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Resource-use Efficiency of Sorghum (*Sorghum bicolor*) Production in Rice (*Oryza sativa*)-fallows in Andhra Pradesh, India

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ABSTRACT The present study examines the resource-use efficiency in sorghum production in coastal region of Andhra Pradesh. Data for the study were collected from 100 sorghum producers in seven villages in the study area pertaining to the 2008-09 crop season. Farm budgeting technique and production function analyses which incorporate the conventional neoclassical test of economic and technical efficiencies were used as the analytical techniques. Findings revealed that the farmers were inefficient in using the resources. The seeds and irrigations were found to be over-utilized, while fertilizers, labourer and agrochemicals were found to be under-utilized. The results showed that appropriate adjustment is required for optimum allocation of resources and to maximize the revenue from the sorghum cultivation.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is one of the main staple food for the world's poorest and most food insecure people. It is known to be cultivated as food grain in Africa and Asia. About 26 per cent of the Indian population is deficient in calories and 28per cent in protein (Chand et al. 2003). Sorghum is a cheap source of energy, protein, iron and zinc next only to pearl millet among all cereals and pulses (Rao et al. 2006). However, it is popularly grown for feed, fodder and more recently for bio-fuel purposes in the world (Kleih et al. 2000).

In India, sorghum is the fourth most important cereal consumed and cultivated during both rainy (*kharif*) and post-rainy (*rabi*) seasons. However, the area under sorghum in India has declined drastically from 18.6 m ha in 1970 to 7.93 m ha in 2007-08. The total production also declined from 9.72 m t to 7.78 m t. With emerging cash requirements, farmers diversified from traditional mono-cropping with sorghum to commercial crops like cotton, pulses and oilseeds. Both profit motivated and consumption driven factors led to this decline. Also the growth in productivity varied across the important sorghum growing states. In contrast, in the recent years, sorghum in rice-fallows in coastal Andhra Pradesh, especially in Guntur district is gaining popularity among the farmers. It has an average sorghum productivity of 5.7 t/ha in 2006-07, which is the highest in the country. The farmers are using inputs especially agrochemicals indiscriminately due to lack of standardized production technologies for this region. Although they are getting higher yields but the profit margin could be increased by using cost-effective technologies. Farmers are also not homogenous with respect to their behaviour in using resources optimally. Under this premises, an attempt was made to analyze the resource-use efficiency of the sorghum growers and the requirements in adjustments for optimum utilization of resources for sorghum cultivation in rice-fallows.

MATERIAL AND METHODS

Study Area

The present study was conducted in July, 2009 in seven villages from two blocks in Guntur district of Andhra Pradesh, namely Athrota, Kamathavaripalam, Dhanthuluru, Siripuram and Kunchavaram from Kollipara block, and Nandivelugu, and Ananthavaram from Tenali block. The Guntur district was purposively selected because the productivity of the sorghum in the district is the highest (5.7 t/ha) in the country and the crop is exclusively cultivated in rice-fallows under zero-tillage condition.

Sampling and Data Collection

In total, sample of 100 farmers was selected randomly comprising all categories of the farmers form the study area. The data pertaining to the crop season 2008-09 were collected on different factors influencing the sorghum cultivation with the help of pre-tested, semi-structured interview schedule by conducting personal interviews, group discussions, field observations and empirical observations.

Analytical Framework

Due to lack of market information regarding prevailing prices of the sorghum and its arrival etc., most of the producers marketed their produce in the village itself, without waiting for the better market opportunity. Gross margin and net farm income analyses (budgeting techniques) were used to estimate cost and returns (over variable costs) per hectare. The production function analysis was used to determine the resource-use efficiency of the inputs used by the farmers. Values were assigned to family labour by obtaining the product of the prevailing wage rate and total mandays of family labour and the same was considered under the variable cost item for calculating cost of production.

The general production function used in the study was implicitly of the form represented in the following equation:

Y = f (X1, X2, X3, X4, X5)

Where;

Y = Gross returns from sorghum (Rs./ha)

X1 = Expenditure on seeds (Rs./ha)

X2 = Expenditure on fertilizers (Rs./ha)

X3 = Expenditure on irrigation (Rs./ha)

X4 = Expenditure on labourer (Rs./ha)

X5 = Expenditure on agrochemicals (Rs./ha)

Choice of Production Function

The Cobb-Douglas (CD) type of production function was used in this study as it is most widely used in the agricultural research and is convenient for the comparison of the partial elasticity coefficient (Prajneshu, 2008). It is a multiplicative type and non-linear in its general form. The marginal productivity of factors, marginal rate of substitution, factor intensity and the efficiency of production can be calculated directly from the parameters in CD type of production function. Thus, CD production function of the following form was fitted to examine the factors affecting the resource productivity of sorghum in rice-fallows.

