



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(9): 370-378
Received: 20-07-2026
Accepted: 28-08-2026

Dipali B Nanajkar
PG Scholar, Department of
Agricultural Economics, College of
Agriculture, Latur, Maharashtra,
India

SH Kamble
Dean PGIABM, Chakur, Professor,
College of Agriculture, Latur,
Maharashtra, India

Ranjeetsingh R Jadhav
PG Scholar, Department of
Agricultural Economics, College of
Agriculture, Latur, Maharashtra,
India

EP Jadhav
PG Scholar, Department of
Agricultural Economics, College of
Agriculture, Latur, Maharashtra,
India

Raut Vishal
PG Scholar, Department of
Agricultural Economics, College of
Agriculture, Latur, Maharashtra,
India

Corresponding Author:
Dipali B Nanajkar
PG Scholar, Department of
Agricultural Economics, College of
Agriculture, Latur, Maharashtra,
India

Resource productivity and resource-use efficiency in rajma (*Phaseolus vulgaris* L.) Production in Beed district of Maharashtra

**Dipali B Nanajkar, SH Kamble, Ranjeetsingh R Jadhav, EP Jadhav and
Raut Vishal**

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i9e.6541>

Abstract

Rajma (*Phaseolus vulgaris* L.) is gaining importance as an alternative pulse crop in the non-traditional growing areas of Maharashtra. The present investigation was carried out in Beed district of Maharashtra to examine the productivity and economic efficiency of resources employed in Rajma cultivation. Primary information was obtained from 90 selected Rajma growers during 2024–25 through a structured interview schedule. A multistage purposive-cum-random sampling technique was adopted for the selection of respondents. The relationship between Rajma output and major production inputs was estimated using a Cobb-Douglas production function. Multicollinearity diagnostics were applied during model specification, and the final analysis considered seed, human labour, fertilizer and plant-protection inputs. Resource-use efficiency was evaluated by comparing the marginal value product of each input with its corresponding marginal factor cost.

The fitted production function explained 87.50 per cent of the variation in farm-level Rajma output, with an adjusted R^2 of 0.8691. Seed showed the highest production elasticity (0.5861), followed by human labour (0.4237), plant protection (0.1785) and fertilizer (0.0940). The aggregate elasticity of 1.2823 indicated increasing returns to scale. Human labour registered the highest marginal physical product at 42.518 kg per man-day, while the corresponding values for seed, fertilizer and plant protection were 17.029 kg/kg, 1.477 kg/kg and 0.400 kg/ml, respectively. The MVP-to-MFC ratios indicated that seed (1.236) and plant protection (1.174) were under-utilized, whereas human labour (0.700) was relatively over-utilized. Fertilizer, with an efficiency ratio of 1.057, was found to be close to the economically efficient level. The estimated resource gaps further indicated scope for increasing seed, fertilizer and plant-protection inputs and reducing excessive labour utilization.

The study suggests that improvements in Rajma production need not depend solely on increasing total input use; rather, greater attention should be given to the efficient combination and allocation of existing resources. Rationalization of labour and appropriate adjustment of under-utilized inputs may improve resource productivity and economic returns from Rajma cultivation in Beed district.

Keywords: Rajma, *Phaseolus vulgaris*, resource productivity, resource-use efficiency, Cobb-Douglas production function, marginal physical product, marginal value product, Beed district

Introduction

Agriculture is an important sector of the Indian economy and continues to provide employment, income and livelihood opportunities to a large proportion of the rural population. Pulses form an important component of Indian agriculture because of their nutritional, economic and ecological significance. They provide an important source of plant-based protein and contribute to the sustainability of cropping systems. In the changing agricultural environment, rising input costs, production risks and fluctuations in returns have encouraged farmers to consider alternative crops that can provide better economic opportunities. Rajma (*Phaseolus vulgaris* L.), commonly referred to as kidney bean, is one of the pulse crops that has considerable potential in this regard. Rajma is valued for its nutritional quality and economic importance. Its grains contain protein, carbohydrates, dietary fibre and several essential minerals, making it an important food legume. In addition to its nutritional contribution, the crop has attracted farmers because of its market demand and potential to provide remunerative returns. Although Rajma cultivation has

traditionally been concentrated in the Himalayan and sub-Himalayan regions, its cultivation has gradually spread to several non-traditional areas of the country. Maharashtra is one such state where the crop has gained attention as part of the process of agricultural diversification.

The emergence of Rajma in the Marathwada region is particularly important from the perspective of farm-level economics. Farmers in this region are exposed to variations in rainfall, input prices, crop prices and returns from conventional crops. Under such conditions, the adoption of relatively short-duration and commercially attractive crops can provide an opportunity to diversify farm enterprises. In Beed district, Rajma cultivation has expanded in selected areas as farmers have explored alternatives to traditional crops. The expansion of the crop has been associated with its comparatively attractive price, potential returns, shorter duration and increasing market demand.

However, the profitability of Rajma cultivation cannot be judged only from its market price or gross returns. The economic performance of the crop is strongly influenced by the quantity and combination of resources used in its production. Cultivation involves the use of seed, human labour, machine labour, fertilizers, plant-protection inputs, irrigation and other farm resources. Since these resources are scarce and costly, their appropriate allocation is essential for achieving higher production at a reasonable cost. An increase in input use does not necessarily result in a corresponding increase in output. Therefore, the economic assessment of how individual resources contribute to Rajma production is necessary for determining whether farmers are using their available resources appropriately.

