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Resource Use Efficiency in Different Rice Based Cropping Systems of Andhra Pradesh

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ABSTRACT

Rice is regarded as the first cultivated crop in Asia as well as important food crop of India. Primary data have been collected from the sample rice farms with the help of pretested scheduled through personal interview with respondent farmers. Resource use efficiency of individual farms has been estimated through Cobb-Douglas production function analysis. The functional analysis revealed that machinery power and fertilizer in paddy, human labour and fertilizer in cotton in cropping system-I was significantly contributed and in the case of cropping system-II human labour and machinery power in kharif paddy, human labour in rabi paddy significantly contributed to the increase in the crop yields and income. The seed in kharif paddy, machinery in rabi paddy negatively significant contributed to the decline in the crop yields and income. In cropping system-III human labour and fertilizer were significant in both kharif paddy and rabi paddy. Seed and fertilizer in case of Groundnut significantly contributed to the increase in the crop yields and income.

Key words: *Resource use efficiency, Cobb-Douglas production function.*

INTRODUCTION

Rice production in India is an important part of the national economy. India is the world's second largest producer of rice, accounting for 20 per cent of the world's rice production rice is India's prominent crop, and is the staple food of the people of the eastern and southern parts of the country. The major rice growing states in India are west Bengal, Uttar Pradesh, Andhra Pradesh, Madhya Pradesh, Odisha, Bihar, Assam, Tamil Nadu, Punjab, Maharashtra, Karnataka, Haryana and Gujarat. Generally the farmers go for cultivation of few selected crops which results in continuous monocropping. Continuous monocropping leads to depletion of the soil fertility status and in the long run the soil becomes non-responsive to the applied fertilizer and unproductive. The objective of any cropping system is efficient utilization of all resources *viz.* land, labour, water, and solar radiation maintaining stability in production and obtaining higher net returns.

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Cropping system is an important component of a farming system represents a cropping pattern used on a farm and their interrelation with farm resources, other farm enterprises and available technology which determined their makeup. The cropping system should provide enough food for the family, fodder for cattle and generate sufficient cash income for domestic and cultivation expenses. Efficiency is the relative performance of the processes used in transferring the given inputs into outputs. Improvement in rice production efficiency by proper resource management within the existing technological framework to increase production hence, becomes an alternative viable solution to achieve self-sufficiency, food security and socio-economic development for the agrarian economy of the state. The resource use efficiency differs from region to region due to the variations in land, fertilizers, availability of resources, irrigation facilities, financial condition and extent of adopting agricultural practices. The consumption of rice is increasing at a rapid rate due to its high income elasticity of demand. So, an increase in production has to come from a breakthrough in productivity and increased efficiency. Efficiency is concerned with a relative performance of the processes used in transferring given inputs into outputs. In Andhra Pradesh rice is grown over an area of 4.75 million hectares with production and productivity of 14.42 million tonnes and 3.04 tonnes per hectare respectively (Directorate of Economics and Statistics, 2013). In Nellore district rice is major crop which is grown in all the seasons.

MATERIAL AND METHODS

The study was carried out in Nellore (rural), Thotapalligudur and Pellakurmandalsof Nellore district of Andhra Pradesh. Major Rice based cropping systems identified in the study area were cropping system-I (Paddy and Cotton), cropping system -II (Paddy-Paddy-Green gram) and cropping system-III (Paddy-Paddy-Groundnut).From the selected three mandals, a list of villages under rice based cropping systems was arranged. From each mandal two villages were selected. Total six villages were selected. The selected villages were Eguvachavali and Chemmidipalem from Pellakurmandal, Kothavellanti and Sajjapuram from Nellore mandal, Mahalakshmipuram and Nelimatikandriga from Thotapalli gudur mandal. The list of all the farmers from the two selected villages of each mandal was obtained from their respective village records. From each of the selected village, 15 farmers were selected at random. Thus 30 farmers in each mandal constituted the sample of the study for the selected rice based cropping systems. The total number of farmers selected for the purpose of study was 90.The primary data were collected by the survey method through well designed schedule for the agricultural year 2013-14. Secondary data were also used for the present study. For selection of the sample, the secondary data pertaining to demographic features, area, cropping pattern, production and productivity of Rice, Cotton, Groundnut and Green gram crops other related data were collected from the District Statistical Office of Nellore.

