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# An Econometric Analysis of Resource Use Efficiency of Finger Millet (*Eleusine coracana* L.) Production in Karnataka

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**ABSTRACT**

The study was conducted in Bengaluru rural and Ramanagara districts of Karnataka to assess the resource use pattern and efficiency in finger millet production. The sampling frame consisted of 30 rainfed and 30 irrigated finger millet producers in each district totaling to 120 farmers. Farm household survey was carried out to collect the primary information from the selected finger millet producers by using the pre-tested interview schedules. Cobb-Douglas type of production function (per hectare) was used to assess the resource use efficiency in finger millet production. Results indicated that, there was significant difference between rainfed and irrigated finger millet production in use of human labour, seeds and fertilizers. The regression co-efficient of human labour (0.11), bullock and machine labour (0.10) and fertilizer (0.15) were found to be statistically significant at one per cent in irrigated situation, whereas in rainfed situation, human labour (0.31), fertilizer (0.04) was statistically significant at one per cent, seed (0.08) was statistically significant at five per cent. The allocative efficiency was estimated by using the geometric mean levels of the output as well as inputs. The ratio of marginal value product (MVP) to marginal factor cost (MFC) under rainfed situation in case of human labour, bullock and machine labour, seed, FYM and fertilizer was 0.68, 0.05, 0.77, 0.07 and 0.46, respectively indicating that, there is no scope for using additional units of the factors and expenditure or use of inputs should be reduced to optimize the production system. Whereas, in irrigated situation,ratio of MVP to MFC was less than one in case of human labour (0.35), bullock and machine labour (0.39), seed (0.69) and irrigation (0.47), indicating that an expenditure of one rupee on human labour, bullock and machine labour, seed and irrigation gives only ₹ 0.35, ₹ 0.39, ₹ 0.69 and ₹ 0.47, respectively. It is evident from the study that, inputs are not optimally utilized in finger millet production. Hence, farmers should be educated regarding the sustainable use of recourses which helps in increasing the returns and reduces cost as most of the resources are over utilized in finger millet production.

**Keywords:** Resource use efficiency, production, Cobb-Douglas, allocative efficiency, sustainable

Agricultural productivity mainly depends upon how efficiently the available scarce resources (factors) are utilized in the production process. Hence, intensive cultivation of agricultural land and use of improved technologies must be accompanied by resource use efficiency that enhances productivity of factors. Resource use efficiency in agriculture may be viewed through technical efficiency, allocative efficiency and economic efficiency. An efficient farmer will allocate his land, labour, capital, water and other scarce resources in an optimal manner to maximize his net income, at least cost, on a sustainable basis (Haque, 2006). The net returns vary significantly from farm to farm as the efficiency of resources and the managerial efficiency of farmers vary. It is evident from many past studies that, farmers' may over-exploit their land and other resources for maximizing farm income in the short run, thereby posing a problem of sustainability of agriculture in the long run.

Improvements in resource use efficiency hence increase in productivity will protect the scarce resource base of the farmers against degradation. More importantly, efficient resource use is the basis for achieving universal food security and poverty reduction strategies particularly in the rural areas.

Finger millet (*Eleusine coracana* L.) is known for its high mineral contents (Chethan and Malleshi, 2007). Finger millet is grown mainly by small and marginal farmers and is the staple diet in many villages across South India. It is also used as a major substitute for rice among the diabetic patients and also the diet conscious people. Karnataka is the second drought prone area next to Rajasthan in India (Srikantha and Indumati, 2011). Since, finger millet is a drought resistant crop, mainly grown in rain fed situation, staple food of farmers in Karnataka, assessment of the existing level of resource-use efficiency in finger millet assumes paramount importance. Hence, the present study was conducted with the specific objective of assessing the resource use pattern and resource use efficiency in finger millet production.

