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# Economic Efficiency of French bean Production in Karnataka: An Economic Analysis

**R. Raghupathi[1*], M. J. Anjan Kumar[1] and A. P. Bhavya[1]**

*[1]Department of Agricultural Economics, College of UAS, GKVK, Bengaluru-560065, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The present study is an attempt to estimate the technical and allocativeefficienciy of French bean (*Phaseolus vulgaris L.)*producing farms in Mysore district of Karnataka, whereFrench bean is cultivated extensively. Data Envelopment Analysis (DEA) and Cobb-Douglas production function were used for estimating theeconomic efficiency and the factors determiningthe same.The study is based on the primary data collected from 70 randomly chosen French bean cultivators comprising of 35 sample farmers each growing Arkasharath and check varieties (Ashok) of French beans. The results revealed that farmers realised 45 per cent higher gross returns (Rs.2,62,500 acre$^{-1}$ ) from cultivation of ArkaSharath as pure crop compared the cultivatingcheck variety (Rs.2,01,750acre$^{-1}$)which indicated cultivation of Arkasharathwas more efficient compared to check variety.The results of the data envelopment analysis revealed that the technical, allocative and economic of Arkasharath variety was found to be 98, 78 and 76 per cent respectively while in case of check variety than were found to be 96, 75 and 73 per cent respectively.

*Keywords: Data enveloped analysis; economic efficiency; cost and returns.*

**Corresponding author: E-mail: raghupathir48@gmail.com;*

## 1. INTRODUCTION

Beans are a large group of leguminous vegetables that serve as the main source of proteins in the vegetarian human diet. French bean is also known as 'meat of the poor'1, 'grain of hope'2 and 'Superfood'3. It is one of the highly relished pulses because of its rich nutritional composition. Majority of the population in India being vegetarian, increased consumption of French bean will supplement their nutritional requirement. In southern Karnataka, French bean is extensively grown as a vegetable for fresh pods. The productivity of French bean is lower cultivate of traditional varieties which are low yielding and the prone to attack of pest and diseases realized in low yield and income to the farmers.

French bean (*Phaseolus vulgaris* L.) is one of the most important leguminous vegetable crops in India. It is known by many names such as a bush bean, common bean, dry bean, dwarf bean, green bean, haricot bean, kidney bean, navy bean, pole bean, rajma, snap bean, string bean, tepary bean or wax bean. It is extensively grown as an intercrop rather than as sole crop. The main constraint expressed by farmers when grown as an intercrop of French bean is low productivity. The main reasons for its extensive cultivation include its short duration, high nutritive values, soil fertility enhancing capacity and wider adoptability.

In the present study hasattempted to analyse the input use pattern, estimate the technical efficiency and constraints involved in cultivation of French bean. Findings of the study would help the followed byfarmers, policymaker'sresearcher and to take appropriate decisions for enhancing productivity and production.

## 2. MATERIALS AND METHODS

To assess the economic efficiency and technical efficiency of French bean cultivation, the required primary data were collected from 70 farmers in Mysore districts of Karnataka, comprising of 35 farmers cultivating Arkasharath and 35 farmers growing local varieties (Ashok) of French bean under irrigated condition the data were collectedthrough personnel interviews with the help of pretested schedule designed for the study. Data were analysed usingthe Data Envelopment Analysis (DEA) technique. Arkasharathvariety of French bean released from Indian Institute of Horticultural Research (IIHR), Bangalore is selected for the study.

### 2.1 Technical, Allocative and Cost Efficiencies

Technical Efficiency (TE) refers to the ability of a farm to produce the maximum feasible output from a given bundle of inputs, or the minimum feasible amounts of inputs to produce a given level of output. Allocative Efficiency (AE) refers to the ability of a technically efficient farm to use inputs in proportions that minimize production costs given input prices. Allocative efficiency is calculated as the ratio of the minimum costs required by the farm to produce a given level of outputs and the actual costs of the farm adjusted for TE. Economic Efficiency (EE) is the product of TE and AE. Thus, a farm is economically efficient if it is both technical and allocative efficient. The popular method of estimating the maximum possible output has been the *Data Envelopment Analysis* (DEA) advocated by Charnes et al., [1]. The details are given below.

