was ₹462.67/q. The overall input-output ratio on Cost C₃ was 1:2.27, indicating positive economic returns after accounting for the comprehensive

cost of cultivation. The B:C ratio was highest on marginal farms (1:2.42) and lowest on large farms (1:2.13).

The findings demonstrate that potato cultivation was economically viable across all farm-size categories in the study area. However, increasing costs with farm size and the large contribution of seed, labour and land-related expenditure indicate the importance of improving input-use efficiency and productivity.

Conclusion

The study concludes that potato cultivation was an economically important and profitable enterprise among the sampled farmers of Ballia district. The crop generated positive net returns over the comprehensive Cost C₃ across all farm-size categories. The overall B:C ratio of 1:2.27 demonstrates that the gross value generated from potato cultivation was substantially higher than the comprehensive cost incurred.

Seed emerged as the most important individual variable cost, followed by human labour and land rental value. Therefore, improvement in the availability and affordability of quality seed, efficient labour management and better

utilization of land and machinery can contribute to reducing production costs.

The increasing yield with farm size indicates the importance of adequate resource availability and timely input application. However, the decline in the Cost C3-based input-output ratio from marginal to large farms suggests that simply increasing expenditure does not necessarily result in proportional increases in economic returns. Greater emphasis should therefore be placed on efficient rather than merely increased input use.

Improved irrigation management, balanced fertilizer application, mechanization, quality seed use, integrated plant protection and timely farm operations may help improve productivity and reduce per-unit production costs. Recent research also indicates that improved production practices, irrigation management, nutrient management and appropriate planting geometry can influence potato productivity and profitability (Singh *et al.*, 2023; Singh *et al.*, 2024; Kumar *et al.*, 2023) ^[10, 11, 19].

In addition, strengthening market linkages, collective marketing, storage and price-information systems can improve farmers' ability to obtain remunerative prices for potato. This is particularly important because price fluctuations and marketing constraints can influence the realized profitability of potato production (Sharma *et al.*, 2023; Mavi and Arora, 2023) ^[12, 13].

Overall, the results suggest that potato cultivation has considerable potential to contribute to farm income in Ballia district, provided that production costs, productivity and market-related risks are managed efficiently.

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