Y = ax1b1x2b2x3b3x4b4x5b5eu

The Cobb-Douglas production function in the form expressed above was linearised into a logarithmic function with a view to getting a form amenable to practical purposes as expressed below.

lnY = ln a + b1lnx1 + b2lnx2 + b3lnx3 + b4lnx4 + b5lnx5 + u

here,

ln = Natural logarithm

a = constant

u = error term

Y, X1, X2,………… X5, are as defined earlier.

Resource-use Efficiency

The estimated coefficients of the relevant independent variables were used to compute the marginal value products (MVP) and their corresponding marginal factor costs (MFC). The ratio of the MVP to MFC was used to determine the resources efficiency as shown in the following equation (Rahman and Lawal 2003).

r = MVP/MFC

here,

r = Efficiency ratio (ratio of the MVP of an input and unit price of the input)

MVP = Marginal value product of a variable input.

MFC = Marginal factor cost (price per unit input)

The marginal productivity of a particular resource represents the additional to gross returns in value term caused by an additional one unit of that resource, while other inputs are held constant. The MVP was obtained by multiplying the marginal physical product (MPP) with the product price per unit. The most reliable and most useful estimate of MVP is obtained by taking resources (Xi) as well as gross return (Y) at their geometric means (Dhawan and Bansal 1977). Since, all the variables of the regression model were measured in monetary value, the slope coefficient of those explanatory variables in the function represented the MVPs, calculated by multiplying the production coefficient of given resources with the ratio of geometric mean (GM) of gross return to the GM of the given resources, that is,

ln Y = ln a + bi ln Xi

Therefore,

dY/dXi = bi [Y/Xi] or, MVP (Xi) = bi [Y(GM)/ Xi (GM)]

here,

Y(GM) = Geometric mean value of gross return in Rupees.

Xi (GM) = Geometric mean value of the ith variable input in Rupees.

As the MFC is price of input per unit, the MFCs of all the inputs will vary while calculating the ratio of MVP to MFC. However, the denominator will always be one, and therefore, the ratio will be equal to their respective MVP (Majumder et al. 2009).

According to the conventional neo-classical test of economic efficiency, a production input is being used efficiently if the ratio of the MVP of an input and the unit price of the input equals unity. Thus,

a) If $r < 1$, it means the resource in question was over utilized hence decreasing the quantity used of that resource increases profit.

b) If $r > 1$, it shows that the resource was being under utilized and increasing the quantity of use will raise profit level.

c) If $r = 1$ it means resource was being efficiently utilized.

The relative percentage change in MVP of each resource required so as to obtain optimal resource allocation that is, $r = 1$ or MVP = MFC, was estimated using the following equation:

$D = (1 – MFC/MVP) \times 100 = (1 – r–1) \times 100$

here,

D = Absolute value of percentage change in MVP of each resource (Mijindadi 1980).

RESULTS AND DISCUSSION

Sorghum is regarded as poor farmers' crop. The total land holding of the farmers is one of the important factors to assess its influence in obtaining monetary benefits from sorghum cultivation. The farm size distribution of the respondents and the returns obtained by them from the sorghum cultivation are depicted in Table 1. All the selected farmers had more than a hectare of land under cultivation. Their gross return (GR) ranged from Rs. 42,895/- to Rs. 48,667/- per ha and net returns from Rs. 23,602/- to Rs. 27,809/- per ha from sorghum cultivation. The GR increased with their land holdings. While 26 per cent of farmers had average farm sizes that ranged between 1 and 2 ha and 49 per cent having 2-3 ha, only 25 per cent of farmers had above 3 ha. This shows the predominance of small and marginal farmers producing sorghum in the rice-fallows. However, farmers with higher land holdings were getting more benefits from the sorghum due to use of higher inputs.