Resource productivity provides an important economic measure for examining the contribution of individual inputs to agricultural production. It helps in understanding the extent to which changes in the use of a particular resource influence the output of Rajma. Inputs such as seed, labour, fertilizers and plant-protection measures may differ considerably in their contribution to production. Estimation of marginal productivity can therefore indicate the additional output associated with an additional unit of a particular input. Such information is useful for identifying resources that have greater potential for improving farm output and for understanding the existing input-output relationship in Rajma cultivation.

Along with productivity, the efficient allocation of resources is a major concern in agricultural production. Resource-use efficiency indicates whether a resource is being utilized at an economically desirable level. The comparison between the value of the marginal product of an input and the cost of using that input provides an economic basis for judging its efficiency. When the value generated by an additional unit of a resource exceeds its corresponding cost, increased utilization may be economically justified. On the other hand, when the cost of an additional unit is greater than the value of the output generated, the resource may be overutilized. Thus, resource-use efficiency analysis helps in identifying possibilities for reallocating inputs and improving the economic performance of farm production.

The need for such analysis is particularly relevant in Rajma cultivation because improved varieties and production technologies have demonstrated higher yield potential than the yields obtained under many farm situations. The difference between potential and actual production suggests that there is scope to improve productivity through better management of available production resources. Efficient allocation of inputs is therefore as important as increasing the quantity of inputs used. Appropriate use of seed, labour, fertilizers, plant-protection inputs and machinery can help farmers improve output while

avoiding unnecessary production expenditure.

For Beed district, the study of resource productivity and resource-use efficiency assumes added importance because Rajma is still an emerging crop in the area. The expansion of its cultivation creates a need for location-specific economic information on input utilization and production performance. Farmers require knowledge about which resources make a significant contribution to output and whether those resources are being used below, near or above their economically optimum levels. Such information can support better farm planning and assist farmers in improving the productivity of scarce resources.

In this context, the estimation of resource productivity and resource-use efficiency provides a scientific basis for evaluating the existing production practices of Rajma growers. It can help identify the major factors influencing production, assess the contribution of individual resources and determine the scope for improving their allocation. The findings can be useful to farmers, agricultural extension agencies and policy makers in developing appropriate production recommendations for the sustainable expansion of Rajma cultivation.

Therefore, considering the increasing importance of Rajma as an alternative commercial pulse crop in Beed district and the need for efficient utilization of scarce farm resources, the present study was undertaken to estimate resource productivity and resource-use efficiency in Rajma production.

Objective of the Study

To estimate resource productivity and resource-use efficiency in Rajma production.

Materials and Methods

The present study was conducted in Beed district of the Marathwada region of Maharashtra with the specific objective of estimating resource productivity and resource-use efficiency in Rajma production. Beed is predominantly an agricultural district where farming activities are influenced by rainfall variability and availability of irrigation resources. In recent years, Rajma cultivation has gained importance in selected areas of the district as an alternative crop due to its relatively attractive returns and suitability for crop diversification. The study was therefore undertaken to examine the utilization and economic contribution of major production resources used by Rajma growers under the prevailing farm conditions.

A multistage purposive-cum-random sampling procedure was followed for the selection of Rajma growers. Beed district was purposively selected considering the comparatively larger area under Rajma cultivation. From the 11 talukas of the district, three talukas having higher area under Rajma cultivation were purposively selected. Subsequently, three villages with relatively larger acreage under Rajma were selected from each selected taluka. From each selected village, ten Rajma growers were randomly selected, resulting in a total sample of 90 Rajma growers from three talukas and nine villages.

Primary data were collected from the selected Rajma growers for the agricultural year 2024–25 using a pre-tested and structured interview schedule. Information relating to the area under Rajma cultivation, quantity and expenditure on major inputs, labour utilization, use of seed, fertilizers, plant-protection measures, machinery and other production resources, quantity of output obtained and price received was collected. The collected data were systematically compiled and used for estimating the relationship between Rajma output and the major production resources and for assessing the economic efficiency of resource utilization.

Resource productivity and resource use efficiency in rajma production

The analytical framework was developed to assess the productivity and economic efficiency of major inputs used in Rajma cultivation based on farm-level cross-sectional data. The analysis included descriptive statistics, estimation of the Cobb-Douglas production function, examination of multicollinearity, model refinement, diagnostic tests, and estimation of marginal physical product, marginal value product, and resource-use efficiency.