## METHODOLOGY

### Primary data

The data was collected from 60 farmers (30 rainfed and 30 irrigated farmers) in Bengaluru rural and Ramanagara districts of Karnataka by employing simple random method of sampling. The data was collected from Bengaluru rural and Ramanagara Districts as these two districts ranks second and third in productivity. Bengaluru urban ranks first in productivity but because of urbanization this was not considered for the study. Data were collected from the sample farmers using pre-tested, well-structured schedule through personal interview method for the agricultural year 2013-14 for irrigated situation and 2014-15 for rainfed situation. The data collected were purely based on the memory of the respondents.

### Resource use efficiency

Cobb-Douglas type of production function (per hectare) was used to assess the resource use efficiency in finger millet production. Linear regression of the Cobb-Douglas type of production function was employed (Doll and Orazem, 1985). The Cobb-Douglas production function was linearized through transformation into a double log (Eq. 1). Ordinary least square (OLS) was used for estimating finger millet production function (Doll and Orazem, 1985).

The specification of the equation for rainfed finger millet cultivation and irrigated finger millet cultivation is given in the equation 1 and 2, respectively.

$$Y = aX_1b_1\ X_2b_2\ X_3b_3\ X_4b_4\ X_5b_5e^u \qquad \ldots(1)$$

$$Y = aX_1b_1\ X_2b_2\ X_3b_3\ X_4b_4\ X_5b_5\ X_6b_6e^u \qquad \ldots(2)$$

Where,

Y = Gross returns (₹)

$X_1$ = Human labour (Man days).

$X_2$ = Bullock and machine labour cost (₹)

$X_3$ = Seeds (kg)

$X_4$ = FYM (Tractor load).

$X_5$ = Fertilizers (₹)

$X_6$ = Irrigation (₹)

a = Intercept

u = Random variable

$b_1$ to $b_6$ indicate regression coefficients of respective inputs and implicitly represents the elasticity of production of respective inputs.

The equations (1 and 2) were transformed into the logarithmic form (log linear) and the same is represented as follows,

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + u \log e \qquad \ldots(3)$$

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + u \log e \qquad \ldots(4)$$

### Marginal Value Product (MVP)

The estimated coefficients were used to compute the MVP. By studying the marginal value product of factors of production, we can assess their relative importance. Marginal Value Product of $X_i$, the $i^{th}$ input is estimated by the following formula,

$$MVP = b_i * \frac{Geometric\ mean\ of\ output}{Geometric\ mean\ of\ i^{th}\ output}$$

$b_i$ is the regression co-efficient of $i^{th}$ input.

### Marginal factor cost (MFC)

Per unit cost of input was taken for those variables expressed in terms of units and 1 was taken for the variables expressed in monetary terms (₹).

The model was estimated as follows,

$$r = \frac{\text{Marginal Value Product}(\text{MVP})}{\text{Marginal Factor Cost}(\text{MFC})}$$

Where, r = efficiency ratio

Based on economic theory, a firm maximizes profits with regards to resource use when the ratio of the marginal return to the opportunity cost is one. The values are interpreted thus,

If r is <1; resource is excessively used or over utilized (no scope to increase the use) hence, decreasing the quantity use of resource increases the profits.

If r > 1; resource is under used or being underutilized (there is a scope to increase the use) hence, increasing its rate of use will increase profit level.

If r = 1; it shows the resource is efficiently used, that is optimum utilization of resource hence the point of profit maximization.

## RESULTS AND DISCUSSION

### Resource use pattern

The extent of input use in rainfed and irrigated finger millet cultivation by farmers revealed that, the use of human labour was found to be higher in irrigated finger millet cultivation (95.20 man days) when compared to rainfed finger millet cultivation (68.08 man days) and this was found to be statistically significant (reasons). The seed rate used was high in rainfed finger millet (23.34 kg ha$^{-1}$) because the sowing method practiced was broadcasting, which usually requires high seed rate whereas, in irrigated situation transplanting (16.21 kgha$^{-1}$) was practiced (Recommended seed rate per hectare for rainfed and irrigated situation is 10-12 kg and 5 kg, respectively). The expenditure on fertilizer was higher in irrigated finger millet cultivation (₹ 5,228) compared to the rainfed finger millet cultivation (₹ 3,914) and was statistically significant (reasons). Per ha FYM applied was 2.86 and 3.13 tractor load in rainfed and irrigated situation, respectively. Use of fertilizer and FYM was more in irrigated situation because of intensive cultivation. About 5.5 and 6.0 bullock pair days was employed per hectare under rainfed and irrigated situation, respectively. However, the differences in the use of bullock labour, machine labour and FYM were found to be statistically non-significant. The expenditure on irrigation was ₹ 3,943 ha$^{-1}$ in irrigated finger millet cultivation (Table 1).

