RESOURCE PRODUCTIVITY OF SORGHUM IN MAHARASTRA STATE, INDIA

Jimjel. Zalkuwi[2], Rakesh Singh[2], Madhusudan Bhattarai[3], O.P Singh[4],

[1.2.4]Department of Agricultural Economics, Institute of Agricultural science, BHU, Varanasi-221 005.

[3]ICRISAT India

ABSTRACT: *The study examined the efficiency of sorghum production in Maharashtra State, India. The technical, allocative and economic efficiencies of farmers producing sorghum were analysed from 100 randomly selected sorghum farmers. The maximum likelihood estimates of the stochastic frontier production function was used for the analysis, and the result revealed that farm size, labour, fertilizer and chemicals were significantly and positively related to sorghum output. The technical efficiency (TE) scores ranged from 0.28-0.94 with a mean TE of 0.67, implying that there is a scope for increasing technical efficiency in sorghum production by 33% in the short-run. The allocative efficiency index ranged from 0.11-0.90 with a mean of 0.54, implying that the average farm has the scope of increasing allocative efficiency by 46% in the short-run. The economic efficiency index ranged from 0.09-0.75 with a mean of 0.37, indicating wide efficiency differential between average farmers and the economically efficient farmers. The result of the stochastic frontier production function analysis showed that the variance parameters that is the sigma squared (d2) and the gamma (ϒ) were statistically significant at 1% level of sorghum production*

Highlights

- Farm size, labour, fertilizer and chemical are the important factors in sorghum production in Maharashtra state
- More than 63 percent farms are operating below the frontier level which indicates the scope for efficiency improvement.
- Overuse of seed was found on sorghum farms

Key words: Technical, Allocative and Economic efficiency, sorghum, Maharashtra,

I. INTRODUCTION

Sorghum (jowar or jowari) is an important nutrition cereal constituting staple diet in the country (Dayakar et al.2005). India contributes about 16% of the world's sorghum production. It is the fourth most important cereal crop in the country. This crop was one of the major cereal staple during 1950's and occupied an area of more than 18 million hectares then reduced to 5.72 million hectares in 2013-2014 (TE 2014).Production increased from 9 million tons in the early 1970s to 12million tons in early 1980 and maintained this level for over a decade until early 1990s, followed by a steep decline to 10.62 million tons 2013-2014. Despite the decrease in area over the years, production has been sustained at 10.62 million tons mainly due to the adoption of improved varieties. Sorghum grain average yields in India is 1170kg/ha in the rainy season and 880kg/ha in the post rainy season in recent years (www.icrisat)

All India total sorghum production has registered a constant growth rate of 0.10% per annum during the period 1967-68 to 2010-2011 which can be mainly attributed to negative production of kharif sorghum rather than positive growth in rabi sorghum production. Though, kharif sorghum yield growth rates were relatively higher, it could not offset the declining growth rates in production, as the growth rates in kharif sorghum area were negative and high. Just opposite is true in the case of rabi sorghum where the area decline was not sufficient to undermine the yield growth, thus resulting in positive production growth rates. Among the states, Maharashtra alone recorded positive growth in production during both kharif and rabi seasons. Based on the performance of sorghum in Maharashtra, it appears that relatively it has a promising future during both kharif and rabi.

Efficiency analysis is an issue of interest given that the overall productivity of an economic system is directly related to the efficiency of production of the components within the system. It is concerned with the relative performance of the processes used in transforming given inputs into output

Introduction of the green revolution in the country led the diversification of cropped area from coarse cereals to fine cereals and other high crops (sorghum). Several studies indicated that the existing low levels of technical efficiency hindered efforts to achieve progress in production (Belete et al., 1991; Seyoum et al., 1997). Despite the significant growth in sorghum production, there are huge inefficiency in the production system of sorghum production. The improvement in the efficiency of production system will have direct positive impact on agricultural growth, nutritional security and rural livelihood in a country like India, where sorghum is one of the major crops. Under these circumstances, it is important to know that whether the producers have the same or different levels of technical, allocative and economic efficiencies

II. METHODOLOGY

Study area: The study was carried in India being the fourth sorghum producer in the world. The highest sorghum producing state was purposively selected that is Maharashtra. The production of sorghum in India is, usually, concentrated in the southern part of in India. So Maharashtra was purposively selected based on its production

Nature and source of data: The primary data were collected from 4 district of the state based on their highest sorghum production, then random sampling was used to select 100 respondents which was used for this study to ascertain the efficiency of sorghum farmers in the study area.