Symbol	Variable	Unit	Role
Y	Rajma output	kg/farm	Dependent variable
X1	Area under Rajma	ha/farm	Initial explanatory variable
X2	Seed	kg/farm	Resource input
X3	Human labour	mandays/farm	Resource input
X4	Machine labour	hours/farm	Initial resource input
X5	Fertilizer	kg/farm	Resource input
X6	Plant-protection chemicals	ml/farm	Resource input

Descriptive Statistical Analysis

Before fitting the production function, the data were screened for missing, zero and negative observations and for possible unit inconsistencies. Arithmetic mean, standard deviation, minimum, maximum and coefficient of variation were used to describe the distribution and variability of output and resource inputs.

$$CV (\%) = (\text{Standard deviation} / \text{Mean}) \times 100$$

Cobb-Douglas Production Function

A Cobb-Douglas production function was employed because its estimated coefficients directly represent production elasticities and can be conveniently used to derive marginal physical products and resource-use-efficiency measures. The general multiplicative form of the model was:

$$Y = A X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6} e^u$$

For estimation by ordinary least squares (OLS), the function was transformed into double-log form:

$$\ln Y = \ln A + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + u$$

Here, β_i denotes the elasticity of Rajma output with respect to the its resource. Thus, β_i measures the percentage change in output associated with a one per cent change in the corresponding input, other factors remaining constant.

Diagnosis and Treatment of Multicollinearity

Multicollinearity among explanatory variables was examined using the Variance Inflation Factor (VIF). In the initial per-farm model, very high VIF values were observed for area under Rajma

Nature of data and Variables

Farm-level cross-sectional data were collected from 90 selected Rajma growers. Total Rajma production per farm, measured in kilograms, was considered the dependent variable. The explanatory variables included area under Rajma, seed, human labour, machine labour, fertilizers and plant protection chemicals. All input variables were measured on a per-farm basis to estimate their contribution to total farm-level Rajma production rather than productivity per hectare.

and machine labour, indicating severe scale-related linear dependence. The initial VIF values were approximately 139.87 for area, 127.65 for machine labour and 14.82 for seed. Alternative theoretically defensible specifications were therefore compared rather than altering or deleting farm observations.

$$VIF_j = 1 / (1 - R_j^2)$$

The final resource-productivity specification excluded area and machine labour because their inclusion generated severe multicollinearity. The retained variables were seed, human labour, fertilizer and plant-protection chemicals. The resulting VIF values were 6.99, 3.75, 1.53 and 4.18, respectively, which were considered acceptable for interpretation. The exclusion was based on multicollinearity diagnostics and model specification, not on a desire to obtain statistical significance.

Final Production-Function Specification

The final model used for estimating resource productivity and resource-use efficiency was:

$$\ln Y = \ln A + \beta_1 \ln (\text{Seed}) + \beta_2 \ln (\text{Labour}) + \beta_3 \ln (\text{Fertilizer}) + \beta_4 \ln (\text{Plant protection}) + u$$

The model was estimated by OLS. HC3 heteroskedasticity-robust standard errors were also reported to make statistical inference more robust to possible non-constant error variance.

Econometric Diagnostic Tests

The adequacy of the final model was assessed using the following diagnostic tests:

Analytical tool	Purpose
Variance Inflation Factor (VIF)	Assessment of multicollinearity among explanatory variables.
Breusch-Pagan test	Test for heteroskedasticity in regression residuals.
White test	General test for heteroskedasticity.
Ramsey RESET test	Assessment of functional-form/specification error.
Jarque-Bera test	Assessment of residual normality.
Durbin-Watson statistic	Reported as a supplementary check on residual serial correlation.
R ² and adjusted R ²	Measurement of explanatory power of the model.
Overall F-test	Assessment of joint statistical significance of the explanatory variables.

Returns to Scale

Returns to scale were estimated by summing the production

elasticities of all inputs retained in the final Cobb-Douglas model:

$$RTS = \sum \beta_i$$

$\sum \beta_i > 1$: increasing returns to scale

$\sum \beta_i = 1$: constant returns to scale

$\sum \beta_i < 1$: decreasing returns to scale

A linear restriction/Wald F-test was used to test the null hypothesis $H_0: \sum \beta_i = 1$. This allowed the numerical classification of returns to scale to be supported by formal statistical inference.

Estimation of Resource Productivity

Average Product

Average product (AP) of the i th resource was estimated as:

$$AP_i = \bar{Y} / \bar{X}_i$$

where $\bar{Y}$ is the mean Rajma output per farm and $\bar{X}_i$ is the mean quantity of the i th resource used per farm.

Marginal Physical Product

For a Cobb-Douglas production function, the marginal physical product (MPP) of an input at the sample mean was derived from its elasticity coefficient as:

$$MPP_i = \beta_i (\bar{Y} / \bar{X}_i)$$

MPP measures the additional physical quantity of Rajma output generated by an additional unit of the respective resource, evaluated at the geometric relationship represented by the fitted production function and the sample means.

RUE criterion	Economic interpretation
$RUE > 1$	MVP exceeds MFC; the resource is relatively under-utilized and there may be scope for increased use, subject to agronomic feasibility.
$RUE = 1$	MVP equals MFC; the resource is being used at the economic optimum.
$0 < RUE < 1$	MVP is below MFC; the resource is relatively over-utilized and its use may require rationalization.
$RUE < 0$	Negative marginal return; the input-output relationship and model specification should be examined before making a conventional efficiency interpretation.

Resource-Use Gap / Adjustment Indicator

For descriptive presentation of the direction and magnitude of resource imbalance, an indicative resource-use gap was computed from the RUE ratio. The percentage gap was expressed as:

$$\text{Resource-use gap (\%)} = (RUE_i - 1) \times 100$$

A positive gap denotes relative under-utilization, whereas a negative gap denotes relative over-utilization. This percentage is an efficiency-gap indicator and should not be interpreted as an exact profit-maximizing percentage change in input use. Exact optimum input quantities would require solving the first-order condition $MVP = MFC$ within the estimated production function while holding the relevant conditions explicit.

