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Fertilizer use pattern and efficiency on different size groups of paddy farms in Guntur district of Andhra Pradesh

B Hadassah, S M Shareef, G Raghunadha Reddy and R Srinivasulu
Department of Agricultural Economics, Agricultural College, Bapatla 522 101, Andhra Pradesh.

ABSTRACT

The nitrogen usage was significantly more than the economic optimum i.e., over-use on all farms of both *kharif* and *rabi* except for small farms where it is under-use. The phosphorus use on all farms of both *kharif* and *rabi* was significantly more than the economic optimum and it was negative for large farms. It was under – use in case of small farms. On all farms of both *kharif* and *rabi*, the usage of potassium was in excess except for small farms of *kharif* where it was under-used. It was negative on large farms of *kharif*. The component pesticides on all the farms in *kharif* and *rabi* was being excessively used except for large farms of *kharif* where its usage was less than optimum. The usage of the component human labour on all farms of both *kharif* and *rabi* was excess and it was negative for large farms of *kharif*. The component irrigation on all the farms of both *kharif* and *rabi* was excessively used. But the average farms of *rabi* was an exception and it was used less than the economic level.

Key words : Fertilizer use pattern, Paddy farms

Agriculture is the backbone of Indian economy as more than 65 percent of the population is directly or indirectly depends on agricultural activities and contributes nearly 32 percent of the national income (Govt. of India, 2000a). The objective of the agricultural sector is to achieve the efficiency, equity and sustainability of the natural resources. Hence, the rapid growth in the agricultural sector is to achieve self reliance in food grains production, to bring equity in distribution of food grains among all sections of people and most importantly to maintain sustainability in the use of natural resources, especially land, water and forest resources. From 1965 to 1980, the agricultural sector is characterized by high level of investment in research and development with a focus on achieving self-sufficiency through increased agricultural production. Andhra Pradesh has the prime position of being one of the major contributors to the agricultural performance in India. Per hectare fertilizer use in Andhra Pradesh is as high as 155.8 kg in 2004-05 and on the other hand, in most of the eastern states, it was less than 10 kg per hectare and in Rajathan, it was only 36.6 kg hectare^{-1} [Intensive Agriculture, 2006]. The level of farm income in paddy farms is indicated by the efficiency with which the resources are utilized. Hence, an attempt was made to verify how efficiency the resources i.e., fertilizers of production were managed by paddy farmers in *kharif* and *rabi* seasons. In this paper, analysis of the fertilizer component was given importance and it is divided in the form of nitrogen, phosphorus and potassium along with other components of production i.e., human labor manures and pesticides etc. If any resource was proved to be inefficiently used from the analysis, appropriate remedial measures could be suggested so as to improve resource productivity and resource use efficiency through better resource utilization and organization. Further the returns to scale, the nature of relationship between farm size and productivity of important inputs were worked out and presented in tables 1&2 .

MATERIALS AND METHODS

Guntur district was purposively selected for the present study based on the paddy growing areas in Andhra Pradesh as it is one of the important paddy growing districts and stood in third place in the state. The list of all the mandals in Guntur district were obtained along with paddy acreage, they were arranged in the ascending order of their paddy growing area and the top three mandals i.e. Bapatla, Karlapalem and Sattenapali were selected. From these mandals, six villages cultivating both *kharif* and *rabi* paddy were selected. The primary data was collected through pretested interview schedules from the farmers . The secondary data was collected from chief planning officer, Guntur, Assistant Statitical Officers, Bapatla, Karlapalem and Sattenapalli Mandal Revenue Offices. The cobb-Douglas production function was fitted to the data to study the fertilizer use pattern and efficiency as it is an efficient user of degrees of freedom and can be used with scanty data. The specific form of production function fitted for the data is

The linear log transformation of this function is

$$\log Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + \log U$$

Where,

Y = Gross output in kgs per ha

X_1 = N in kgs per ha

X_2 = P in kgs per ha

X_3 = K in kgs per ha

X_4 = Pesticides in L per ha

X_5 = Human labour in man days

X_6 = Irrigation water in ha cm

a = intercept

U=error term

b_1 to b_6 – Production elasticities of respective inputs.