### 2.2 Data Envelopment Analysis (DEA)

The DEA method is a frontier method that does not require specification of a functional form or a distributional form and can accommodate scale issues. DEA was applied by using both classic models CRS (Constant Returns to Scale) and VRS (Variable Returns to Scale) with input orientation, in which one seeks input minimization to obtain a particular production level. Under the assumption of constant returns to scale, the linear programming models for measuring the efficiency of farmers Coelli et al. [2] model was used.

$$\text{Min } \theta \lambda \theta$$

$$\text{Subject to } -yi + Y\lambda \geq 0$$

$$\theta Xi - X\lambda \geq 0$$

$$\lambda \geq 0 \qquad (1)$$

Where,

$y_i$is a vector (*mx1*) of output of the $i^{th}$French bean cultivating farmer

$x_i$is a vector (*kx1*) of inputs of the $i^{th}$French bean cultivating farmer

*Y* is an output matrix (*nxm*) for n French bean cultivating farmer

*X* s an input matrix *(n x k*) for n French bean cultivating farmer

θ is the efficiency score, a scalar value which measures efficiency of $i^{th}$French bean cultivating farmer. If θ=1, French bean cultivating farmers will be efficient; otherwise, they will be inefficient.

λ is a vector (*nx1*) whose values are calculated to obtain the optimum solution. For inefficient $i^{th}$ French bean cultivating farmers, the λ values will be the weights used in the linear combination of other, efficient, french bean cultivating farmers, which influence the projection of the inefficient French bean cultivations farmers on the calculated frontier [3-6].

The measure of technical efficiency obtained in the model with variable returns is also named pure technical efficiency as it is free of scale effects, and the following linear

Programming model is used for estimation.

$$\text{Min } \theta \lambda \theta$$

Subject to $-yi + Y\lambda \geq 0$

$$\theta Xi - X\lambda \geq 0$$

$$N1\lambda = 1$$

$$\lambda \geq 0 \qquad (2)$$

Where N1is a vector (*n x1*) of ones.

When there are differences between the values of the efficiency scores in the models CRS and VRS, scale inefficiency is confirmed, indicating that the returns to scale is variable, i.e., it can be increasing or decreasing (Fare and Grosskopf,1994). The scale efficiency values for each analysing unit can be obtained by the ratio between the scores for technical efficiency with constant and variable returns as follows.

$$\theta s = \theta_{CRS}(X_K, Y_K)/\theta_{VRS}(X_K, Y_K) \qquad (3)$$

Where,

$\theta_{CRS}(X_K, Y_K)$is the technical efficiency for the model with constant returns
$\theta_{VRS}(X_K, Y_K)$ is the technical efficiency for the model with variable returns
θs is scale efficiency

It was pointed out that model (1) makes no distinction as to whether farmer respondents are operating in the range of increasing or decreasing returns [2]. The only information that one has is that if the value obtained by calculating the scale efficiency in (2) is equal to one, the French bean cultivating farmers will be operating with constant returns to scale. However, when θs is smaller than one, increasing or decreasing returns to scale can occur. Therefore to understand the nature of scale inefficiency, it is necessary to consider another problem of linear programming i.e., the convexity constraint of a model (1), μ1λ=1, is replaced by μ1λ<1 for the case of non-increasing returns, or by μ1λ>1, for the model with non-decreasing returns. Therefore, in this paper, the following models were also used for measuring the nature of efficiency.
Non-increasing returns