Marginal Value Product

The marginal value product (MVP) of each resource was estimated by valuing its marginal physical product at the Rajma output price:

$$MVP_i = MPP_i \times P_y$$

Where, P_y is the farm-gate price of Rajma. In the present analysis, the output price used for the calculations was ₹8.23 per kg, as supplied for the analysis.

Marginal Factor Cost

Marginal factor cost (MFC) represents the market cost of one additional unit of the respective resource. The following unit prices were used in the resource-use-efficiency analysis

Resource	Unit	MFC used (₹/unit)
Seed	kg	113.35
Human labour	man-day	500.00
Fertilizer	kg	11.50
Plant-protection chemicals	ml	2.80

Resource-Use Efficiency

Economic efficiency in the use of each resource was assessed by comparing its marginal value product with its marginal factor cost. The resource-use-efficiency ratio (RUE), also referred to as the MVP-MFC ratio, was calculated as:

$$RUE_i = MVP_i / MFC_i$$

Final Analytical Model Used in the Study

After addressing severe multicollinearity in the initial per-farm specification, the final model retained seed, human labour, fertilizer and plant-protection chemicals. This model was used for estimating the production elasticities, marginal physical products, marginal value products and resource-use-efficiency ratios. Area and machine labour were not included in the final efficiency model because their inclusion generated severe scale-related multicollinearity; the underlying farm observations themselves were not altered.

$$\ln Y = \ln A + \beta_1 \ln (\text{Seed}) + \beta_2 \ln (\text{Labour}) + \beta_3 \ln (\text{Fertilizer}) + \beta_4 \ln (\text{Plant protection}) + u$$

Summary of Analytical Tools

Component	Analytical tool / measure
Descriptive statistics	Mean, SD, minimum, maximum and CV
Production-function analysis	Cobb-Douglas double-log production function estimated by OLS
Robust inference	HC3 heteroskedasticity-robust standard errors
Multicollinearity	Variance Inflation Factor (VIF)
Heteroskedasticity	Breusch-Pagan and White tests
Functional form	Ramsey RESET test
Residual normality	Jarque-Bera test
Supplementary residual check	Durbin-Watson statistic
Returns to scale	Sum of elasticities and Wald/F restriction test
Resource productivity	Average Product and Marginal Physical Product
Economic productivity	Marginal Value Product
Resource-use efficiency	MVP/MFC ratio
Resource gap	$(RUE - 1) \times 100$ as an indicative efficiency-gap measure

Results and Discussion

Estimated Cobb–Douglas production function for Rajma

The Cobb–Douglas production function was estimated using farm-level data collected from 90 selected Rajma growers. Seed, human labour, fertilizer and plant protection were considered as the major explanatory variables influencing Rajma output. The estimated coefficients represent the production elasticities of the

respective inputs. Their statistical significance was assessed using HC3 robust standard errors, t-statistics and p-values. The goodness of fit and overall significance of the model were evaluated using R^2 , adjusted R^2 and the F-test. The sum of the estimated production elasticities was used to determine the nature of returns to scale. The estimated results are presented in Table 1.

Table 1: Estimated Cobb–Douglas production function for Rajma

Sr. No.	Variables	Production elasticity (β)	HC3 robust SE	t- value	P- value	Significance
	Constant	2.0144	0.4568	4.41	<0.001	***
1	Seed	0.5861	0.1050	5.58	<0.001	***
2	Human labour	0.4237	0.1614	2.63	0.010	**
3	Fertilizer	0.0940	0.0548	1.71	0.090	*
4	Plant protection	0.1785	0.0818	2.18	0.032	**

Model Statistics

Statistics	Value
Number of Observations	90
R^2	0.8750
Adjusted R^2	0.8691
Overall F- test	Significant
Probability of F	<0.001
Sum of elasticities	1.2823
Returns to scale	Increasing
Test of RTS =1	P=0.0068

The estimated Cobb–Douglas production function showed a satisfactory fit for the farm-level Rajma production data. The model explained 87.50 per cent of the variation in Rajma output, as indicated by the R^2 value of 0.8750, while the adjusted R^2 was

0.8691. The significant F-test ($p < 0.001$) confirmed that the explanatory variables, when considered jointly, significantly influenced Rajma production.

