Journal of Agricultural Development and Policy, 2025
Volume 35, No. 1, 21-27
https://doi.org/10.63066/23220457.35.1.004

NAAS - 4.34
UGC CARE List Journal

Profitability Analysis of Maize Cultivation: A Strategic Approach to Reduce Dependence on Paddy in Punjab

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Abstract

The present study examines the profitability of maize cultivation in Punjab during 2022-24. The primary data collected from the sampled of 100 maize farmers from two blocks of Punjab. The results showed that per acre cost of cultivation for maize was Rs. 15590.390 and Rs.23462.66 for paddy. The gross returns and net returns over total cost were observed as higher in paddy (Rs.53406.17 and Rs. 29943.51, respectively) as compared to maize crop. The production function analysis showed that seed and labor were positively and significantly affects the maize and paddy production. The study suggests incentivizing maize cultivation through subsidies and assured procurement to promote crop diversification. Efficient resource use and policy support could enhance profitability and sustainability, reducing farmer's dependence on paddy and mitigating groundwater depletion.

Keywords: Maize, Paddy. Cost, Return, Production, Efficiency

JEL Classification: Q01 , Q12 , Q18, O13

Introduction

Agriculture plays a vital role in the Indian economy. It contributes about 19 per cent to the country's total gross domestic product of Rs. 43.62 lakh crore, provides jobs to over 60 per cent of rural households, and is the main source of livelihood for people in rural India (GoI, 2023). India is one of the largest producers of paddy in the world and the second-largest exporter of rice globally. The total area of 47.83 million hectares was under paddy cultivation in India with production of 135.75 million tonnes (FAO, 2023). In Punjab, area under paddy was 30.98 lakh hectares with production of 129.91 lakh tonnes of rice (Indiastat, 2023). Maize is the second most significant cereal crop worldwide and is sometimes referred to as the "Queen of Cereals." The world produced around 1040 million metric tonnes of maize, with the United States and China producing the most, at roughly 38 per cent and 23 per cent of the total. With a quantity of 26 million metric tonnes, India makes up around 2 per cent of this output. In India, maize farming employs around 650 million person-days at the agricultural and adjacent business ecosystem levels, with at least 15 million farmers cultivating the crop. Crucially, maize makes up more than 2 per cent of the entire value of the product produced by all agricultural crops (Chowti and Basavaraja, 2015). In India, the majority of maize is used for animal feed. Poultry feed, which accounts for about 47 per cent of global maize consumption, is the primary use and main driver of maize demand. Feed for livestock makes up 13 per cent, 20 per cent of maize is consumed through food, of which 13per cent is consumed directly and 7 per cent is consumed in the form of processed food (Yadav *et al,* 2016). Emphasizing the importance of agricultural diversification, it has been observed that Punjab has significant potential for cultivating a variety of high-value crops and related enterprises. Recently, the Punjab government submitted a diversification plan to the Union government, aiming to shift 1.2 million hectares of paddy land to other crops such as maize, cotton, sugarcane, agroforestry, pulses, fruits, and vegetables in the kharif season. For this purpose, the funds demanded by the state government from union government are worth about Rs.5000 crores (Kaur *et al,* 2015). Crop diversification in Punjab is a challenge as well as an opportunity. The challenge is that it appears to be a difficult task due to the public procurement of paddy and wheat and their relative profitability at current prices and productivity level, and the opportunities would be in generating employment and involving a number of additional stakeholders in the food-supply chain while maintaining at least current farm income level. Maize is one of the best alternate crops, as the profits in Maize-Potato-Wheat rotation come after Paddy-Potato-Wheat rotation (Kaur and Kaur, 2012). The main goal of farmers is to maximize profit by increasing output and reducing costs. Thus, resource use must

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be analyzed for efficient and sustainable maize production. Keeping these points in view the study was undertaken to determine resource use efficiency and profitability of maize production in Punjab.

Data Sources and Methodology

Selection of study area

The present study has been undertaken during 2022-2023 in Hoshiarpur districts of Punjab. In Punjab, area under maize was 115 thousand hectare and production was 410 thousand metric tones (India stat, 2022).

