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Production efficiency and optimal allocation of resource in cultivation of sugarcane

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Abstract
The result of the cross section data collected from 100 sugarcane growers of the Kawardha block of Kabirdham district in Chhattisgarh the comparison of marginal value productivity of resources with their acquisition cost shows that increase in expenditure on manure & fertilizers and machine power contribute significantly to wards gross income from sugarcane crop. There exists little possiblility of getting additional income from sugarcane crop in the area under the existing capital outlay and adoption a pattern. The gross income from sugarcane can be increased by re-allocation of resources in optimal direction and also by reducing the expenditure on human labour and increasing it on seed, manure and fertilizers irrigation, and machine power, Cobb-Douglas production function and test of resource use and allocative efficiency were used to analyze the data. The production function analysis shows that the coefficients were higher and significant for manure and fertilizers and machine power in cultivation of sugarcane. The fitted production function explains more than 85.00 per cent of variation in the gross income from sugarcane due to included variables.

Keywords: Sugarcane, Cobb-Douglas production function, Allocative efficiency, Gross income.

Introduction
Sugarcane (*Saccharum officinarum L.*) is one of the important commercial crops of the world and is cultivated in about seventy five countries. The leading countries are India, Brazil, Cuba, Mexico and Thailand. The sugar industry plays an important role in the agricultural economy of India. Sugarcane is also most important commercial crop of the country and the sugar industry occupies an important place in the economy of our country. Sugarcane crop provides raw material to over 25 other industries and sugar industry is one of the largest agro-based processing industry responsible for socio-economic development of rural masses and national economy of our country. Nearly 40 million growers and their dependents are involved in the cultivation of sugarcane. Industry provides employment to more than five lakh skilled and unskilled workers in the manufacturing of sugar, gur and khandsari. In terms of sugarcane production, In India, about 60 per cent of sugarcane is milled for the production of sugar, about 30 per cent for gur and khandsari, and the remaining 10 per cent is used for seed. Brazil has the highest area (5.34 million ha) while Australia has the highest productivity (85.10 tonnes per ha). India ranks second among the sugarcane growing countries of the world in terms of area and production after Brazil with an area under sugarcane cultivation of 5.34 million ha (2014-15) with an average yield of 72.30 tonnes per ha. The area under sugarcane cultivation in India is 5,032 thousand ha (2014-15) and cane production is 356.56 million tonnes with 70.86 tonnes/ ha productivity. India's sugar production was estimated to be around 24.5 million tonnes as compared to annual consumption of 23 million tonnes. In Chhattisgarh, sugarcane is cultivated in 28.33 thousand ha area with production and productivity of 38.35 thousand tonnes and 71.20 tonne/ha, respectively during 2014-15. Chhattisgarh state which has been known as "rice bowl" of the country is now set to create a niche for itself in the sugar production. The state govt. requires 57,500 metric tonnes of sugar per annum for distribution to the ration card holders through the public distribution system. The sugar production in all the three factories (Kawardha, Balod and Surajpur) in the state had reached to 63916 metric tonnes 2014-15. In Kabirdham district the share of sugarcane area to total net cropped area was 54.7%. The scope of sugarcane is bright in the Chhattisgarh plains and it is cultivated in 20.93 thousand ha area. The production of sugarcane in Chhattisgarh plain was 10.46 lakh metric tonnes with average productivity of 49.96 tonnes per ha (2014-15).

Research Methodology
Chhattisgarh state is having 27 districts. Out of 27 districts of Chhattisgarh, Kabirdham district has highest production and area of the sugarcane. Therefore Kabirdham district was selected.

From selected block 5 villages were selected randomly. Viz, Khamhi, Kothar, Dharmpura, Birkona and Chardongari for the present study. From the list of sugarcane growers, 20 sugarcane growers from each village were selected randomly, thus total 100 sugarcane growers. Were collected from the selected farmers through personal interview with the help of pre-tested interview schedules designed for the purpose. The study required primary as well as secondary data, primary data from the farmers were collected through personal interview method with the help of well-prepared interview schedule. The data used in the study to fulfill various objectives were collected from the selected farmers through personal interview with the help of pre-tested interview schedules designed for the purpose. The household's survey was conducted for the agricultural year 2015-2016. The analytical tools used for the study area as follows.