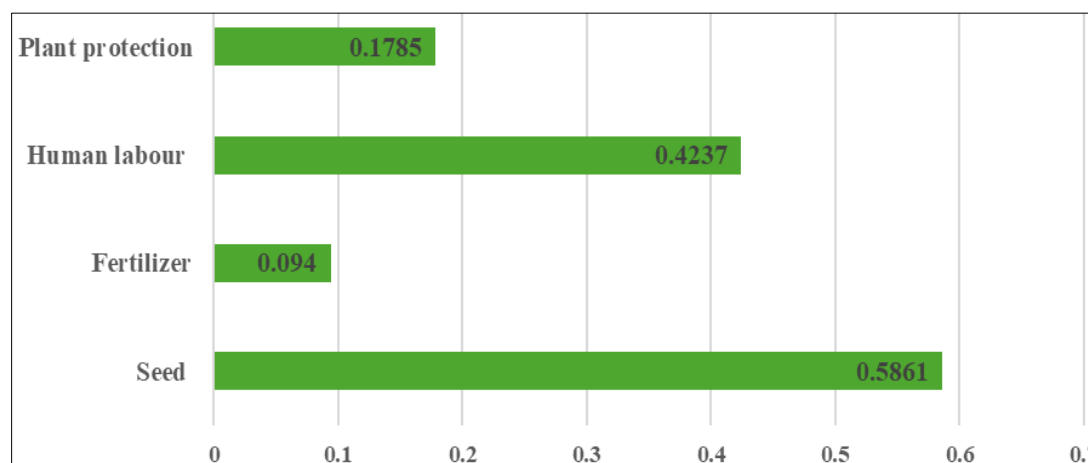


Fig 1: Cobb–Douglas Production Function for Rajma

Among the individual inputs, seed had the highest production elasticity (0.5861), which was statistically significant at the 1 per cent level. This implies that a one per cent increase in seed use, with other inputs held constant, was associated with a 0.5861 per cent increase in Rajma output. Human labour also showed a positive and significant elasticity of 0.4237 at the 1 per cent level, indicating its substantial contribution to crop production. Fertilizer recorded a positive elasticity of 0.0940, significant at the 10 per cent level, suggesting a relatively modest production response to increased fertilizer use. Plant protection had an elasticity of 0.1785 and was significant at the 5 per cent level, indicating that appropriate plant protection practices contributed positively to Rajma output.

The relative magnitude of the coefficients followed the order of

seed (0.5861), human labour (0.4237), plant protection (0.1785) and fertilizer (0.0940). Thus, seed and human labour were the most responsive inputs within the range of resource use observed among the sample farmers. The positive coefficients of all the variables indicated that each selected resource had a favourable association with Rajma production.

The sum of the production elasticities was 1.2823, which was significantly greater than unity ($P=0.0068$), indicating increasing returns to scale. This suggests that a proportionate expansion in the use of the selected production resources could generate a more than proportionate increase in Rajma output. The findings therefore indicate considerable scope for improving Rajma production through appropriate and balanced allocation of production resources.

Average and marginal productivity of resources in Rajma production

Average productivity indicates the overall crop yield per unit of input, while marginal productivity measures the additional yield

generated by applying one extra unit of that specific resource. Evaluating these economic metrics is essential for determining resource-use efficiency and optimizing input allocation to maximize profitability in rajma cultivation.

Table 2: Average and marginal productivity of resources in Rajma production

Resource	Mean input/farm	Elasticity (β)	Average Product	Marginal Physical Product (MPP)
Seed	115.21 kg	0.5861	29.056 kg/kg	17.029 kg/kg
Human labour	33.36 mandays	0.4237	100.360 kg/mandays	42.518 kg/manday
Fertilizer	213.11 kg	0.0940	15.708 kg/kg	1.477 kg/kg
Plant Protection	1495.85 ml	0.1785	2.238 kg/ml	0.400 kg/ml

Table 2 presents the estimated average and marginal productivity of the major resources used in Rajma production. The mean use of seed, human labour, fertilizer and plant protection chemicals were 115.21 kg, 33.36 man-days, 213.11 kg and 1,495.85 ml per farm, respectively. The production elasticities were positive for all the selected resources, indicating that each input contributed positively to Rajma output within the observed range of resource use.

Human labour recorded the highest average product of 100.360 kg per man-day, followed by seed (29.056 kg/kg), fertilizer (15.708 kg/kg) and plant protection chemicals (2.238 kg/ml). Similarly, the marginal physical product was highest for human labour at 42.518 kg per additional man-day. The corresponding MPPs for seed, fertilizer and plant protection were 17.029 kg/kg, 1.477 kg/kg and 0.400 kg/ml, respectively.

The production elasticity was highest for seed (0.5861), followed by human labour (0.4237), plant protection (0.1785) and fertilizer (0.0940). This indicates that changes in seed and labour use were relatively more responsive to changes in Rajma output than changes in fertilizer and plant protection inputs. The positive MPP values for all resources further indicate that additional use of each input was associated with an increase in output, although the magnitude of the response varied considerably across

resources.

The sum of the estimated production elasticities was 1.2823, indicating increasing returns to scale. Hence, a proportionate increase in the selected production resources was associated with a more than proportionate increase in Rajma output. The results suggest that appropriate adjustment and balanced utilization of production inputs could provide scope for improving Rajma productivity. The findings are broadly in agreement with Kumar, who also reported positive input elasticities along with resource-use imbalances in Rajmash production.

Resource productivity and resource-use efficiency in Rajma Production

Resource productivity refers to the output obtained per unit of input used in Rajma production, whereas resource-use efficiency indicates the extent to which available inputs are utilized effectively and economically. Assessing these measures helps to identify the optimal use of production resources, reduce inefficient input application and improve farm returns. Efficient use of inputs such as seed, labour, fertilizer and plant protection are therefore important for enhancing the productivity and profitability of Rajma cultivation.