**Table 1:** Resource - use pattern in rainfed and irrigated finger millet cultivation (ha$^{-1}$)

| Sl. No. | Particulars | Rainfed | | Irrigated | | 't' Value (Qty.) |
|---|---|---|---|---|---|---|
| | | Quantity | Value (₹) | Quantity | Value (₹) | |
| 1 | Human labour (Man days) | 68.08 | 13,617 | 95.20 | 19,040 | -6.18** |
| 2 | Bullock labour (BP days) | 5.41 | 4,318 | 6.25 | 5,000 | -1.40 NS |
| 3 | Machine Labour (hours) | 11.51 | 8,449 | 12.70 | 9,841 | -1.38 NS |
| 4 | Seeds (kgs) | 23.34 | 350 | 16.21 | 300 | 4.59** |
| 5 | FYM (tractor load) | 2.86 | 5,991 | 3.13 | 7,039 | -1.06 NS |
| 6 | Fertilizer cost | — | 3,866 | — | 5,228 | -3.71** |
| 7 | Irrigation cost | — | — | — | 3,943 | — |

*Note: 1. ** - Significant at one per cent.*
*2. NS- Non-significant.*
*3. In case of fertilizer, value was used for comparison*

### Labour use

The details regarding total labour employed in rainfed and irrigated finger millet cultivation is presented in Table 2. Finger millet is a labour intensive crop where women labour was mainly used for transplanting, weeding and threshing operations. Use of labour was found substantially higher in irrigated situation (95 man days) compared to that of rainfed situation (68 man days) and was statistically significant. Use of human labour was high in irrigated situation due to transplanting method of sowing, irrigation practices and the yield was also high which requires more number of labour for harvesting and post-harvest operations. More than 45% of the total labour was used for harvesting and threshing. In rainfed cultivation, out of 68 man days of labour employed, 37 man days was employed for harvesting and threshing followed by weeding and irrigation (16 man days), cleaning and bagging (7), manure and fertilizer application (5) and sowing (3 man days).

**Table 2:** Labour utilization pattern in rainfed and irrigated finger millet cultivation (ha$^{-1}$)

| Sl. No. | Particulars | Rainfed | | | Irrigated | | | 't' Value |
|---|---|---|---|---|---|---|---|---|
| | | Men | Women | Total Mandays | Men | Women | Total Mandays | |
| 1 | Nursery/ Sowing/ Transplanting | 2 (5) | 1 (2) | 3 (4) | 6 (11) | 11 (20) | 14 (15) | -20.12** |
| 2 | Manure and Fertilizer application | 5 (14) | 0 (0) | 5 (7) | 6 (11) | 0 (0) | 6 (6) | -1.73 NS |
| 3 | Weeding and irrigation | 1 (3) | 20 (48) | 16 (24) | 12 (23) | 16 (29) | 24 (25) | -6.32** |
| 4 | Harvesting and threshing | 24 (65) | 18 (43) | 37 (54) | 23 (44) | 28 (50) | 44 (47) | -3.31** |
| 5 | Others (cleaning and bagging) | 5 (14) | 3 (7) | 7 (10) | 6 (11) | 1 (2) | 7 (7) | -0.31 NS |
| | **Total** | 37 (100) | 42 (100) | 68 (100) | 53 (100) | 56 (100) | 95 (100) | — |

*Note: 1. Figures in parentheses indicates percentage.*
*2. ** - Significant at one per cent.*
*3. NS= Non-significant.*

In irrigated finger millet cultivation, totally 95 man days of labour was employed ha$^{-1}$. Among these, majority of labour was utilized for harvesting and threshing (44 man days) followed by weeding and irrigation (24 man days) and nursery and transplanting (14 man days).