Functional analysis

Production function analysis was used to study the resource productivity and resource use efficiency. Among different types of production functions, Cobb-Douglas production function was selected for the present study because of its relative advantage over other production functions. Elasticities of production of resources can be obtained directly and the sum of the elasticities of production provides the estimates of returns to scale. It has greater use in economic analysis indicating marginal value products at geometric mean levels of inputs.

The Cobb-Douglas production function is specified in the following power form:

$$Y = a\, X_1^{b_1}\, X_2^{b_2}\, X_3^{b_3}\, X_4^{b_4}\, X_5^{b_5} \ldots\ldots e^{\mu}$$

X_1= Human labour in mandays

X_2= Tractor power in hours

X_3= Farm yard manure in tonnes

X_4= Fertilizers in kgs.

X_5= seed in kgs

a= Intercept

μ= Stochastic disturbance term

e= Napier base

b_1 to b_5 partial elasticity coefficients of X_1 to X_5 inputs.

It can be presented in logarithmic form as

$l_nY_c = l_n A + b_1 l_nX_1 + b_2 l_nX_2 + b_3 l_nX_3 + b_4 l_nX_4 + b_5 l_nX_5 + b_6 l_nX_6 + \mu$

In order to know the goodness of fit the adjusted coefficient of multiple determination (R^{-2}) was calculated using the following formula:

$$\overline{R}^2 = \left[1-\left(1-R^2\right)\times\left[\frac{(n-1)}{(n-k)}\right]\right]$$

Where

R^2 = Unadjusted coefficient of multiple determination.

n = Number of sample observations

k = Number of parameters estimated from the sample including intercept

Marginal value products

Equality of marginal value product to factor cost is the basic condition that must be satisfied to assess resource use efficiency. In Cobb-Douglas production function, marginal physical product of X**j,** the j^{th} input factor is given by the following equation.

$$Y_i = A\ X_{1_i}^{b_1}\ X_{2_i}^{b_2} \ldots\ldots X_{j_i}^{b_j}\ .\ e^{\mu_i}$$

For i = 1 ton farms.

j = 1 to k inputs

$$\text{MPP of Xj input} = \frac{b_j \overline{Y}}{\overline{X}_j}$$

Where

MPP= Marginal Physical Product of j^{th} input.

Bj= Partial elasiticity coefficient of j^{th} input.

$\overline{Y}$= output of the crop at its geometric mean level.

$\overline{X}_j$= j^{th} independent variable at its geometric mean level.

The marginal value product for each factor is obtained by multiplying the MPP of each factor with unit price of output ie.

MVP = MPP x P_y

Marginal value productivities are compared with acquisition costs in order to study the resource use efficiency. An input is said to be efficiently used when its MVP = MFC.

RESULTS AND DISCUSSION

Farmers have limited inputs and their goal is to maximize farm income from the resources available with them. Hence, in order to operate the farm business at an optimum level, they make some adjustments in the allocation of their resources. The question that arises is whether the farmers on different types of farms respond equally to economic opportunities and make rational use of resources. Keeping this in mind, the present study was carried out to examine the input-output relationship and the resource use efficiency i.e., factor productivity in production of different crops under identified cropping systems in the study area. The use of Cobb-Douglas production function in agriculture is well known. This function was used by many authors to establish input-output relationship in several crops and is popular among Agricultural economists. Hence, the Cobb-Douglas production function which gave best fit was selected to establish the input-output relationship. The regression coefficients of different inputs used in the production function were estimated and the results are presented in Table 1,2 and 3.

Resource productivity in different crops cultivated under Cropping system-I

It is apparent from Table -1 that the regression coefficient of machine power (x_2), and fertilizers (x_4) were positively significant at 10 per cent level. The regression coefficients are the elasticity coefficients of production in Cobb-Douglas production function, as they show percentage response of output to one per cent change in input. One per cent change in machine power (x_2) and fertilizers (x_4) would result in an increase of 0.2109, and 0.4456 per cent respectively in the yield on **kharif** paddy in cropping system I. The adjusted coefficient of multiple determination (R^2) was 0.8266 which implied that 82.66 per cent of variation in the **kharif** paddy output was explained by the independent variables.