(a) Analytical Procedure for estimation of resource productivity: The Cobb-Douglas production function for sugarcane production enterprise can be expressed as:

$Y = a X_1^{b1}. X_2^{b2}. X_3^{b3}. X_4^{b4}. X_5^{b5}. X_6^{b6}. Ebe$

It is converted into logarithmic form so that it can be estimated by the least square method. The logarithmic form of the Cobb-Douglas production function is expressed as under:

$\text{Log } Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + be \log E$

Where:
Y: Dependent variable (Grass value of output),
A: Constant or Intercept Value,
X_1 to X_6: Are independent variable,
$b_1$tob$_6$: are regression coefficients of X1 to X6 variables, respectively,
E: Error term.
X1: Expenditure on Human Labour (Rs/ha),
X2: Expenditure on Seed (Rs/ha),
X3: Expenditure on Manure and Fertilizer (Rs/ha),
X4: Expenditure on Plant protection (Rs/ha),
X5: Expenditure on irrigation (Rs/ha),
X6: Expenditure on machine power (Rs/ha).

(a) Test of resource use and allocative efficiency: In order to test allocative efficiency of resource in sugarcane production, alternative techniques were used in this study and they were as follows.

(1) Ratio of marginal value productivity and marginal cost: From the above production function the M. V. P. of each resource are worked out. The marginal value productivity is computed from the elasticities of production using the geometric mean of input and output as follows:

$MVPX_k = (bx) \left(\overline{Y} / \overline{X}_k \right)$

Where: $MVPX_k$: Marginal value productivity of X_k factor, $\overline{Y}$: Gross value of output (in Rs) at geometric mean, $\overline{X}_k$: Factor of production at geometric mean, b_k: Regression coefficient of k^{th} input. After estimation of MVP it was compared with MC of each other.

(2) Re-allocation of resources: The following formula is used to derive optimum levels of resources:

$$X_k = \frac{Bk_. \overline{C}}{\sum (b_1 + b_2 + b_3 + \ldots\ldots\ldots\ldots + b_k)}$$

Where:
B1 to b_k: Regression coefficients of 1st to Kth variables,
$\overline{C}$: Is capital constants.

Result and Discussion

Production Function analysis: The production function analysis was also carried out to examine the resource use efficiency in sugarcane production using Cobb-Douglas production function with the help of least square technique and the coefficients for major resources on different size of holdings along with value of R^2 and F ratio is estimated which is presented in table 1

The R^2 and adjusted R^2 that is coefficient of multiple determinations and coefficient of multiple determinations adjusted for degree of freedom for sugarcane farms, as a whole, clearly indicates that fitted function explains 85.2 per cent variation in gross income from sugarcane due to included variations. The F ratio for fitted function was found to be highly significant at aggregate level indicated that fitted Cobb-Douglas production function model is more useful and best fitted. The elasticities of production which indicate per cent change in gross income resulting from per cent change in input, while the other resources are held constant. From the table it is observed that the elasticities of production of each input on all the sample sugarcane farms are less than one, indicating diminishing returns to each variable input that is if we increase input by one per cent then production of sugarcane will increase by less than one per cent. On overall holdings expenditure on manure and fertilizers and machine power were found to have significant influence in explaining the variability in gross income. The gross incomes from sugarcane increase significantly if expenditure on manures and fertilizers, human labour and machine power. The one per cent increase in the value of manures and fertilizers would have brought about 0.367 per cent increase in the gross income from sugarcane, while one per cent increases in expenditure on human labour would increases gross income by 0.115 per cent on overall holdings. Similarly on overall holdings expenditure on manure and fertilizers, machine power influenced gross income from sugarcane significantly. The one per cent increase in expenditure on manure and fertilizer and machine power would results in 0.367 and 0.393 per cent increase in gross income from sugarcane. On aggregate basis the co-efficient for expenditure on irrigation, and machine power would contribute, significantly in expenditure in explaining variation in gross income. The one per cent increase in expenditure in these inputs individually keeping other inputs at fixed level would result in 0.367 and 0.393 per cent increase in gross income, respectively. The return to scale is the sum of the elasticties of variable factors included in the power function, which indicates the behaviour of change of total return while chancing all the inputs simultaneously in the same proportion. At the overall level the sum of regression was 0.852 indicating diminishing return to scale. The overall results of production function analysis clearly indicates that expenditure on manure and fertilizers contribute significantly in increasing gross income from sugarcane cultivation at aggregate level, the expenditure on machine power was also found to contribute significantly in gross income on overall holdings.

Table 1: Production function coefficients of sugarcane on sample holdings-

S. No.	Production function coefficient variables	Overall Average
01	Log A	2.386
02	X1 human labour	0.115 (0.138)
03	X2 seed	0.018 (0.106)
04	X3mannure &fertilizer	0.367* (0.175)
05	X4 Plant protection	-0.051 (0.107)
06	X5 Irrigation	.010 (0.237)
07	X6 machine power	0.393** (0.186)
08	R^2%	85.2
09	Adjusted R^2%	84.3
10	F	8940.7**
11	∑ bi	0.852

(Figure in parentheses indicate standard errors of respective coefficients)
** indicate significance at 1% probability level,
* indicate significance at 5% probability level.