Table 3: Resource productivity and resource-use efficiency in Rajma Production

Resource	Elasticity	MPP	MVP (Rs/unit)	MFC (Rs/unit)	RUE	Status
Seed	0.5861***	17.029 kg/kg	140.15	113.35	1.236	Under – utilized
Human labour	0.4237**	42.518 kg/man day	349.92	500	0.700	Over-utilized
Fertilizer	0.0940*	1.477 kg/kg	12.15	11.50	1.057	Near optimum/ slightly under- utilized
Plant Protection	0.1785**	0.400 kg/ml	3.29	2.80	1.174	Under- utilized

Note: ***, ** and * indicate significance at 1%, 5% and 10% respectively

Table 3 presents the estimates of production elasticity, marginal physical product (MPP), marginal value product (MVP), marginal factor cost (MFC) and resource-use efficiency (RUE) for the major inputs used in Rajma production. All the selected resources showed positive production elasticities, indicating a positive association with Rajma output within the observed range of input use. Seed recorded the highest elasticity (0.5861) and was significant at the 1 per cent level, followed by human labour (0.4237), plant protection (0.1785) and fertilizer (0.0940). The sum of the elasticities was 1.2823, indicating increasing returns to scale.

The RUE estimates revealed differences in the economic use of the selected inputs. Seed recorded an MPP of 17.029 kg/kg, an MVP of ₹140.15 per kg and an MFC of ₹113.35 per kg, resulting in an RUE of 1.236. This indicates under-utilization of seed. Plant protection also showed under-utilization, with an MPP of 0.400 kg/ml, MVP of ₹3.29 per ml, MFC of ₹2.80 per ml and an RUE of 1.174. In contrast, human labour recorded an MPP of 42.518

kg per man-day and an MVP of ₹349.92 per man-day against an MFC of ₹500.00, resulting in an RUE of 0.700 and indicating over-utilization. Fertilizer was close to the economically efficient level, with an RUE of 1.057, suggesting only a small scope for additional use.

The deviation of RUE from unity indicates that the existing allocation of resources was not fully economically efficient. The results suggest scope for increasing seed and plant protection use, while human labour should be used more judiciously. Fertilizer application was relatively close to the optimum level and therefore requires only limited adjustment. Overall, the findings indicate that better allocation of production resources could improve the economic efficiency and profitability of Rajma cultivation. The results are broadly consistent with Datarkar, who also reported deviations from optimal resource allocation and emphasized the importance of improving input-use efficiency for enhancing farm-level returns.

Table 4: Estimated resource-use gap and adjustment in Rajma production

Resource	Mean use per farm	MVP (RS/Unit)	MFC (RS/Unit)	RUE (MVP/MFC)	Resource gap (%)	Indicative optimum use	Direction
Seed	115.21 kg	140.15	113.35	1.236	23.64	142.45 kg/farm	Increase
Human labour	33.36 mandays	349.92	500.00	0.700	- 30.02	23.35 mandays/farm	Reduce/rationalize
Fertilizer	213.11 kg	12.15	11.50	1.057	5.69	225.23 kg/farm	Marginal increase
Plant Protection	1495.85 ml	3.29	2.80	1.174	17.44	1756.77 ml/farm	Judicious increase

Table 4 describes the economic position of the major production resources used by the sampled Rajma growers in terms of their existing use, marginal value product (MVP), marginal factor cost (MFC), resource-use efficiency (RUE), resource-use gap and estimated optimum requirement. The resource-use gap indicates the difference between the quantity of an input currently being used and the level associated with economic efficiency. An RUE ratio equal to one represents the point at which the value generated by an additional unit of input is equal to its corresponding cost. The results showed considerable variation in the efficiency of resource allocation among the selected inputs.

The average quantity of seed used was 115.21 kg per farm, with an MVP of ₹140.15 per kg and an MFC of ₹113.35 per kg. Consequently, the RUE ratio was 1.236, indicating that the value of the additional output obtained from seed was higher than its cost. The estimated resource-use gap was 23.64 per cent, and the corresponding optimum quantity was 142.45 kg per farm. Thus, the existing seed use could be increased by about 27.24 kg per farm to move towards the estimated economically efficient level. Human labour showed an opposite pattern. The sample farmers used an average of 33.36 man-days per farm, whereas the MVP was ₹349.92 per man-day compared with an MFC of ₹500.00. The resulting RUE ratio of 0.700 indicates that the cost of an additional unit of labour exceeded the value of the output generated by it. The resource-use gap was estimated at -30.02 per cent, and the optimum requirement was 23.35 man-days per farm. Hence, labour use exceeded the estimated economic requirement by approximately 10.01 man-days per farm. Rationalization of labour use, particularly in operations where manual work can be reduced without affecting timely crop management, may therefore improve the economic efficiency of Rajma production. The existing fertilizer use was 213.11 kg per farm, with an MVP of ₹12.15 per kg and an MFC of ₹11.50 per kg. The resulting RUE ratio of 1.057 was close to unity, indicating that fertilizer use was comparatively near the economically efficient level. Nevertheless, a small positive resource-use gap of 5.69 per cent was observed. The estimated optimum requirement was 225.23 kg per farm, suggesting a relatively small adjustment of 12.12 kg per farm. Such adjustment should preferably be guided by crop requirement and balanced nutrient management to avoid unnecessary expenditure on fertilizer.