On cotton farms, the adjusted coefficient of multiple determination (R^2) was 0.8190 indicating that the variables included in the model explained about 81.90 per cent of variation in the yield of cotton. Of the four variables included in the model, human labour (x_i), and fertilizers (x_4) were positively significant at 1 per cent and 5 per cent levels respectively. This means that keeping other variables constant, 1 per cent increase in human labour and fertilizers would result in an increase of 0.9152, and 0.1097 per cent respectively in the cotton yields. The variable manures (x_3) was positively related but found non-significant.

Resource productivity in different crops cultivated under Cropping system-II

It is apparent from Table -2 that the regression coefficient of human labour (x_1**),** machine power (x_2) were positively significant at 5 and 10 per cent level. This means that 1 per cent increase in human labour, machine power, over its geometric mean level, keeping other factors constant would result in an increase of 2.6863 and 0.5333 per cent respectively in the yield on kharif paddy in cropping system-II. seed was negatively contributed to crop yields and it was significant at 10 per cent level .This means that keeping other variables constant, 1 per cent increase in seed would lead to a decline in the yield of kharif paddy by 1.0346 per cent . The adjusted coefficient of multiple determination (R^2) was 0.8965 which implied that 89.65 per cent of variation in the kharif paddy output was explained by the independent variables included in the model.

On rabi paddy farms, the adjusted coefficient of multiple determination was 0.8868 indicating that the variables included in the model explained about 88.68 per cent of variation in the yield of rabi paddy. Of the four variables included in the model, human labour (x_i) was positively significant at 5 per cent level. This means that keeping other variables constant, 1 per cent increase in human labour would result in an increase of 2.1571 per cent in the rabi paddy yields. Machine power (x_2) was negatively contributed to crop yields and the results was statistically significant at 5 per cent level .This means that keeping other variables constant, 1 per cent increase in machine power would lead to a decline in the yield of rabi paddy by 0.1724. The variable manures (x_3) and fertilizer were positively related but non-significant.

Resource productivity in different crops cultivated under Cropping system-III

It is apparent from Table -3 that the regression coefficient of human labour (x_i), was positively significant at 10 per cent level. This means that 1 per cent increase in human labour would result in an increase of 0.7645 per cent in the yield on kharif paddy in cropping system III. Fertilizer (x_4) was negatively related but significant at 1 per cent level indicating that one per cent increase in fertilizer would lead to a decline in the yield of kharif paddy by 0.0661. The adjusted coefficient of multiple determination (R^2) was 0.7989 which implied that 79.89 per cent of variation in the kharif paddy output was explained by the independent variables included in the model.

On rabi paddy farms, the adjusted coefficient of multiple determination was 0.8198 indicating that the variables included in the model explained about 81.98 per cent of variation in the yield of rabi paddy. Of the four variables included in the model, human labour (x_i) was positively related and significant at 1 per cent level. This means that keeping other variables constant, 1 per cent increase in human labour would result in an increase of 0.9493 per cent in the rabi paddy yields. Fertilizer was positively significant at 1 per cent levels. This means that keeping other variables constant, 1 per cent increase fertilizers would result in an increase of 0.8015 per cent in the rabi paddy yields. The variable manures (x_3) was positively related but non-significant.

On groundnut farms, the adjusted coefficient of multiple determination was 0.7982 indicating that the variables included in the model explained about 79.82 per cent of variation in the yield of groundnut. Of the four variables included in the model, seed (x_5) was positively related and significant at 1 per cent level. This means that keeping other variables constant, 1 per cent increase in seed would result in an increase of 0.9056 per cent in the groundnut yields. Fertilizer (x_4) was negatively related and significant at 10 per cent level indicating that one per cent increase in fertilizer would lead to a decline in the yield of groundnut by 0.06171. The variable human labour (x_i), machinery power(x_2) were positively related but non-significant

Allocative efficiency of resources

To examine the economic efficiency of resource use, the marginal value product of each factor (MVP) was compared with its acquisition cost (MFC). MVP/MFC ratio indicates the potentiality of inputs for further use.

Its higher value (greater than unity) shows greater potentiality for further use. The negative ratio indicates overuse of the input and suggests reduction in the present level of input use. The resource is said to be allocated efficiently or optimally if MVP=MFC. The ratios of MVP to their acquisition cost per unit (MFC) were calculated only for the significant resources in the different cropping systems.