$$\text{Min } \theta \lambda \theta$$

Subject to $-yi + Y\lambda \geq 0$

$$\theta Xi - X\lambda \geq 0$$

$$\mu 1\lambda \leq 1$$

$$\lambda \geq 0 \qquad (4)$$

Non-decreasing returns

$$\text{Min } \theta \lambda \theta$$

Subject to( -)$yi + Y\lambda \geq 0$

$$\theta Xi - X\lambda \geq 0$$

$$\mu 1\lambda \geq 1$$

$$\lambda \geq 0 \qquad (5)$$

It is to state here that all the models presented above should be solved n times, i.e., the model is solved for each French bean cultivations farmers in the sample. In the present study, Gross returns (≠) was used as an output (Y-dependent variable) and expenditure on seeds and fertilizers (≠), human labour expenditure (≠), FYM (≠), Plant protection chemicals (t) and expenditure on equipment replacement (≠) were used as inputs (Independent variable). The models were solved using the DEAP version 2.1 taking an input orientation to obtain the efficiency level [7,8].

## 2.3 Factors Determining the Technical Efficiency of French Bean

To analyse the factors determining the technical efficiency of French bean, regression analysis

**Table 1. Comparative economics of arkasharath variety and check variety of french bean cultivation (Rs. / acre)**

| Sl. No | Particulars | Unit | Arkasharath | | Check variety | | %change in cost of Arkasharath over check variety |
|---|---|---|---|---|---|---|---|
| | | | Quantity | Value (Rs) | Quantity | Value (Rs) | |
| A | **Variable cost** | | | | | | |
| 1 | Human labour | Mandays | 65 | 22750 (24.46) | 40 | 14000 (16.49) | 8750.00 (38.46) |
| 2 | Bullock labour | Pairdays | 1.53 | 1224 (1.32) | 1.61 | 1288 (1.52) | -64.00 (-5.23) |
| 3 | Machine labour | Hours | 7.5 | 7500 (8.06) | 6.3 | 6300 (7.42) | 1200.00 (16.00) |
| 4 | Seeds | Kgs. | 30 | 6000 (6.45) | 36 | 5400 (6.36) | 600.00 (10.00) |
| 5 | FYM | tonnes | 8.69 | 21725 (23.36) | 6.32 | 15800 (18.61) | 5925.00 (27.27) |
| 6 | Chemical fertilizer | Kgs. | 200 | 2700 (2.90) | 180 | 2430 (2.86) | 270.00 (10.00) |
| 7 | PPC | Rs. | | 5160 (5.55) | | 6585 (7.76) | -1425.00 (-27.62) |
| 8 | Irrigation | Inches | 5.3 | 1060 (1.14) | 4.5 | 900 (1.06) | 160.00 (15.09) |
| 9 | Mulching material | Rs. | | 8000 (8.60) | | 8000 (9.42) | 0.00 (0.00) |
| 10 | Transportation of resources | Rs. | | 450 (0.48) | | 500 (0.59) | -50.00 (-11.11) |
| | Sub total | | | 72344 (77.77) | | 65403 (77.05) | 6941.00 (9.59) |
| | Interest on working capital at 7% | Rs. | | 2170.32 (2.33) | | 1962.09 (2.31) | 208.23 (9.59) |
| | Total variable cost | Rs. | | 74514.32 (80.11) | | 67365.09 79.36) | 7149.23 (9.59) |
| B | Fixed cost | | | | | | 0.00 |
| 1 | Land revenue | Rs. | | 15 (0.02) | | 15 (0.02) | 0.00 0.00) |
| 2 | Depreciation | Rs. | | 540 (0.58) | | 445 (0.52) | 95.00 (17.59) |
| 3 | Rental value of land @ 10% of gross returns.. | Rs. | | 15000 (16.13) | | 15000 (17.67) | 0.00 0.00) |
| 4 | Interest on fixed capital at 10% | Rs. | | 2950 (3.17) | | 2063.5 (2.43) | 886.50 (30.05) |
| | Total fixed cost(B) | | | 18505 (19.89) | | 17523.5 (20.64) | 981.50 (5.30) |
| | Total cost of cultivation(A+B) | | | 93019.32 (100.00) | | 84888.59 (100.00) | 8130.73 (8.74) |
| C | Returns | | | | | | 0.00 |
| 1 | Main product | Tons | 17.5 | 15000 | 13.45 | 15000 | 4.05 |
| 2 | Gross returns | Rs. | | 262500 | | 201750 | 60750.00 |
| 3 | Net returns | Rs. | | 169480.7 | | 116861.4 | 52619.00 |
| 4 | Returns per rupee of investment | | | 2.82 | | 2.38 | 0.45 |