The average use of plant protection chemicals was 1,495.85 ml per farm. Their MVP was ₹3.29 per ml, while the corresponding

MFC was ₹2.80 per ml, resulting in an RUE ratio of 1.174. The positive difference between MVP and MFC indicates under-utilization of this input. The estimated resource-use gap was 17.44 per cent, with an indicative optimum requirement of 1,756.77 ml per farm. Therefore, the use of plant protection chemicals could be increased by approximately 260.92 ml per farm, with application guided by the occurrence and severity of pest and disease problems.

Taken together, the results demonstrate that the existing combination of production resources was not fully aligned with their respective economic optimums. Seed and plant protection chemicals were below their estimated efficient levels, whereas human labour was used beyond the economically desirable level. Fertilizer use was comparatively close to the optimum. The differences in RUE ratios from unity provide evidence of scope for improving the allocation of farm resources. In particular, reducing excess labour use could release funds for inputs showing positive resource-use gaps.

The economic scope for such internal adjustment is evident from the estimated input costs. A reduction of 10.01 man-days of labour at ₹500.00 per man-day would save approximately ₹5,005.00 per farm. Against this saving, the additional expenditure required for seed was estimated at ₹3,087.65 (27.24 kg × ₹113.35), fertilizer at ₹139.38 (12.12 kg × ₹11.50), and plant protection chemicals at ₹730.58 (260.92 ml × ₹2.80). The combined additional expenditure would therefore be ₹3,957.61 per farm, leaving an estimated balance of ₹1,047.39. This suggests that a substantial part of the observed resource imbalance could be addressed through better redistribution of existing farm expenditure rather than through a large increase in total production costs.

The findings emphasize the importance of resource reallocation, particularly through moderation of excess labour use and appropriate adjustment of inputs that remain below their estimated economic levels. Improving the timing and quantity of input application, together with efficient labour management, could contribute to better resource productivity and profitability in Rajma cultivation. The results are broadly comparable with Patel et al. (2025) ^[4], who reported deviations from economically efficient input use and highlighted the importance of appropriate resource allocation for improving farm-level production and profitability.

Table 5: Absolute resource gaps

Resource	Existing mean use	Indicative optimum use	Absolute gap	Gap (%)	Economic status
Seed	115.21 kg	142.45 kg	27.24 kg	23.64 %	Under -utilized
Human labour	33.36 mandays	23.35 mandays	-10.01 mandays	30.02 %	Over -utilized
Fertilizer	213.11 kg	225.23 kg	12.12 kg	5.69 %	Near optimum
Plant Protection	1495.85 ml	1756.77 ml	260.92 ml	17.44 %	Under -utilized

Table 5 presents the absolute resource gaps between the existing and estimated optimum levels of major inputs used in Rajma (*Phaseolus vulgaris*) production. The table provides the mean quantity of each input currently used by the sample farmers, the corresponding indicative optimum requirement, the absolute

difference between the two levels, the percentage resource gap and the resulting resource-use status. The absolute resource gap is useful for identifying the extent and direction of adjustment required in individual inputs to approach the economically efficient level, where the marginal value product and marginal

factor cost are approximately equal.

The existing mean use of seed was 115.21 kg per farm, compared with an estimated optimum requirement of 142.45 kg per farm. The difference of 27.24 kg represents a positive resource gap of 23.64 per cent, indicating under-utilization of seed. Thus, the sample farmers could increase seed use by approximately 27.24 kg per farm to approach the estimated economically efficient level. The positive gap suggests that the additional value generated from seed use is higher than its corresponding cost within the range considered in the analysis.

Human labour showed an opposite situation. The existing average use was 33.36 man-days per farm, whereas the estimated optimum requirement was only 23.35 man-days. The resulting absolute gap was -10.01 man-days, equivalent to an over-utilization gap of 30.02 per cent. This indicates that labour was being employed beyond the level justified by its marginal economic contribution. Therefore, a reduction or rationalization of approximately 10.01 man-days per farm could improve the economic allocation of labour and reduce avoidable production expenditure.

In the case of fertilizer, the existing mean application was 213.11 kg per farm against an estimated optimum level of 225.23 kg. The absolute deficit was 12.12 kg per farm, representing a relatively small resource-use gap of 5.69 per cent. Since the corresponding RUE ratio was close to unity, fertilizer use was classified as near the economically optimum level. Only a limited adjustment of about 12.12 kg per farm appears necessary, and any such adjustment should be consistent with crop nutrient requirements and balanced fertilizer management.

Plant protection chemicals recorded an existing mean use of 1,495.85 ml per farm compared with an estimated optimum requirement of 1,756.77 ml. The resulting absolute gap was 260.92 ml per farm, corresponding to a positive resource-use gap of 17.44 per cent. This indicates under-utilization of plant protection inputs and suggests scope for increasing their use by approximately 260.92 ml per farm towards the estimated economically efficient level. Such adjustment should preferably be based on the actual occurrence of pest and disease problems and the recommended application requirements.

The overall pattern of absolute resource gaps indicates that the selected Rajma growers had scope to improve the allocation of production resources. Seed and plant protection chemicals showed positive gaps, indicating the need for additional use, while human labour showed a negative gap, indicating excess utilization. Fertilizer recorded only a small positive gap and was therefore relatively close to its estimated optimum. These results demonstrate that the direction and magnitude of adjustment differed considerably among inputs and that uniform changes in all resources would not be economically appropriate.