III. ANALYTICAL TOOL

The stochastic frontier production model was used to determine the efficiency of the sorghum farmers;

The Empirical Stochastic Frontier Production Model

The stochastic frontier production function used in this study was specified as follows:

$$LogYi = Bo + B1log X1 + B2logX2 + B3logX3 + \ldots\ldots\ldots\ldots B6log X6 + Vi - Ui \quad (1)$$

Where

Y = Output of sorghum (kg)

X1 = Farm size (hectares)

X2 = Amount of family labour used (man-days)

X3 = Quantity of sorghum seed planted (kg)

X4 = Quantity of fertilizer used (kg)

X5== Quantity of chemicals used (litres)

Vi = Random noise (white noise) which are N(0,δ2, V)

Ui = Inefficiency effects which are non-negative, half normal distribution N(0,δ2, U)

Operational definition of the variables of empirical stochastic production function for Sorghum Production is as follow:

i. Output of Sorghum farmer: This is the total yield obtained per hectare by farmers in kilogram equivalent weight.
ii. Farm size: This is the size of land used in producing Sorghum crop by the farmers.
iii. Quantity of fertilizer: This refers to the quantity of fertilizer use in kilograms.
iv. Quantity of Seed: This refers to the quantity of seed in Kilogram equivalent weight used for planting by the farmers.
v. Chemicals: this refers to the quantity of herbicide used in litres.
vi. Labour: This is the total man days of labour per hectare supplied by house hold and hired during the farm operation. The standard man day is 8 hours per day.

The technical efficiency of sorghum production for ith farmers, defined by the ratio of observed output as to the corresponding frontier production associated with no technical inefficiency, is expressed by;

$$TE = Exp(-Ui) \text{ so that } O \leq Te \leq 1 \quad (2)$$

Variance parameters are δ2 =

$$\delta 2V + \delta 2U \text{ and } \gamma = \delta 2U / \delta 2 \quad (3)$$

So that O≤ γ ≤1

The inefficiency model is defined by,

$$Ui = \delta o + \delta 1Z1 + \delta 2Z2 \quad (4)$$

Where,

Ui = inefficiency effect

Z1 = Age of farmer (in years)

Z2 = Literacy level (in years)

The operational definition of the empirical inefficiency parameter of the stochastic frontiers for Sorghum Production is given as:

i. **Age:** This is the age of individual farmers involved in the farm operation.

ii. **Literacy level:** This is measured as the numbers of years put in by farmers to acquired basic formal education. Specifically 'O' years denotes no formal education: 6 years denote primary education. 12 years denote secondary education. 15 years denote diploma and NCE holder: while greater than 15 years denotes graduates

3.5.3. The empirical stochastic frontier cost model

The Cobb-Douglas functional form was used to specify the cost production technology of the farms. The explicit Cobb-Douglas cost function model used in determining technical efficiency of sorghum farmers in the study is given:

LnCy=β0+β1LnP1+β2LnP2+β3LnP3+β4LnP4+β5LnP5+Vi-Ui (5)

Where:

Ln=Logarithm to base e

Cy=Total production cost (₦/ha) of the ith farmer

P1=Cost of land

P2=Cost of labour (in man days)

P3= Cost of seed in kg

P4=Cost of fertilizer in kg

P5=Cost of chemical in litres

V and U as previously defined.

The operational definitions of the variables of the empirical stochastic cost function are as follows.

I. Total production cost: This measures the total cost of production per hectare in the last cropping season by the farmers. Since fixed cost of production is negligible in the short run, the study only used variable cost of production per hectare as a proxy for total production cost.
II. Cost of land: This is measured as the amount of money or its equivalent paid as rent of land during the last cropping season. Where produce is given, the study used value of 10% of the total output as a proxy for expenses.
III. Cost of labour: This is the amount of money paid for the labour during farm operations. It is measured in rupees per hectare.

IV. Cost of seed: This is the total expenses on seed incurred by the farmer during the last cropping season. It is measured in rupees per hectare.
V. Cost fertilizer: This is the total expenses on inorganic fertilizer incurred by the farmer during the last cropping season. It is measured in rupees per hectare.
VI. Cost of chemicals: This is the total expenses on herbicides incurred by the farmer during the last cropping season. It is measured in rupees per hectare.