RESULTS AND DISCUSSION

The production elasticities of the resources, returns to scale and the nature of relationship between farm size and productivity of important inputs were worked out and presented in tables 1 and 2,3,4,5,& 6.

Production elasticities of resources:

Kharif

Small farms

It can be observed from table 1 that the coefficient of multiple determination (R^2) was 0.7622 indicating that 76 per cent variation in yield was explained by the selected input variables. The unexplained 24 per cent variation might be due to the inter farm difference in soil fertility and other exogenous factors. The R^2 value showed that goodness of fit of the Cobb-Douglas production function.

The estimated of nitrogen (X_1) was positive and non significant. It did not significantly contribute to increase in the value of output.The coefficient of phosphorus (X_2) was positive and significant at 5 per cent level. It can be inferred that for every increase in one per cent of input of input, the gross value of output increase by 0.368 per cent. The coefficient of potassium (X_3) was positive and non significant. It did not significantly contribute to increase in the value of output. The coefficient of pesticides (X_4) was positive and non-significant. It implies that this input did not significantly contribute to increase in the value of gross out put.The elasticity coefficient for the human labour (X_5) was positive and significant at 5 per cent level. It would indicate that for every increase in one per cent the gross value of output increase by 0.147 per cent.The coefficient of irrigation (X_6) was positive and non significant. It did not significantly contribute to increase in the value of output.

The sum of regression coefficients (S b_i) was greater than one indicating increasing returns to scale.

Large farms

The table 2 showed that the coefficient of multiple determination (R^2) was 0.857, which indicates 86 per cent variation in yield and was explained by the selected input variables. The remaining 14 per cent variation might be attributed to the inter farm differences in soil fertility, skill of the farmer and other factors not included in the study. The R^2 value showed the goodness of fit to the Cobb-Douglas production function.

The coefficient of nitrogen (X_1) was positive and non significant. It did not significantly contribute to increase in the value of output.The estimated coefficient of phosphorus (X_2) was positive and significant at one per cent level. This implies that for every increase in one per cent of input, the gross value of output increase by 0.555 per cent.The coefficient of potassium (X_3) was found to be non significant. The elasticity of potassium was negative. It did not significantly contribute to increase in the value of output.The coefficient of pesticides (X_4) was found to be positive and significant at one per cent level. This would indicate that for every increase in one per cent of manures, the gross value of output increase by 0.689 per cent.The coefficient of human labour (X_5) was negative and non-significant. It did not significantly contribute to increase in the value of output.The elasticity coefficient for irrigation (X_6) was positive and significant at 5 per cent level. It can be inferred that for every increase in one per cent of this input, the gross value of output increase by 0.079 per cent.

The sum of regression confident ($\sum b_i$) was greater than one indicating increasing returns to scale.

Average farms

It can be noticed from table 3 that the coefficient of multiple determination (R^2) was 0.946 indicating that 95 per cent variation in yield was explained by the selected input variables. The remaining 5 per cent of variation might be attributed to other extraneous factors. The R^2 value showed that goodness of fit of the Cobb-Douglas production function.

The estimated coefficient of nitrogen (X_1) was found positive and non-significant. This implies that it did not significantly contribute to increase in the value of output. The coefficient of phosphorus (X_2) was positive and significant at one per cent level. This would indicate that for every increase in one per cent of this input, the gross value of output increase by 0.529 per cent. The elasticity coefficient for potassium (X_3) was positive and non-significant. It did not significantly contribute increase in the value of output. The coefficient of pesticides (X_4) was positive and significant at one per cent level. It can be inferred that for every increase in one per cent of this input the gross output increase by 0.305 per cent. The coefficient of human labour (X_5) was positive and significant at 5 per cent level. This would indicate that for every increase in one per cent of this input the gross value of output increase by 0.0937 per cent. The estimated coefficient of irrigation (X_6) was found positive and significant at 5 per cent level. This would indicate that for every increase in one per cent of this input the gross value of output increase by 0.099 per cent.

The sum of regression coefficients ($\sum b_i$) was greater than one indicating increasing returns to scale.

Rabi

Small farms

The table 4 showed that the coefficient of multiple determination (R^2) was 0.879, which indicates 88 per cent variation in yield and was explained by the selected input variables. The unexplained 12 per cent variation might be due to the inter farm difference in soil fertility and other exogenous factors. The R^2 value showed the goodness of fit to the Cobb-Douglas production function.