Selection of Sample

Multistage random sampling technique was used for the selection of study sample. At the first stage, two blocks (Garhshankar and Mahilpur) with maximum area under maize were selected for the present study. At the second stage, clusters of villages from each block were selected where concentration of maize as well as paddy growers was the highest. At the third stage, farmers were randomly selected from clusters of villages from each block. The maize growers were selected purposively who cultivated maize as seasonal crop and grow paddy as well. Hence, a total of 100 farmers were selected for the study.

Benefit cost ratio

Benefit cost analysis is used to determine the viability of cash flows generated from an investment. The benefit cost ratio compares the present value of all benefits generated from an investment to the present value of all costs.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns}}{\text{Total cost}}$$

Cobb-Douglas Production Function

The elasticity of inputs/factor used in the production of maize as well as paddy was worked out by fitting Cobb-Douglas production function (Charles Cobb and Paul Douglas, 1928). Cobb-Douglas production function was fitted on the basis of higher value of R^2, theoretical plausibility of sign and magnitude of parameter estimate and severity of multicollinearity. The following variables were used in order to determine the factors affecting the yields of maize and paddy.

$$Y = aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} u_i$$

Log-log equation

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + \log u_i$$

Y = Yield (qtl/acre)

X_1= Seeds (kg/acre)

X_2= Farm Yard Manure (kg/acre)

X_3= Fertilizers (kg/acre)

X_4= Plant Protection Chemicals (kg/acre)

X_5=Humanlabour (Mandays)

u_i= Error term

a = Intercept

b_1 to b_5 are the elasticity coefficients

Adjusted coefficient of multiple determination

Adjusted R^2 is a modified version of R^2 that has been adjusted for the number of predictors used in the model. Adjusted R^2 adjusts the statistic based on the number of independent variables in the model. That is the desired property of a goodness-of-fit statistic. The adjusted value of R^2 is calculated as follows (Gujarati *et al,* 2012).

$$\bar{R}^2 = 1 - (1 - R^2)\frac{n - 1}{n - k}$$

Where,

R^2=Coefficient of multiple determination, n=Number of sample observations

$\bar{k}$=Number of parameters estimated

$\bar{R}^2$=Adjusted R^2

Resource-use efficiency

To ensure maximum profit and efficiency of resources, a farmer must utilize resources at the level where their marginal value product (MVP) is equal to their marginal factor cost (MFC) under perfect competition (Tambo and Gbemu, 2010). The efficiency of a resource would be determined by the ratio of MVP of inputs (based on the estimated regression coefficients)and MFC.

$$r = \frac{\text{MVP}}{\text{MFC}}$$

$$\text{MVP}x_i = \left\{\beta_i \frac{\bar{y}}{\bar{x}_i}(P_y)\right\}$$

Here,

$MVPx_i$ = Marginal value product of the i^{th} input,

$\bar{y}$=Geometric mean of output

$\bar{x}_i$ = Geometric mean of input

β_i = Estimated coefficient (or) elasticity of the i^{th} input, i= 1, 2, 3, ……n

P_y = Price of crops (Rs/qtl.)

The decision rule for the efficiency analysis is if : r=1; resource is been used efficiency r>1; resource is under-utilized and increased utilization will increase output r<1; resource is over utilized and reduction in its usage would lead to maximization of profit.

Results and Discussion

The table 1 shows that the costs, returns, and cost-saving structure of paddy and maize crops across different farm sizes. It was observed that the per acre cost of seed was higher in large farm category (Rs.3,177.78) followed by