It is assumed that the cost inefficiency effects are independently distributed and Ui arises by truncation (at zero) of the normal distribution with mean, µij and variance ɗ2, where µij is defined by

µy =ɗ0 + ɗ1zij+ ɗ2zij+ ɗ3zij+ ɗ4zij+ ɗ5zij (6)

Where:

µij= Cost inefficiency of the ith farmer

Z1=Family size (Number)

Z2=Farming experience (years)

Z3=Literacy level (Number)

Z4=Extension contact (Number of meetings)

3.5.4. Allocative efficiency

Allocative efficiency measures the degree of correctness in the adoption of factor proportion to current input prices. A producer is allocative efficient if production occurs in a sub set of the economic boundary of the production possibilities set that satisfies the producer's behavioural objective. The Allocative Efficiency (AE) in the use of variable inputs is worked as the ratio of

AEij =MGRj/OGRij

Where
MGRj =Maximum possible gross revenue of the jth farms
OGRij =Gross revenue at the optimum level of the ith input with all input remaining at same level of the activity by jth farmer
Farm specific optimum input level level (Xij) equated by marginal value product of the input with its price
Xij* = [pi/bo*] -1/[1-bi] (8)
Where
Pi =per unit price of input (i)
Bo =bi = ∑t-0n-1 bi
In order to determine optimal use of a resource, keeping the other resource constant, MVP and opportunity cost (factor) of that resources will be compared. The marginal product cost MPC will be estimated from the parameter of Cob Douglas production function.
The criterion for determining the optimality of resource use;
MVP/MPC > 1 underutilization of resource
MVP/MPC = 1 optimal use of resource
MVP/MPC < 1 excess use of resources

3.5.5. Economic efficiency

Economic Efficiency is combination of both technical and allocative Efficiencies. Technical and allocative efficiencies are mutually exclusive, and simultaneous achievement of both efficiencies provided the sufficient condition to ensure economic efficiency.
EEj =TEj x AEEj (8)

Where;
TEj = farm specific technical efficiency of jthfarmer
AEEj = allocative efficiency of all input on jthfarm

IV. RESULT AND DISCUSSION

Efficiency Estimation in Sorghum Production

This section examines the relative performance of the process used in transferring given input into output. The technical, allocative and economic efficiency of the respondents in sorghum production were estimated using stochastic frontier functions

Technical Efficiency.

The maximum likelihood estimate of the stochastic frontier production for sorghum farmers in the study area is presented in Table 1. The estimated coefficients of all the Parameters of the production function were positive. This means that total sorghum output increases by the value of each coefficient as the quantity of each variable input increases by one percent. All the inputs used in the model except seed were statistically significant at 1%, 5% and 10% level.

TABLE 1
MAXIMUM LIKELIHOOD ESTIMATES OF THE PARAMETERS OF THE STOCHASTIC FRONTIER PRODUCTION FUNCTION

Variable	Parameter	Coefficient	t-ratio
Production factors			
Constant	β0	5.1671***	12.4552

Farm size (X1)	β1	0.8457***	4.9781
Labour (X2)	β2	0.3308***	3.6577
Seed (X3)	β3	0.0554	0.3328
Fertilizer (X4)	β4	0.1682*	1.950
Chemicals (X5)	β5	0.1243**	2.3305
Inefficiency effects			
Age (ZI)	ɗ1	-0.1001**	-2.0707
Literacy level (Z2)	ɗ1	-0.5484***	-3.3482
Diagnostic statistics			
Sigma squared (ɗ2)		0.2200***	3.1100
Gamma (ʹϒ)		0.5179***	4.8537

*** Estimates are significant at1% level,
** Estimates are significant at 5% level.
*Estimates are significant at 10% level

TABLE 2
TECHNICAL EFFICIENCY RATING OF THE SORGHUM FARMERS

Efficiency	Frequency	Percentage
<0.40	5	5
0.40 – 0.49	10	10
0.50 – 0.59	16	16
0.60 – 0.69	23	23
0.70 – 0.79	23	23
0.80 – 0.89	20	20
0.90 – 1.00	3	3
Total	100	100
Minimum efficiency	0.2864	
Maximum efficiency	0.9350	
Mean efficiency	0.6774	

Source: Computed from Stochastic Frontier Result

Stochastic Frontier Production Function and Inefficiency Model Result

The maximum likelihood estimates of the stochastic frontier production function and inefficiency model results are presented in Table 1. The estimate for parameters of the stochastic frontier production function indicates that the elasticity of output with farm size was positive and approximately 0.8457, and it was statistically significant at 1 % level. This implies that a one percent increase in area under sorghum production will raise output of sorghum by 0.8457%. This shows that land is a very important factor in sorghum production. This finding is at tandem with the findings of; Maurice et al., (2005); Udoh and Folake (2006); Zalkuwi(2012), that land has a positive sign and statistically significant.