Fourteen man days of labour was used for nursery and transplanting which was found statistically significant as against three man days for sowing in rainfed finger millet cultivation. Labour man days used for weeding and irrigation in case of irrigated finger millet cultivation was 24, whereas it was 16 man days for weeding in rainfed finger millet cultivation. Significantly more number of man days was employed in irrigated finger millet cultivation than in rainfed finger millet cultivation for harvesting and threshing.

### *Bullock and machine labour*

In finger millet cultivation, bullock labour is mainly used for inter-cultivation and land preparation activities. In rainfed area, 5.41 bullock pair days was used, of which 63% was used for inter-cultivation and 37% for land preparation and sowing. Similar use was also noticed in case of irrigated situation (Table 3).

Machine labour was mainly used for land preparation, threshing and marketing and transportation. In rainfed finger millet cultivation, 11.50 hours of machine labour was utilized of which 62%, 26% and 22% was used for land preparation, threshing and marketing and transportation. In irrigated area, 12.70 hours of machine labour was employed. Forty seven per cent of the machine labour was used for land preparation followed by 29% for threshing and marketing and 24% for transportation. There is a significant difference in the use of machine labour for land preparation and transportation between rainfed and irrigated finger millet cultivation (Table 3).

## Resource-use efficiency in rainfed and irrigated finger millet production

### *Cobb-Douglas production function estimates in finger millet production*

The Cobb-Douglas type of production function as specified in the methodology chapter was used to identify the factors influencing finger millet production in rainfed and irrigated situations. The Cobb-Douglas production function was estimated by using Ordinary Least Squares (OLS) technique and the regression coefficients represent individual elasticity of production. It is to state that, if the value of elasticity of production is less than one meaning, a unit increase in the input would result in less than a unit increase in the gross returns.

**Table 3:** Bullock and machine labour utilization pattern in rainfed and irrigated finger millet-cultivation (ha$^{-1}$)

| Sl. No. | Operation | Rainfed | | Irrigated | | 't' Value (BP) | 't' Value (M. hrs.) |
|---|---|---|---|---|---|---|---|
| | | BP days | Machine (hrs.) | BP days | Machine (hrs.) | | |
| 1 | Land preparation and sowing | 2.00 (37) | 7.00 (62) | 2.00 (32) | 6.00 (47) | -0.88 NS | 2.21* |
| 2 | Transportation | 0.00 (0) | 2.50 (22) | 0.00 (0) | 3.00 (24) | — | -8.17** |
| 3 | Inter -cultivation | 3.41 (63) | 0.00 (0) | 4.25 (68) | 0.00 (0) | -1.64 NS | — |
| 4 | Threshing and marketing | 0.00 (0) | 3.00 (26) | 0.00 (0) | 3.70 (29) | — | -1.84 NS |
| | **Total** | 5.41 (100) | 11.50 (100) | 6.25 (100) | 12.70 (100) | — | — |

*Note: 1. Figures in parentheses indicates percentage; 2. ** - Significant at one per cent; 3. * - Significant at five per cent. 4. NS= Non-significant.*

**Rainfed situation:** The co-efficient of multiple determination ($R^2$) for rainfed finger millet cultivation was 0.57 indicating that the variables included in the production function explained about 57% of the variation in the production (Table 4). Yield elasticities as the estimated coefficients for the variables were generally less than one, implying existence of inelastic-relationships between yield and most of the variables (Kidoido *et al.*, 2002).

The regression co-efficient of human labour, bullock and machine labour, seeds, FYM and fertilizer was 0.3112, 0.0207, 0.0865, 0.0096 and 0.0490, respectively. However, human labour, fertilizer was statistically significant at one per cent, seed was statistically significant at five per cent and the remaining factors like FYM, bullock and machine labour were found to be non-significant.