was attempted, considering the technical efficiency score as dependent variable (Yield) and human labour, bullock labour, machine labour, seed, fertilizer, FYM and plant protection chemicals used in the case French bean cropas independent variables.

The empirical model was:

$$Y= aX1 + bX2 + cX3 + dX4 + eX5 + fX6+ gX7 + e \quad (6)$$

Where,

Y = Yield
X1 = Seed (kg/acre)
X2 = chemical fertilizer (kg)
X3= Human labour (man days)
X4= Bullock labour (pair days)
X5= FYM (tons)
X6= Tractor(hours)
X7 = Plant protection chemicals (Rs.)

## 3. RESULTS AND DISCUSSIONS

It is evident from the Table 1 that Arkasharathcultivating farmers used higher human labour (65 man-days), machine labour (7.5 hours), and chemical fertilisers (200 kgs) compared to 40 man-days of human labour, 6.3 hours of machine labour, and 180kgs of chemical fertilisers in the case of check variety.

The total variable cost was Rs. 74,514.32 (80.11) and Rs.67, 643.19 (79.36%) for Arkasharathfarms and local French bean check variety farms, respectively.In the case of Arkasharthfarms, among the various items of expenditure, the cost of human labour was the highest (Rs. 22750) and accounted for 24.46 per cent of the total cost of cultivation whereas as it was Rs. 14000 (16.49) in the case of check variety growing farms. The cost of chemical fertilisers accounted for 2.90per cent and 2.86 per cent per acre of total cost in Arkasharathfarms and check variety of French bean respectively. The expenditure incurred on farmyard manure was relatively less in Arkasharathgrowing farms (Rs.21,725) compared to check variety growing farms (Rs. 15,800). With respect to usage of bullock labour also farmers growing check variety spent more(Rs. 1,288) comparedto those growing Arkasharathvariety (Rs. 1,224).

The proportion of total fixed cost in total cost of cultivation was 20.64 per cent (Rs. 17,524) in the case of check variety growing farms while it was 19.89 per cent (Rs.18,505) in the case of Arkasharathfarms. The rental value of land was was the major item of cost and it was Rs.15, 000(17.67%) in the case of check variety farms whereas it was Rs. 15, 000(Rs.16.13%) in the case of Arkasharathgrowing farms. Farmers spent Rs. 6,585 (7.76%) and Rs. 5,160 (5.55%) on plant protection chemicals in the case of local variety and Arkasharathvariety growing farms, respectively. The cost of mulching material in both categories of farmers was nearly the same.

The French bean yield obtained was 17.50 tonnes in the case of Arkasharathas against 13.45 tonnes in the case of check variety. Valuing at the market price, the gross returns realized by the Arkasharath (Rs. 2,62,500) variety growing farmers was 44.98 per cent higher than check variety growing farmers (Rs. 2,01,750). The net returns realized by Arkasharathfarmers and check variety farmers were Rs. 1,69,481 and Rs. 1,16,861 respectively.

In terms of expressed that human labour and machine labour is 38.46 and 16.00percent, higher in case of Arkasharath compared to local variety practices. The farmyard manure, plant protection chemicals and seed rate is 14.28, 27.61 and 15.00 percent lower in Arkasharath farmers compared to case of local variety farmers.

It is evident from the Table 2 that in the case of Arkasharath farms, about 85.71 per cent farms (under the assumption of constant returns to scale) performed with technical efficiency level of 0.9 and above. While (under the assumption of variable returns to scale)91.20 per cent farms performed with technical efficiency score was 0.9 and above. The average technical efficiency score registered by the respondents was 0.95 and 0.98 under the assumptions of constant returns to scale and variable returns to scale, respectively.