medium (Rs.3,119.35) small farm category (Rs.3,051.71) and Rs.3,097.81 was at an overall level. The higher cost of maize seeds (Rs. 3097.81/acre) as compared to paddy (Rs. 1491.65/ acre) reflect the differences in seed technology, particularly the use of hybrid varieties in maize, which are typically more expensive but may offer better yields or pest resistance and a difference of Rs.1606.16 was observed in seed price. The operational cost incurred on fertilizers, plant protection chemicals, human labour-use and machinery use was much higher in paddy crop. Paddy has a high fertilizer demand is likely linked to continuous standing water in rice paddies, which can lead to nutrient loss, requiring more fertilizer application. Maize is a less water-intensive crop, has lower nutrient leaching, leading to better fertilizer efficiency. Human Labour costs has been much higher for paddy (Rs. 7792.82/ acre) than maize (Rs. 3450.90/acre). The major proportion of variable cost in both the crops was dominated by human labour followed by machinery charges and plant protection chemicals. Expenditure on manures and fertilizers appeared to be the most dominant cost component constituting 24.45 per cent of the total cost followed by hired human labour claiming 22.13 per cent. Similar results have been shown by Lyngkhoi *et al,* 2021. The study by Kumar *et al*, 2013 also reported that the expenditure incurred on the human labour was used for performing the operation like transplanting, weeding and harvesting in paddy crop. Family labour cost was found to be higher in small farm category as compared to medium and large farm categories in both the crops. Machine labour component had the second highest contribution after the human labour because the farmers were dependent on the hiring of machines for various farm operations i.e with the growing diffusion of technology in paddy, there has been widespread mechanization of almost all farming operations. Paddy incurs slightly higher interest on working capital due to its higher overall cost of cultivation, as it requires more inputs compared to maize. Paddy cultivation is more input-intensive, with higher costs in seeds, fertilizers, labor, machinery, and plant protection chemicals. Similar results were reported by Esar *et al,* 2024. At overall level, the total cost for paddy was Rs. 23,462.66 per acre, whereas for maize, it was Rs. 15,590.39 per acre, resulting in savings of Rs. 7872.27 for cultivating maize instead of paddy. A major chunk of cost incurred on human labour-use i.e., Rs. 4,341.92 per acre was saved.

Return structure of maize and paddy

The gross returns from cultivation of maize came to be Rs. 29,163.89 per acre on an overall level. The gross returns were the highest in large farm category Rs. 35,045.62 followed by medium farms Rs. 30 693.96 and small farm category Rs. 25,678.55. It indicated that large farmers have obtained more gross returns followed by medium and small farms categories. At an overall level, per acre net returns were Rs. 13,573.50, and highest in large farm category i.e. Rs. 17,724.32 followed by medium farm Rs. 14,776.48 and small farm category Rs. 11032.86. The net return was found to be the lowest in the marginal farmer group at Rs. 11032.86/ acre. This may be due to their adherence to old traditional systems of farming and lack of good quality planting material which is common among resource poor farmers (Ansari *et al,* 2015; Lyngkhoi *et al,* 2021). The higher net income was highest in large farmers was mainly due to better management and improved agricultural technology and suitable quality of seeds, timely and appropriate application of irrigation and plant protection practices, efficient supervision, and management. Similar results of maize profitability were narrated by Devi and Suhasini, 2016; Singh *et al*, 2018; Ramadhan *et al,* 2024 in their studies. Benefit cost ratio of maize production was recorded highest (1.96) for large farmers followed by medium farmers (1.93), small farmers (1.75). At an overall level benefit cost ratio was (1.87), it indicates that the maize growers earned a gross income of Rs.1.87 by investing Re. one per acre on maize production. Similar results have been shown by Bakhsh *et al*, 2006; Murthy *et al* 2015; Singh *et al* 2018; Kumar *et al* 2023 Ramadhan *et al,* 2024. Maize crop is suitable for intensive cultivation and generated ample opportunity of employment of growers.

Table1 also shows the per acre gross returns for paddy was found to be Rs. 29163.89 . After deducting the total cost (Rs. 15590.39 per acre) out of the gross return, the return over variable cost was found to be Rs. 13573.50 per acre. The results of our study are in line with Kaur, 2022, who reported similar findings in their study on paddy cultivation in Punjab. The benefit cost ratio was highest for large farm category (2.30) followed by medium farm category (2.28) and small farm category (2.25), respectively. At an overall level, benefit cost ratio was 2.28 which indicates that paddy growers earned a gross income of Rs. 2.28 by investing Re. 1.00 per acre of paddy production. Similar results have been shown by Barwal and Sharma, 2023; Bakhsh *et al,* 2006.