One per cent increase in the use of human labour, seed and fertilizer above its geometric mean level will lead to 0.3112, 0.0865 and 0.0490% increase in gross return (₹) from its geometric mean level. The overall regression model was found to be significant at one per cent. The strong positive effect of seed rate on grain yield was expected since plant population densities in farmer broadcast finger millet are reportedly lower than the optimum recommendation for the crop (Kidoido *et al.*, 2002). Under broadcast method of sowing, the crop was unevenly distributed i.e. overcrowded in some areas and sparsely distributed in others. Hence, there is a need to educate and motivate the farmers to adopt mechanized sowing for attainment of optimum plant population density and, consequently, optimum yields, apart from easing on weeding labour requirements (Nyende *et al.*, 2001).

**Irrigated situation:** The co-efficient of multiple determination ($R^2$) for irrigated finger millet cultivation was 0.64. The specified Cobb-Douglas production function was significant at one per cent.

The regression co-efficient of human labour (0.1193), bullock and machine labour (0.1003) and fertilizer (0.1593) were found to be statistically significant at one per cent. Whereas the regression co-efficient of seed (0.0363), FYM (-0.0308) and irrigation (0.0306) were non-significant. One per cent increase in the use of human labour, fertilizer, bullock and machine labour above its geometric mean level will lead to 0.1193, 0.1593 and 0.0363% increase in gross return (₹) from its geometric mean level (Table 4).

## Allocative efficiency

Allocative (price) efficiency refers to the ability of the firm to combine inputs and outputs in optimal proportions in the light of prevailing prices, and is measured in terms of behavioral goal of the production unit like observed vs optimum cost or observed profit vs optimum profit. The allocative efficiency was estimated by using the geometric mean levels of the output as well as inputs. The geometric mean level of input use in rainfed and irrigated finger millet production are presented in Table 5 and 6, respectively. Results of allocative efficiency indicated that, resources were not optimally utilized in both rainfed (Table 5) and irrigated situation (Table 6).

**Rainfed situation**: The ratio of MVP to MFC in case of human labour, bullock and machine labour, seed, FYM and fertilizer was 0.68, 0.05, 0.77, 0.07 and 0.46, respectively (Table 4). Indicating that, for every additional rupee spent on these inputs would

**Table 4:** Estimates of the Cobb-Douglas production function in rainfed and irrigated finger millet production [Dependent variable (Y): Gross returns in rupees $ha^{-1}$]

| Sl. No. | Variables | Parameters | Rainfed finger millet | Irrigated finger millet |
|---|---|---|---|---|
| 1 | Intercept | a | 4638** (18.64) | 2842** (17.22) |
| 2 | Human labour in Mandays ($X_1$) | $b_1$ | 0.3112** (4.66) | 0.1193** (2.59) |
| 3 | Bullock and machine labour in ₹ ($X_2$) | $b_2$ | 0.0207 (0.38) | 0.1003** (2.30) |
| 4 | Seeds in kg ($X_3$) | $b_3$ | 0.0865* (2.00) | 0.0363 (1.13) |
| 5 | FYM in tractor load ($X_4$) | $b_4$ | 0.0096 (0.80) | -0.0308 (-1.90) |
| 6 | Fertilizer in ₹ ($X_5$) | $b_5$ | 0.0490** (4.82) | 0.1593** (3.85) |
| 7 | Irrigation in ₹ ($X_6$) | $b_6$ | — | 0.0306 (0.88) |
| 8 | Co-efficient of multiple determination | $R^2$ | 0.57 | 0.64 |
| 9 | F value | | 14.15** | 10.49** |