Similarly in the case of farmers growing check variety 25.71 per cent farmersperformed with technical efficiency level higher than equal to 0.9 under the assumption of constant returns to scale. The average technical efficiency score was 0.94 and 0.96 under the assumptions of constant returns to scale and variable returns to scale, respectively. Thus it could be observed that Arkasharath farmers exhibited greater technical efficiency in French bean cultivation than check variety farmers under the both CRS and VRS.

**Table 2. Categorisation of french bean farmers according to technical efficiency, allocative efficiency and economic efficiency scores**

| Sl. No | Level of efficiency (%) | Arkasharath farms | | | | | |
|---|---|---|---|---|---|---|---|
| | | Constant return to scale(CRS) | | | Variable return to scale(VRS) | | |
| | | Technical efficiency | Allocative efficiency | Economic efficiency | Technical efficiency | Allocative efficiency | Economic efficiency |
| 1 | 90 and above | 30 (85.71) | 5 (14.28) | 5 (14.28) | 32 (91.20) | 8 (22.85) | 8 (22.85) |
| 2 | 80 to 89.99 | 4 (11.42) | 11 (31.42) | 8 (22.85) | 2 (5.71) | 7 (20.00) | 9 (25.71) |
| 3 | 70 to 79.99 | 1 (2.85) | 8 (22.85) | 9 (25.71) | 1 (2.85) | 8 (22.85) | 5 (14.28) |
| 4 | 60 to 69.99 | 0 (0.00) | 5 (14.28) | 7 (20.00) | 0 (0.00) | 5 (14.28) | 7 (20.00) |
| 5 | 50 to 59.99 | 0 (0.00) | 4 (11.42) | 4 (11.42) | 0 (0.00) | 4 (11.42) | 5 (14.28) |
| 6 | <50 | 0 (0.00) | 2 (5.71) | 2 (5.71) | 0 (0.00) | 3 (8.57) | 1 (2.85) |
| 7 | Total | 35 (100) | 35 (100) | 35 (100) | 35 (100) | 35 (100) | 35 (100) |
| | Mean | 0.95 | 0.75 | 0.73 | 0.98 | 0.78 | 0.76 |
| | | Check variety farms | | | | | |
| 1 | 90 and above | 28 (25.71) | 10 (28.57) | 9 (25.71) | 31 (74.28) | 14 (40.00) | 11 (31.42) |
| 2 | 80 to 89.99 | 5 (14.28) | 2 (5.71) | 1 (2.85) | 4 (11.42) | 3 (8.57) | 2 (5.71) |
| 3 | 70 to 79.99 | 3 (8.57) | 7 (20.00) | 8 (22.85) | 1 (2.85) | 9 (25.71) | 10 (28.57) |
| 4 | 60 to 69.99 | 0 (0.00) | 8 (22.85) | 1 (2.85) | 0 (0.00) | 5 (14.28) | 4 (11.42) |
| 5 | 50 to 59.99 | 0 (0.00) | 5 (14.28) | 5 (14.28) | 0 (0.00) | 1 (2.85) | 7 (20.00) |
| 6 | <50 | 0 (0.00) | 3 (8.57) | 11 (31.42) | 0 (0.00) | 3 (8.57) | 1 (2.85) |
| 7 | Total | 35 (100) | 35 (100) | 35 (100) | 35 (100) | 35 (100) | 35 (100) |
| | Mean | 0.94 | 0.73 | 0.71 | 0.96 | 0.75 | 0.73 |

*Note: figures in parentheses are percentages to the respective totals*

With regard to allocative efficiency is concerned 31.42 percent of Arkasharathfarmers and 28.57percent of check variety farmers attained efficiency level 0.8-0.9 under the CRS assumption. In case of allocative efficiency of under assumption of VRS 22.85 per cent performed with efficiency more than above 0.9 per cent. While in case of check variety of allocative efficiency 25.71 per cent of farmer's performed with efficiency more the 0.7 per cent respectively. It shows that, check variety farmers are comparatively less efficient than the Arkasharathvariety cultivating farmers. The average allocative efficiency score was 0.75 and 0.78 for Arkasharathfarmers under the assumption of CRS and VRS, respectively, the corresponding figures were 0.73 and 0.75 for check variety farmers.