Production Function

Cobb Douglas production function revealed that coefficient of multiple determination (R^2) indicated that 86 per cent of the variation in the yield of maize was explained by independent variables included in the model (Table 2). The production function revealed that the co-efficient of seeds and human labour were positively related with the yield and significant at 1 per cent level. It could be inferred that 1 per cent change in seeds, and human labour, will change a yield by 1.042, and 0.237 per cent, respectively. The coefficient of fertilizers was negative and significant at 5 per cent level that means 1 per cent increase in fertilizers would decrease yield by -0.087 per cent. This indicated that irrationally use of fertilizers by the maize growers. The sum of the elasticity coefficient was 1.19, indicating the increasing returns to scale and cultivators are operating under sub optimal level. Similar results were showed

Table 1: Comparative costs and return structure of maize and paddy crop of the sampled respondents (Rs./acre)

Particulars	Paddy (I)				Maize (II)				Savings in Cost (III=I-II)	% age changes (%)
	Small	Medium	Large	Overall (I)	Small	Medium	Large	Overall (II)		
Seeds	1423.86	1541.2	1582.37	1491.65	3051.71	3119.35	3177.78	3097.81	-1606.16	51.85
	(6.27)	(6.43)	(6.37)	(6.36)	(20.88)	(20.00)	(18.35)	(19.87)		
FYM	2289.35	2367.82	2409.99	2338.34	2027.03	2146.55	2240.1	2108.98	229.36	9.81
	(10.08)	(9.88)	(9.71)	(9.97)	(13.84)	(13.49)	(12.93)	(13. 53)		
Fertilizers										
Urea	861.55	874.9	882.85	870.08	602.73	654.3	733.55	651.13	218.95	25.16
	(3.79)	(3.65)	(3.56)	(3.71)	(4.12)	(4.11)	(4.23)	(4.18)		
DAP	1375.61	1763.47	1813.78	1578.24	904.29	1050.87	1216.06	1028.44	549.8	34.84
	(6.06)	(7.36)	(7.31)	(6.73)	(6.17)	(6.6)	(7.02)	(6.6)		
MOP	119.5	185.3	230.2	162.97	13.13	20.36	46.58	22.21	140.76	86.37
	0.53	(0.77)	(0.93)	(0.69)	(0.09)	(0.13)	(0.27)	(0.14)		
Total fertilizers	2356.65	2823.67	2926.84	2611.28	1520.15	1725.52	1996.2	1701.78	909.5	34.83
	10.37	11.78	11.79	11.13	10.38	10.84	11.52	(10.92)		
Plant Protection chemicals	3647.22	3820.18	3952.03	3764.93	1822.07	2081.09	2349.52	2018.62	1746.31	34.83
	(16.06)	(15.93)	(15.92)	(16.05)	(12.44)	(13.07)	(13.56)	(12.95)		
Human Labour										
Family Labour	2477.77	2498.32	2536.91	2497.49	890.47	1037.73	1215	1006.94	1490.55	59.68
	(10.91)	(10.42)	(10.22)	(10.64)	(6.08)	(6.52)	(7.02)	(6.46)		
Hired Labour	5168.1	5269.83	5579.38	5295.33	2395.57	2473.77	2514.04	2443.96	2851.37	53.85
	(22.75)	(21.98)	(22.48)	(22.57)	(16.35)	(15.54)	(14.51)	(15.68)		
Total Labour	7645.87	7768.15	8116.29	7792.82	3286.04	3511.5	3729.04	3450.9	4341.92	55.72
	(33.66)	(32.4)	(32.7)	(33.21)	(22.44)	(22.06)	(21.53)	(22.13)		
Machinery charges	4668.71	4926.73	5081.1	4833.73	2473.52	2830.28	3284	2719.14	2114.59	43.75
	(20.54)	(20.55)	(20.47)	(20.6)	(16.89)	(17.78)	(18.96)	(17.44)		
Interest on working capital @ 7% for half period	684.39	726.23	753.61	629.89	465.15	503.18	544.66	493.16	136.73	21.71
	(3.01)	(3.03)	(3.04)	(2.68)	(3.18)	(3.16)	(3.15)	(3.15)		
Total Cost	22716.05	23973.98	24822.23	23462.66	14645.7	15917.48	17321.3	15590.39	7872.27	33.55
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)		
Yield (Qtl/acre)	24.90	26.62	27.50	25.94	14.36	16.53	17.05	15.56		
Gross Returns	51151.01	54619.80	57031.87	53406.17	25678.55	30693.96	35045.62	29163.89		
Net returns	28434.96	30645.82	32209.64	29943.51	11032.86	14776.48	17724.32	13573.50		
Benefit Cost Ratio	2.25	2.28	2.30	2.28	1.75	1.93	1.96	1.87		