***Note:*** *1. **- Significant at 1%; 2. * - Significant at 5%; 3. Figures in parentheses represents 't' value.*

**Table 5:** Resource - use efficiency in rainfed finger millet cultivation ($ha^{-1}$)

| Variables | Input use at geometric mean level | Coefficient | MVP | MFC | MVP/MFC |
|---|---|---|---|---|---|
| Human labour (Mandays) | 65.39 | 0.3112 | 136.66 | 200 | 0.68 |
| Bullock and Machine labour (₹) | 11,927.69 | 0.0207 | 0.05 | 1 | 0.05 |
| Seed (kgs) | 21.49 | 0.0865 | 11.55 | 15 | 0.77 |
| FYM (tractor load) | 1.90 | 0.0096 | 144.07 | 2096 | 0.07 |
| Fertilizer (₹) | 3,056.92 | 0.0490 | 0.46 | 1 | 0.46 |

**Table 6:** Resource - use efficiency in irrigated finger millet cultivation ($ha^{-1}$)

| Variables | Input use at geometric mean level | Coefficient | MVP | MFC | MVP/ MFC |
|---|---|---|---|---|---|
| Human labour (Mandays) | 91.49 | 0.1193 | 69.41 | 200 | 0.35 |
| Bullock and Machine labour (₹) | 13,687.81 | 0.1003 | 0.39 | 1 | 0.39 |
| Seed (kgs) | 14.64 | 0.0363 | 13.19 | 19 | 0.69 |
| FYM (tractor load) | 2.57 | -0.0308 | -636.91 | 2253 | -0.28 |
| Fertilizer (₹) | 4,731.50 | 0.1593 | 1.79 | 1 | 1.79 |
| Irrigation (₹) | 3,469.87 | 0.0306 | 0.47 | 1 | 0.47 |

give return of ₹ 0.68, ₹ 0.05, ₹ 0.77, ₹ 0.07 and ₹ 0.46. The ratio of MVP to MFC was less than one for all inputs. Hence, there was no scope for using additional units of the factors. Expenditure on all inputs must be reduced for optimum allocation of resources and also induces sustainability in production process. Similar results were observed in the study conducted by Praveen and Mishra (2011). Resources are utilized more than the requirement and this is also evident by the excess use of seed rate.

**Irrigated situation**: The ratio of MVP to MFC was less than one (over used but are still in the rational region of the production)in case of human labour (0.35), bullock and machine labour (0.39), seed (0.69) and irrigation (0.47), indicating that an expenditure of one rupee on of human labour, bullock and machine labour, seed and irrigation gives only ₹ 0.35, ₹ 0.39, ₹ 0.69 and ₹ 0.47, respectively. Hence, there was no scope for using additional unit of the input. The negative ratio for FYM (-0.28) indicated that FYM was used at higher level than necessary resulting in loss. Hence, the withdrawal of FYM would enhance the profit in irrigated finger millet production. MVP to MFC ratio for fertilizer was more than one indicating that there is scope to increase the use of fertilizer (Vasanthi *et al*., 2015). An investment of one rupee on fertilizer would give additional gross return of ₹ 1.79 (Table 6). The null hypothesis that, the resources are not efficiently utilized in finger millet production was accepted. Hence number of management factors such as method of sowing, transplanting, irrigation and application of right doses of inputs and input mix play an important role in optimum utilization of the scarce resources and also to increase the productivity (Selvarajan *et al*., 1997).

## CONCLUSION

It is evident from many studies that, the resources are not efficiently utilized and it is also similar in case of finger millet. Results revealed that, most of the resources in both rainfed and irrigated finger millet cultivation were over utilized. Hence, there is a need to educate farmers regarding the efficient and sustainable use of the scarce resources which helps in increasing the crop productivity vis-a-vis returns. The common method of sowing practiced in rainfed cultivation was broadcasting which resulted in uneven planting density leading to competition among plants which hinders the crop productivity. Finger millet is a labour intensive crop, which calls to encourage mechanization as there is scarcity of labour. Extension activities are needed to educate the farmers regarding the optimum and timely use of scarce resources. Optimizing the use of resources reduces cost on one hand and increases returns on the other hand and sustainable production process is possible if the resources are used optimally.

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