Value of the coefficients of individual inputs revealed that all of them were not positively related to the returns from sorghum cultivation. Expenditure on fertilizers and labourers were positively and significantly affected the returns from sorghum at one percent level and expenditure on agrochemicals at 5 per cent level. It is pointed that there is scope to increase use of fertilizers as well as labourers. Fertilizers' cost involved in sorghum production was of Rs. 2,877/- per ha. In other words, introduction of mechanization has a scope where the labourer requirement was more. The labour wages used were of Rs.10,052/- per ha. Use of agrochemicals could be encouraged. The farmers generally used agrochemicals such as, pre-emergence herbicides (paraquat and atrazine) one day after sowing and pesticides (endosulfan and bavistin). Cost of agrochemicals incurred was of Rs.1,211/- per ha. However, expenditure on irrigation negatively and significantly (at 5 per cent level) affected the returns from sorghum. Normally, two irrigations were applied by the farmers. Expenditure made for irrigations was of Rs.4,956/- per ha. It was also found more than enough. Reasons may be less water requirement of the crop and humid climate in this coastal area. Though, the expenditure on seed also affected the returns from sorghum negatively but the effect was not significant; it was due to shortage of the hybrid seeds in local market. It was not due to the seeds quantity used for the cultivation. An average seeds costs incurred was Rs.818/- per ha by the farmers; it was reported that the cost of seeds was up to Rs.200/- per kg.

Table 1. Distribution of farm size and average revenue from sorghum cultivation

Farm size range (ha)	*Average farm size (ha)*	*No. of respondents*	*Average gross returns (Rs./ha)*	*Average net returns (Rs./ha)*
1-2	1.643	26	42895	23602
2-3	2.401	49	46899	26839
3-4	3.415	21	47282	26542
>4	4.984	4	48668	27809

Since the coefficient of the Cobb-Douglas production function has the elasticity, it can be inferred that 1 per cent increase in the expenditure on fertilizers, labourer and agrochemicals will lead to 0.54, 0.912 and 0.038 per cent increase in the returns from sorghum, respectively (Table 2). The value of the function coefficient: 0.648 shows decreasing returns to scale.

This suggests that the farmers in the area employed more of some of the resources.

Table 2. Estimated values of co-efficient and related statistics of the production function

Variable	*Coefficient*	*Standard Error*	*t Stat*	*P-value*
Intercept	121.39*	2.709	1.772	0.080
Expenditure on seed	-0.067	0.486	-0.137	0.891
Expenditure on fertilizers	0.540***	0.048	11.320	0.000
Expenditure on irrigation	-0.775**	0.238	-3.259	0.002
Expenditure on labourer	0.912***	0.114	8.003	0.000
Expenditure on agrochemicals	0.038**	0.018	2.144	0.035
R2	0.718			
F-value	47.84***			

* Statistically significant at 1 per cent level
** Statistically significant at 5 per cent level
*** Statistically significant at 1 per cent level

Given the level of technology and prices of both inputs and outputs, efficiency of resource-use can further be ascertained by equating the MVP to the productive MFC of resources. A resource is said to be optimally allocated if there is no significant difference between the MVP and MFC i.e. if the ratio of MVP to MFC =1.

Table 3 further revealed that the ratio of the MVP to the MFC was greater than unity for all the inputs but was less in seeds and irrigation. This implies that fertilizers, labourers and agrochemicals were under-utilized, while negative values of the ratio for seeds and irrigation inputs demonstrated that they were over-utilized. It means that the returns from sorghum were likely to increase if more of inputs such as fertilizers, labourers and agrochemicals were used. Using more labourer in such a labour-intensive cultivation would enable increase of the returns from this crop.

The adjustment in the MVPs for optimal resource-use (per cent adjustment) in Table 3 indicates that for optimum allocation of resources more than 88per cent increase in fertilizer was required, while approximately 76 per cent and 30 per cent increase in labourers and agrochemicals were needed, respectively. The seeds and irrigations were over-utilized, which required approximately 127 per cent and 114 per cent reduction, respectively of these inputs for optimal sorghum production. The level of adjustments for use of various resources to earn

Table 3. Estimates of measures of technical efficiency of inputs used in sorghum production

Input	*Mean (Rs./ha)*	*AVP*	*MVP*	*MFC*	*MVP /MFC*	*Efficiency*	*Per-cent adjustment required*
Seed	818	55.93	-3.74	1.00	-3.74	Over utilized	126.74
Fertilizers	2877	15.90	8.59	1.00	8.59	Under utilized	88.36
Irrigations	4956	9.23	-7.15	1.00	-7.15	Over utilized	113.99
Labourers	10052	4.55	4.15	1.00	4.15	Under utilized	75.90
Agrochemicals	1211	37.76	1.43	1.00	1.43	Under utilized	30.07

optimum returns will serve as a bench-mark for the sorghum growers in the area, government agricultural agencies and agro-based companies. They can effectively harness the present findings for advancement in agricultural technology particularly and sustainable agricultural development in general.

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