The production elasticity of labour was 0.3308 and statistically significant at one %level, indicating that availability of labour increases the likelihood of the farmer to go into crop diversification. This is because crop diversification guarantees substantial labour cost savings which otherwise will be incurred when there is no crop diversification. Different crops have different labour intensity; hence, diversification is common among crops with low labour intensity than those with high labour intensity

The production elasticity of seed was 0.0554, and it was not statistically significant this implies that a one percent increase in one kg of seed under sorghum production will decrease the output of sorghum production0.0554%. So seed is not an important factor of production.

The production elasticity for fertilizer was significant at 10 % level. Fertilizer improves the productivity of existing land by increasing crop yields per hectare. A 1% increase in the use of fertilizers would increase output of sorghum crop by 0.1682%, from the findings therefore is an indication that fertilizer is a critical variable input in sorghum production in the study area which increase the output of sorghum farmers. This finding agrees with comparable findings by Daniel et al. (2013) who reported positive relationship between fertilizer and output of farmers.

Chemicals have an elasticity coefficient of 0.1243 and statistically significant at 5%. This findings means that a 1% increase in the quantity of chemical use in sorghum production would increase output by 0.1243%. The use of chemical reduces expenditure on weeding and at the same time reduces fatigue and drudgery associated with the production process. This finding implies that the use of chemical increases productivity and also enables farmers to cultivate large hectares of land that in turn bring about increase in output

Determinants of Technical Inefficiency

Table 1 presents the coefficients of inefficiency function that explain levels of technical inefficiency among the respondents. It should be noted that the signs of the coefficient in the inefficiency model are interpreted in the opposite way and as such a, negative sign means that, the variable increase efficiency and positive sign mean that it decreases efficiency (Adebayo, 2007). The coefficient of age (-0.1001) had a negative sign and inconsonance with apriori expectation. It was statistically significant and different from zero at 5%, this implies that increase in the age of the farmers by one unit (year) will increase the technical efficiency of the farmers.

The estimated coefficient for years of literacy level was (-0.5484), it was statistically significant at 1%. Implying that, respondents' with high years of literacy, are not more technically efficient than those with lower years of literacy level. This result is consistent with previous studies conducted by Shehu and Mshelia. (2007) and Zalkuwi(2012)

The estimated sigma square (δ2) in Table 1 were large (0.2200) and significantly different from zero at 1% level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. The variance ratio of gamma (γ) which was associated with the variance of technical inefficiency effect in the stochastic frontier was estimated to be 0.5178. This indicates that 51%of the total variation in study area was due to differences in technical efficiency (TE). This also implies that the ordinary least squares estimates may not be adequate to explain the inefficiency variation among the respondents hence the use of stochastic frontier production function.

Technical Efficiency of Sorghum Farmer in the study area

The technical efficiency in Table 2 was derived from MLE result of the stochastic production function. The result shows that the TE of the respondents was less than 1 (100 %) hence the variation in TE exist among respondents. It means that, all the respondents produced below maximum efficiency. The minimum efficiency was 0.2864, while their maximum efficiency was 0.9350, and their mean efficiency were 0.6774. The distribution of the farm efficiency for sorghum production shows that, majority (69 %) of them operated above 59 % of their maximum efficiency and 31 % operated below 59%

TABLE 3

MAXIMUM LIKELIHOOD ESTIMATE OF THE PARAMETERS OF THE STOCHASTIC COST FUNCTION

Variable	Parameter	Coefficient	t-ratio	
Cost factors				
Constant	β0	-0.1531	-0.1624	
Cost of land (P1)	β1	0.1585***	7.4996	
Cost of labour (P2)	β2	0.2202***	3.5386	
Cost of seed (P3)	β3	0.4744***	3.8908	