Economic efficiency score for ArkaSharath farmers was 0.73 and 0.76 under the assumption of CRS and VRS, respectively, whereas as in the case of check variety farmers it was 0.71 and 0.73 under the assumption of CSR and VRS, respectively. It was evident from the analysis that farmers of ArkaSharathoperating at higher economic and allocative efficiency compared check variety farmers in using production inputs.

**Table 3. Factors associated with technical efficiency of French bean –cultivation farmers in Karnataka**

| Sl. No | Variables | ArkaSharth variety farmers | | Check variety farmers | |
|---|---|---|---|---|---|
| | | Coefficients | t Stat | Coefficients | t Stat |
| 1. | Intercept | 4.500 | 2.590 | 0.420 | 9.299 |
| 2. | Seed(kg) | 0.082 | 0.192 | 0.116 | 2.328** |
| 3. | Chemical fertilizers (Kg) | -0.011 | -0.042 | 0.092 | -0.970 |
| 4. | Human labour | -0.021 | 4.395** | 0.131 | 2.260** |
| 5. | Bullock labour (no's.) | -0.066 | -0.204 | 0.215 | 1.959 |
| 6. | Farmyard manure (load) | 0.201 | 0.852 | 0.078 | 0.946 |
| 7. | Tractor (hrs.) | 0.043 | 0.280 | 0.094 | -0.264 |
| 8. | PPC | -0.203 | -0.590 | 1.061 | 3.163** |

*Note: PPC- Plant Protection Chemicals; ** Significance at 5 per cent level*

The estimates of production function analysis presented in Table 3 revealed that the, regression coefficient of human labour was positive and significant at five per cent level of probability for both the Arkasharthvariety (4.32) and check variety (2.25), in case of arkasharath variety 1 per cent increasing human labour decreases yield by 0.021per cent where in case of check variety increases yield by 0.116 per cent. In case of check variety farms the regression coefficient of seeds was positive (2.32) and it contributed significantlyfive per cent level of probability. In the case of check variety, regression coefficient of Plant Protection Chemicals was positive (3.16) and it also contributed significantly at five per cent level of probability.

## 4. CONCLUSIONS

The gross returns realized by the Arka Sharth farmers growing as pure crop was Rs.2,62,500,per acre whereas it was Rs.2,01,750 by check variety (local variety of French bean) farmers with a difference of Rs. 60,750 per acre, higher than check variety of Farms. The net return of arka sharath was the higher (Rs.1,69,480 per acre) Arka Sharath of French bean farms than (Rs. 1,16,841 per acre) for check variety farms, with a difference of Rs. 52,619 higher than the local variety of French bean. The technical, allocative and economic of arka sharath variety was found to be 98, 78, and 76 per cent respectively while in case of check variety thus was found to be 96, 75 and 73 per cent respectively.

Technical efficiencies have been estimated for one of the important vegetables, viz. French bean using data envelopment analysis (DEA). The factors influencing the technical efficiency of French bean production have been analysed determined using the regression equation. The input use pattern in French bean production among different categories of farmers highlighted that most of the applied inputs were found to be in lower than the recommended acreage. This suggests that there is potential to increase the overall production, by in French bean cultivation.

The Arka Sharath variety of French bean performing well in field conditions and offering higher returns to the farmersin comparison with check varieties. The main emphasis of this study is on increasing the production, income and employment opportunity at farmer's level. In this context, the study will be of great importance to recognize whether the improved IIHR (Indian Institute of Horticultural Research) technology verities is profitable and whether it has provided additional production opportunities to the technology adopters.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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