Note- Figures in the parentheses are percentages to the total

by Singh *et al,* 2018 and Barwal *et al,* 2022.

The ratio of MVP to MFC for inputs like seeds (1.02), FYM (4.05), human labour (2.75) in the study area of maize crop is more than unity and positive indicates that the farmers are underutilizing the resources and usage would lead to profit maximization (Table 3). Similarly, Sharma and Kumar (2019) observed that FYM and seeds was greater than unity which indicating that their inputs are under-utilized and was due to the absence of technical knowledge.

The results on resource use efficiency for maize farmers in the study area suggest that the farmers were not efficiently allocating the resources. That it, seeds and FYM were underutilized. Maize output in the study area could be increase if increase the use of seed and FYM. The

Table 2: Estimated coefficients of Cobb Douglas production function for maize crop

Particulars	Coefficients	Standard Error	p-value
Intercept	0.067	0.10	0.543
Seeds	1.042***	0.14	0.00
FYM	0.092	0.14	0.35
Fertilizers	-0.087**	0.04	0.032
Plant protection chemicals	-0.0036	0.08	0.97
Humanlabour	0.237***	0.07	0.00
∑bi	1.19		
R^2	0.86		
AdjustedR^2	0.85		

*Note:*** and ** significant at1 and 5 per cent level, respectively*

Table 3: Ratios of marginal value productivities of resources to their factor costs of maize growers in the study area

Particulars	Coefficients	APP	MPP	P*y*	MVP	MFC	*r*	Remarks
Seeds	1.04	4.2	4.39	2090	9169.6	9000	1.02	Underutilized
FYM	0.092	2.1	0.19	2090	404.8	100	4.05	Underutilized
Fertilizers	-0.09	0.4	-0.03	2090	-72.7	1680	-0.04	Overutilized
Plant protection chemicals	0.004	14.3	-0.05	2090	-107.5	150	-0.72	Overutilized
Humanlabour	0.24	2.2	0.53	2090	1100.7	400	2.75	Underutilized

Note: APP=Average Physical Product, MPP= Marginal Physical Product, MVP= Marginal value product, MFC=Marginal Factor Cost.

aforementioned results are also consonance with the results obtained by similar studies on resource use efficiency in maize production conducted in Nepal (Neupane *et al* (2024). Fertilizers (-0.04) and plant protection chemicals (-0.72) were less than unity indicates that fertilizers and plant protection chemicals were over-utilized. Over utilization of fertilizer was also explored in previous studies (Barwal *et al*, 2023). There was more scope for exploitation, the use of these resources to maximize the production and to increase the gross returns. It is also imperative from the study that optimum use of over utilized inputs caused in reduction of expenses incurred which is in line with Dahal and Rijal, 2019.