Marginal Value Product: The marginal value productivity of each selected input was estimated at geometric mean of gross output and their respective input factors for sugarcane crop. The data on marginal value products, marginal cost, its ratio and marginal benefit are presented in table-2.

The use of human labour on overall holdings was found to be inefficient because the ratio of MVP to MC were not significantly different from unity. The ratio of MVP and MC for human labour in man equivalent is non-significantly different from unity indicating that the sugarcane growers are using on an average this factor inefficiently revealing that the use of human labour should be extended to get a higher gross income from sugarcane crop on overall holdings. The Marginal benefit on overall holdings was Rs-9.85. It is very surprising that whatever results obtained by various researcher regarding the efficiency of manure and fertilizers indicate that it was inefficiently used in most of the cases but in the present study utilization of fertilizer and manure resulting in efficient use of these inputs on overall holdings. Since irrigation is the important inputs in the cultivation of sugarcane its use on size of holdings found to be efficient and one rupee invested on irrigation at aggregate level would result in additional income of 2.25 in the cultivation of sugarcane. Seed is a major resource in the production of the crop.

Table 2: Marginal value productivity and marginal cost of resources in the production of sugarcane on sample holdings (Rs. /Unit)

S. No.	Variables	Particulars	Overall average
01	X1 human labour	MVP	140.15
		MC	150
		Ratio	0.93
		M. B.	-9.85
02	X2 seed	MVP	0.95
		MC	1.00
		Ratio	0.95
		M. B.	-0.05
03	X3mannure &fertilizer	MVP	2.39
		MC	1.00
		Ratio	2.39**
		M. B.	1.39
04	X4 Plant protection	MVP	-1.05
		MC	1.00
		Ratio	-1.05
		M. B.	-2.05
05	X5 Irrigation	MVP	2.25
		MC	1.00
		Ratio	2.25**
		M. B.	1.25
06	X6 machine power	MVP	3.60
		MC	1.00
		Ratio	3.60**
		M. B.	2.60

It was utilized inefficiently on overall holdings, would have results in loss of 0.05. Sugarcane cultivation requires much more investment in preparing the field for planting and this requires deep ploughing, furrow making and therefore use of machine power is required heavily and this its use was found to be efficient.

Through, overall results of MVP, marginal cost and ratio of MVP and MC, revealed that further increase in expenditure on human labour, seed, manure and fertilizers and machine power would results in increase in gross income from sugarcane but this is possible only when there are no capital constraints.

Optimal resource allocation: The optimal resource allocation was done with the present level of expenditure on resources under study and a possibility of increase in income through use of resources in optimal direction was examined for sugarcane crop and data on the same is presented in table-3.

From the data under capital constraints condition it is observed that further increase in expenditure on manures and fertilizer, irrigation and machine power by reducing expenditure on seed, human labour and plant protection would result in increase in gross income from sugarcane by Rs. 46290 per ha.

Therefore it can be concluded that there is possibility of increasing gross income from sugarcane with the existing capital outlay and available technology if resources are re-allocated in optimal direction.

Table 3: Existing and Optimal Resource Level and Return from Sugarcane cultivation (Rs./ha)

Resources	Overall holdings		
	Existing resource use	**Optimal resource use**	**Gap**
X1 human labour	7124.29 (20.71)	6251.00 (18.18)	873.29
X2 seed	11542.10 (33.56)	9262.00 (26.93)	2280.1
X3 mannure & fertilizer	5169.51 (15.03)	5825.00 (16.94)	-655.49
X4 Plant protection	2633.57 (7.65)	2631.00 (7.651)	2.57
X5 Irrigation	5715.29 (16.62)	6825.00 (19.84)	-1109.71
X6 machine power	2199.16 (6.39)	3589.92 (10.44)	-1390.76
Expenditure Level	34383.92 (100)	34383.92 (100)	0
Estimated Grass income	210630	256920.92	46290
Estimated Net income	110461.01	156751.01	46290

(Figure in parentheses show percentage to total expenditure)

Conclusions-

The following major conclusions were drawn from this study. The gross income from sugarcane can be increased by reducing the expenditure on human labour and increasing the expenditure on seed, manure and fertilizers irrigation, and machine power. But this possibility can prevail under unlimited capital supply only. Under existing capital supply and present level of technological adoption there exists possibility of increasing gross income through re allocation of resources in optimal direction. The production function analysis shows that the coefficients were higher and significant for manure and fertilizers and machine power in cultivation of sugarcane. The fitted production function explains more than 85.00 per cent of variation in the gross income from sugarcane due to included variables.

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