The estimated gaps also indicate the possibility of improving resource allocation through internal adjustment of farm expenditure. A reduction of 10.01 man-days of human labour at ₹500.00 per man-day would result in a saving of approximately ₹5,005.00 per farm. The additional expenditure required for the identified input gaps would be ₹3,087.65 for seed (27.24 kg × ₹113.35), ₹139.38 for fertilizer (12.12 kg × ₹11.50) and ₹730.58 for plant protection chemicals (260.92 ml × ₹2.80). The combined requirement would therefore be ₹3,957.61 per farm. Consequently, the saving generated through rationalization of excess labour would be sufficient to cover the estimated additional expenditure on the under-utilized inputs, leaving a balance of approximately ₹1,047.39 per farm. This illustrates that improved resource allocation need not necessarily involve a proportionate increase in total farm expenditure.

Thus, the results suggest that greater economic efficiency in Rajma cultivation could be achieved through selective adjustment of individual inputs rather than indiscriminate increases in resource use. Increasing inputs with positive resource gaps, maintaining fertilizer use close to the economic optimum and reducing excess labour employment would help bring the resource combination closer to an economically efficient position. The findings are broadly consistent with Chavan et al. (2020) ^[1], who reported allocative inefficiencies in the use of production resources in chickpea cultivation and emphasized the importance of appropriate adjustment of farm inputs to improve resource productivity and economic efficiency.

Conclusion

The analysis of Rajma production showed that seed, human labour, fertilizer and plant protection inputs all had a positive contribution to farm output. Among these resources, seed and human labour had relatively greater influence on production. The estimated production function explained 87.50 per cent of the variation in Rajma output, indicating a satisfactory fit of the model. The sum of the production elasticities was 1.2823, confirming the presence of increasing returns to scale. This indicates that Rajma production can be increased through improved and balanced use of the major production inputs.

The productivity estimates revealed positive marginal returns from all the resources considered. Human labour had the highest marginal physical product, followed by seed, fertilizer and plant protection. However, the resource-use efficiency estimates showed that the prevailing input combination was not fully optimal from an economic point of view. Seed and plant protection were found to be under-utilized, whereas human labour was over-utilized. Fertilizer use was close to the economically optimum level.

The estimated resource gaps indicated the need for an additional 27.24 kg of seed, 12.12 kg of fertilizer and 260.92 ml of plant protection chemicals per farm, while human labour use could be reduced by about 10.01 man-days. Therefore, the economic efficiency of Rajma production can be improved by increasing the use of under-utilized inputs, maintaining fertilizer application near the optimum level and reducing unnecessary dependence on manual labour. Overall, rational allocation of farm resources, timely input application and improved production management can contribute to higher Rajma productivity and better economic returns to farmers.

References

1. Chavan RV, More SS, Shelke RD. Resource productivity and resource use efficiency in chickpea production. *Int J Curr Microbiol Appl Sci*. 2020;9(5):2997-3001. doi:10.20546/ijcmas.2020.905.355.
2. Kumar A, Rohila AK, Pal VK. Profitability and resource use efficiency in vegetable cultivation in Haryana: application of Cobb-Douglas production model. *Indian J Agric Sci*. 2018;88(7). doi:10.56093/ijas.v88i7.81601.
3. Kumar S, Singh SP, Bhat A, Dwivedi S, Kachroo J. Resource use efficiency in Rajmash production by hill farmers of Jammu region of J&K state. *J Food Legumes*. 2018;31(2):117-118. doi:10.59797/journaloffoodlegumes.v31i2.126.
4. Patel UB, Leua A, Patel PM, Joshi R, Padaliya M. Resources use efficiency and resources utilization efficiency of major crops in North Gujarat, India. *Asian J Agric Ext Econ Sociol*. 2025;43(1):90-106. doi:10.9734/ajaees/2025/v43i12676.
5. Tanuja N, Upadhyay AD. Resource use efficiency analysis

- for cucumber production in the Bishnupur District of Manipur and Sepahijala District of Tripura, India. *Asian J Agric Ext Econ Sociol.* 2025;43(6):159-166. doi:10.9734/ajaees/2025/v43i62771.
6. Vasudeva Naik K, Jalikatti V, Chourad R, Ashok N. Resource use efficiency of soybean in Belagavi District of Karnataka, India. *Int J Curr Microbiol Appl Sci.* 2018;7(1):2155-2161. doi:10.20546/ijcmas.2018.701.259.
 7. Das KK, Sharma A. Effects on input use on rapeseed and mustard production in Nagaon District of Assam, India. *Int J Curr Microbiol Appl Sci.* 2018;7(5):629-634. doi:10.20546/ijcmas.2018.705.077.
 8. Felix KT, Govindarajan PLL, Rashtrarakshak VP. Optimizing resource use efficiency for sustainable paddy production in South India: a regional study. *Front Sustain Food Syst.* 2025;9. doi:10.3389/fsufs.2025.1665774.
 9. Department of Pulses Development, ICAR–Indian Institute of Pulses Research. Rajmash (*Phaseolus vulgaris* L.). Government of India/ICAR.