Allocative efficiency of resources in cropping system-I

It is seen from the Table- 4 that for the ratio of MVP to MFC in case of machine power was 2.00 for paddy in cropping system-I which implies that one more rupee of investment on machine power would add Rs.2.00 to the gross income in the paddy production. The ratio of MVP to MFC in case of fertilizers was 3.64 for paddy in cropping system-I which implies that one more rupee of investment on fertilizers would add Rs.3.64 to the gross income in the paddy production cropping system-I. For cotton, the MVP/MFC ratios for human labour was 4.29 which implies that one more rupee of investment on machine power would add Rs.4.29 to the gross income in the cotton production. The MVP/MFC ratios for fertilizer was 1.17. This implies that every additional rupee spent on these inputs would add Rs.1.17 to the returns in cotton production.

Allocative efficiency of resources in cropping system-II

It is seen from the Table-5 that for the ratio of MVP to MFC in case of human labour was 13.88 for kharif paddy in cropping system-II which implies that one more rupee of investment on machine power would add Rs.13.88 to the gross income in the kharif paddy production. The ratio of MVP to MFC in case of machine power was 4.56 for paddy in cropping system-II which implies that one more rupee of investment on machine power would add Rs.4.56 to the gross income in the kharif paddy production in cropping system-II. The MVP/MFC ratios for seed was (-37.69) indicating that there was over use of this resource suggesting the decrease in the present level of input use.

For rabi paddy the MVP/MFC ratios for human labour was 11.74 which implies that one more rupee of expenditure on human labour would add Rs.11.74 to the gross income in the rabi paddy production. The MVP/MFC ratios for machinery power was (-1.68) indicating that there was over use of this resource suggesting the decrease in the present level of input use.

Allocative efficiency of resources in cropping system-III

It is seen from the Table-6 that the ratio of MVP to MFC in the case of human labour was 3.6 for kharif paddy in cropping system-III which implies that one more rupee of expenditure on human labour would add Rs.3.6 to the gross income in the kharif paddy production. The ratio of MVP to MFC in case of fertilizers was -0.47 for paddy in cropping system-III which indicating that there was over use of this resource suggesting the decrease in the present level of input use in the kharif paddy production cropping system-III. For rabi paddy the MVP/MFC ratios for human labour was 5.15 which implies that one more rupee of investment on human labour would add Rs.5.15 to the gross income in the rabi paddy production. The MVP/MFC ratios for fertilizers was 4.91 which implies that one more rupee of investment on fertilizers would add Rs.4.91 to the gross income in the rabi paddy production. For groundnut the MVP/MFC ratios for seeds was 7.04 which implies that one more rupee of investment on fertilizers would add Rs.7.04 to the gross income in the groundnut production. The ratio of MVP/MFC fertilizers was -0.56 indicating that there was over use of this resource suggesting the decrease in the present level of input use.

TABLE-1 Production elasticities of input factors in paddy and cotton in cropping system- I

S. No.	Particulars	paddy	Cotton
1	Intercept	-2.10	-3.58
2	Human labour(x_1)	0.0748 (0.5831)	0.9152** (16.3739)
3	Machinery labour(x_2)	0.2109*** (2.0034)	-0.0127 (-0.7906)
4	Farm yard manure(x_3)	0.1697 (1.3186)	0.0082 (0.3321)
5	Fertilizer(x_4)	0.4456*** (1.772)	0.1097 * (2.1192)
	Adjusted R^2 (R^{-2})	0.8266	0.8190

Note: Figures parentheses indicate the respective standard error; ** indicate significant at 1per cent, * indicate significant at 5 per cent and *** indicate significant at 10 per cent level.

Table-2 Production elasticities of input factors of crops in cropping system- II

S. No	Particulars	Kharif paddy	Rabi paddy
1	Intercept	-3.3459	-2.2196
2	Human labour(xi)	2.6863* (2.1910)	2.1571* (2.1867)
3	Machinery labour(x_2)	0.5333*** (1.9728)	-0.1724* (-2.4490)
4	Farm yard manure (x_3)	-0.7377 (-0.7832)	0.9438 (0.8854)
5	Seed	-1.0346*** (-1.784)	0.023 (0.354)
6	Fertilizers (x_4)	-0.4485 (-0.6148)	0.0553 (0.2961)
	Adjusted R^2 (R^{-2})	0.8965	0.8868

Note: Figures parentheses indicate the respective standard error; ** indicate significant at 1per cent, * indicate significant at 5 per cent and *** indicate significant at 10 per cent level.