Cost of fertilizer (P4)	β4	0.2518**	2.0730	
Cost of chemical (P5)	β5	0.0287	0.0616	
Inefficiency effects				
Age (ZI)	ď1	-2.3062	-0.2102	
Literacy level (Z2)	ď2	-0.0310	-3.3682	
Diagnostic statistics				
Sigma squared (ď2)		0.3559***	3.6827	
Gamma (΄Υ)		0.5205***	4.0125	

Source: Computer printout of frontier 4.1

*** Significant at 1% **Significant at 5%*Significant at 10%

The maximum likelihood estimate of the parameter of the stochastic cost frontier model of the sorghum farmers in the study area used in estimating allocative efficiency is presented in Table3. All parameters estimated have the expected sign. Most of the parameters estimates are significant except cost of chemical meaning that these factors are significantly different from zero and thus are an important determinant of sorghum output except for the cost of chemical not significant. The results imply that the variable (cost of land, cost of labour, cost of seed and cost of fertilizer) used in the analysis have a direct relationship with total cost of production. The cost elasticity with respect to all input variables used in the production analysis are positive , implying that an increase in the cost of land , cost of labour, cost of seed, and cost of fertilizer increases production cost. That is 1% increase in the cost of land will increase the total production cost by approximately 0.16%, 1% increase in the cost of labour will increase total production cost by 0.22% ,1% increase in the cost of seed will increase total production cost by 0.47% and 1% increase in the cost of fertilizer will increase production cost by 0.25%

TABLE 4
FREQUENCY DISTRIBUTION OF ALLOCATIVE EFFICIENCY RATING OF THE SORGHUM FARMERS

Efficiency	Frequency	Percentage
<0.40	20	20
0.40 – 0.49	17	17
0.50 – 0.59	14	14
0.60 – 0.69	19	19
0.70 – 0.79	20	20
0.80 – 0.89	9	9
0.90 – 1.00	1	1
Total	100	100
Minimum efficiency	0.1144	
Maximum efficiency	0.9000	
Mean efficiency	0.5445	

Source: Computed from Stochastic Frontier Result

The distribution of farmers' allocative efficiency indices derived from the analysis of the stochastic cost function is presented in Table 4. The allocative efficiency of the sampled farmers ranged from 0.1144 to 0.9000. The mean allocative efficiency is estimated to be 0.5445, meaning that the average farmer in the study area has the scope for increasing allocative efficiency by 45% in the short-run under the existing technology, this would enable the average farmer equate the marginal value product (MVP) of the inputs to the total production

TABLE 5
FREQUENCY DISTRIBUTION OF ECONOMIC EFFICIENCY RATING OF THE SORGHUM FARMERS

Efficiency	Frequency	Percentage
<0.40	62	62
0.40 – 0.49	15	15
0.50 – 0.59	12	12
0.60 – 0.69	8	8
0.70 – 0.79	3	3
0.80 – 0.89	0	0
0.90 – 1.00	0	0
Total	100	100
Minimum efficiency	0.0951	
Maximum efficiency	0.7476	
Mean efficiency	0.3729	

Source: Computed from Stochastic Frontier Result

V. ECONOMIC EFFICIENCY

Table 5 show that the economic efficiency of sorghum farmers ranged from 0.0951-0.7476, this indicates that a wide gap exists between the efficiency of best economically efficient farmers and that of the least economically efficient farmer. The mean economic efficiency is 0.37, indicating that sorghum farmers are economically inefficient in the use of scarce resources. The estimate reveals that for an average farmer in the study area to attain the level of the most economically efficient farmer in the sample, the farmer must experience efficiency gain of 38% (i.e., 0.75 - 0.37). The least economically efficient farmer will however require efficiency gain of about 65% (i.e., 0.75 - 0.10) to be able to attain the level of the most economically efficient farmers in the sample. Amaza and Olayemi (2002) observed that a wide variation in farmer-specific efficiency level is a common phenomenon in developing countries. The minimum efficiency was 0.0951, while their maximum efficiency was 0.7674, and their mean efficiency were 0.3729.

The distribution of the farm efficiency for sorghum production shows that, majority (89 %) of them operated below 59 % of their maximum efficiency and 21 % operated above 59%

VI. CONCLUSION

It may be concluded from the study that under the given socio-economic and farm conditions (including technology), the production of sorghum can be increased since the farmers operate below the frontier level.

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