The results of Cobb-Douglas production function for paddy cultivation is represented in Table4. The seeds, FYM, and human labour have positive and significant impact on the yield of paddy crop. It means 1 per cent increase in seeds and FYM resulted in 0.80 and 0.22 per cent increase in the yield which is line with the study conducted by Dhakal *et al,* 2015 and Sapkota *et al,* 2018. The sum of the elasticity coefficients was 0.709 which indicated that the production function exhibited decreasing returns. These results were in conformity with the findings of Dhakal *et al,* 2015; Hasan,

Table 4: Estimated coefficients of Cobb Douglas production function for paddy crop

Particulars	Coefficients	Standard error	p-value
Intercept	0.453	0.18	0.013
Seeds	0.809*	0.42	0.064
FYM	0.22**	0.10	0.024
Fertilizers	-0.11*	0.14	0.09
Plant protectionchemicals	0.153	0.097	0.118
Human labour	-0.21**	0.09	0.034
∑bi	0.71		
R^2	0.88		
Adjusted R^2	0.87		

*Note: *, **significant at 10 and 5 per cent level, respectively*

Table 5: Ratios of marginal value productivities of resources to their factor costs of paddy growers in the study area

Particulars	Coefficients	APP	MPP	P*y*	MVP	MFC	*r*	Remarks
Seeds	0.81	4.8	3.87	2040	7898.7	7500	1.05	Underutilized
FYM	0.22	0.8	0.17	2040	337.9	120	2.82	Underutilized
Fertilizers	-0.11	0.2	-0.02	2040	-50.10	1680	-0.03	Overutilized
Plant protectionchemicals	0.15	0.3	0.05	2040	104.8	150	0.70	Overutilized
Humanlabour	-0.21	0.4	-0.07	2040	-151.90	400	-0.38	Overutilized

Note:APP=Average Physical Product, MPP=Marginal Physical Product, MVP=Marginal value product, MFC=Marginal Factor Cost.

2008; Mukherjee *et al*, 2015 and Choudhri and Singh, 2019. The value of R^2 was 0.88 indicates that 88 per cent of the variation in the yield of paddy was explained by independent variables included in the model.

The wisdom of cultivator lies on the level of use of resources, procurement purchase at reasonable price, timely application and trail up recommended agronomic practices for realizing higher returns from the cultivation of farm enterprise. The resource use analysis give an idea about usage of scarce resources and needs to improve the use of particular resource for increasing returns from farm business. The ratio of MVP to MFC for inputs like fertilizers (-0.03) and plant protection chemicals (0.70) was less than unity indicated that all there inputs were over utilized and there was a need to reduce the use of these inputs to get the optimum level of output in the study area of paddy crop (Table 5). There was ample scope for exploitation the use of these resources to maximize the production and to increase the gross returns. Efficiency ratio for human labour (-0.38) was also less than unity which indicates that there was a need to reduce the use of human labour to get the optimum level of output. Wongnaa and Ofori, 2012 and Barwal *et al* 2022 obtained similar results for human labour.

Conclusions and Policy Implications

The study concluded that maize cultivation in Punjab, compared to paddy, offers significant cost savings, particularly in terms of lower per-acre cultivation costs, human labor, and machinery use. Despite the higher gross returns and net profits associated with paddy cultivation, the cost efficiency of maize offers a viable alternative for farmers, especially with incentives for crop diversification. The result highlights the underutilization of resources like seeds, labor, and fertilizers in both maize and paddy cultivation. Government policies should focus on providing training programs for farmers on efficient resource management and promoting best agricultural practices to optimize output and reduce costs.

The government should ensure the introduction of a remunerative MSP for maize to encourage farmers to shift from paddy cultivation. Along with this, creating an assured procurement system for maize would reduce market risks, promoting its cultivation. The government should establish the maize processing industries that use maize as raw material (e.g., food processing, biofuels, and textile industries). This would create a higher value and market demand for maize, and support rural employment. Policymakers should continue to encourage farmers to diversify their crops by offering incentives for cultivating maize, pulses, vegetables, and fruits, as outlined in the Department of Agriculture's Twelfth Five-Year Plan. By reducing the dependency on water-intensive crops like paddy, the long-term sustainability of farming in Punjab can be improved.

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Received: March 19, 2025 Accepted: May 05, 2025