Table-3 Production elasticities of input factors of crops in cropping system- III

S. No	Particulars	*kharif*paddy	*Rabi* paddy	Groundnut
11	Intercept	-1.8029	-2.3257	-3.7263
22	Human labour(xi)	0.7645*** (3.2529)	0.9493** (4.4903)	0.1445 (0.6855)
33	Machinery labour (x_2)	0.1423 (1.3122)	-0.1140 (-0.6632)	0.0020 (0.038)
44	Farm yard manure (xs)	0.1433 (1.5511)	0.1475 (0.8997)	-0.0617
55	Fertilizers(x_4)	-0.0661** (-2.2253)	0.8015** (2.33610)	-0.06171*** (-1.8698)
66	Seed (x_5)	-	-	0.9056** (7.0460)
	Adjusted R^2 (R^{-2})	0.7989	0.8198	0.7982

Note: Figures parentheses indicate the respective standard error; ** indicate significant at 1per cent, * indicate significant at 5 per cent and *** indicate significant at 10 per cent level.

Table -4 Allocative efficiency of resources in cropping system-I

S.No	Particulars	Paddy			Cotton		
		MVP	MFC	MVP/ MFC	MVP	MFC	MVP/ MFC
1.	Seed	-	-	-	-	-	-
2.	Human labour	-	-	-	751.36	175	4.29
3.	Machine power	2004	1000	2.0	-	-	-
4.	Farm Yard Manure	-	-		-	-	-
5.	Fertilizers	146.88	40.33	3.64	47.25	40.33	1.17

Note: MVP : Marginal Value product ( ) MFC : Marginal Factor Cost ( )

Table -5 Allocative efficiency of resources in cropping system-II

S. No	Particulars	*Kharif*paddy			*rabi*paddy		
		MVP	MFC	MVP/ MFC	MVP	MFC	MVP/ MFC
1.	Seed	-	-	-	-	-	-
2.	Human labour	2429	175	13.8	2054.73	175	11.7
3.	Machine power	4564.4	1000	4.56	-1685.7	1000	-1.68
4.	Seed	-1130	30	-37.69	-	-	-
5.	Fertilizers	-	-	-	-	-	-

Table -6 Allocative efficiency of resources in cropping system-III

S. No	Particulars	*kharif*paddy			*Rabi* paddy			Groundnut		
		MVP	MFC	MVP/ MFC	MVP	MFC	MVP/ MFC	MVP	MFC	MVP/ MFC
1.1	Seed	-	-	-	-	-	-	634.01	90	7.04
22.	Human labour	632.20	175	3.6	902.79	175	5.15	-	-	-
33.	Machine power	-	-	-	-	-	-	-	-	-
44.	Farm Yard Manure	-	-	-	-	-	-	-	-	-
55.	Fertilizers	-19.09	0.33	-0.47	198.22	40.33	4.91	-22.6	30	-0.56

SUMMARY AND CONCLUSIONS

The functional analysis revealed that machinery power and fertilizer in paddy, human labour and fertilizer in cotton in cropping system-I was significantly contributed to the increase in the crop yields and income. The MVP to MFC ratio was greater than unity for machinery power and fertilizer in paddy, human labour and fertilizers in cotton in cropping system-I indicating greater potentiality for further use.

In the case of cropping system-II human labour and machinery power in kharif paddy, human labour in rabi paddy significantly contributed to the increase in the crop yields and income. The seed in kharif paddy, machinery in rabi paddy negatively significant contributed to the decline in the crop yields and income. The MVP to MFC ratio was greater than unity for human labour, machinery power in kharif paddy, human labour in rabi paddy in the cropping system-II indicating greater potentiality for further use. Machinery power in rabi paddy was less than unity indicating lesser potentiality for further use.

In the case of cropping system-III human labour and fertilizer were significant in both kharif paddy and rabi paddy. Seed and fertilizer in case of groundnut significantly contributed to the increase in the crop yields and income. The MVP to MFC ratio was greater than unity for human labour in kharif paddy, human labour and fertilizer in rabi paddy, seed in groundnut it indicating greater potentiality for further use. Fertilizer in kharif paddy and groundnut were less than unity. It indicating lesser potentiality for further use.

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