The coefficient of nitrogen (X_1) was positive and significant at 5 per cent level. It can be inferred that for every increase in one per cent of this input the gross value out put increase by 0.3183 per cent. The estimated coefficient of phosphorus (X_2) was positive and significant at 5 per cent level. It implies that for every increase in one per cent of this input, that for every increase in one per cent of this input, the gross value of output increase by 0.183 per cent. The coefficient of potassium (X_3) was positive and non-significant. It did not significantly contribute to increase in the value of output. The elasticity coefficient for pesticides (X_4) was found positive and non-significant. It did not significantly contribute to increase in the value of output.The coefficient of human labour (X_5) was positive and significant at one per cent level. It would indicate that for every increase in one per cent, the gross value of output increase by 0.383 per cent.The coefficient of irrigation (X_6) was positive and significant at 5 per cent level. It could indicate that for every one per cent increase of this input, the gross value of output increase by 0.125 per cent.

The sum of regression coefficients ($\sum b_i$) was equal to one indicating constant returns to scale.

Large farms

It can be observed from table 5 that the coefficient of multiple determination (R^2) was 0.751 indicating that 75 per cent variation in yield was explained by the selected input variables. The remaining 25 per cent variation might be attributed to the inter farm differences in soil fertility, skill of the farmer and other factors not included in the study. The R^2 value showed that good ness of fit of the Cobb-Douglas production function.

The coefficient of nitrogen (X_1) was positive and non-significant. It would indicate that it did not significantly contribute to increase in the value of output. The estimated coefficient of phosphorus (X_2) was negative and non-significant. It did not significantly contribute to increase in the value of output. The coefficient of potassium (X_3) was found to be positive and non-significant. It did not significantly contribute to increase in the value of output.The coefficient of pesticides (X_4) was found positive and non-significant. It did not significantly contribute to increase in the value of output.The coefficient of human labour (X_5) was positive and significant at one per cent level. This would indicate that for every increase in one per cent of human labour, the gross value of output increase by 0.322 per cent.The estimated coefficient of irrigation (X_6) was positive and non-significant. It did not significantly contribute to increase in the value of output.

The sum of regression coefficients ($\sum b_i$) was greater than one indicating increasing returns to scale.

Average farms

The table 6 showed that the coefficient of multiple determination (R^2) was 0.8985, which indicates 90 per cent variation in yield and was explained by the selected input variables. The remaining 10 per cent of variation might be attributed to other extraneous factors. The R^2 value showed the goodness of fit to the Cobb-Douglas production function.

Table 1. Production elasticities of inputs, returns to scale and coefficient of multiple determination of small farm for paddy - *kharif*

S.No.	Item	Regression coefficients (b_i)	Standard errors (SE b_i)	Statistic 't' values
	Gross output (kg ha^{-1}) Y			
1	Nitrogen (kg ha^{-1}) X_1	0.106695	0.0912030	1.1698653NS
2	Phosphorus (kg ha^{-1}) X_2	0.367635	0.1444938	2.5443**
3	Potassium (kg ha^{-1}) X_3	0.07135	0.0693160	1.0293803NS
4	Pesticides (kg ha^{-1}) X_4	0.23941	0.1685566	1.4203755NS
5	Human labour (Mandays ha^{-1}) X_5	0.14708	0.0595871	2.4683921*
6	Irrigation water (Ha.cm) X_6	0.08833	0.1069903	0.8255989NS

Constant (a) 2.020989 , Sum of elasticities 1.0205 , No. of observations : 30, R^2 value 0.7622

Table 2. Production elasticities of inputs, returns to scale and coefficient of multiple determination of large farm for paddy - *kharif*

S.No.	Item	Regression coefficients (b_i)	Standard errors (SE b_i)	Statistic 't' values
	Gross output (kg ha^{-1}) Y			
1	Nitrogen (kg ha^{-1}) X_1	0.05967	0.1042231	0.5725630 NS
2	Phosphorus (kg ha^{-1}) X_2	0.55513	0.1148249	4.8345499**
3	Potassium (kg ha^{-1}) X_3	-0.10145	0.0846521	1.1984348 NS
4	Pesticides (kg ha^{-1}) X_4	0.68954	0.2203459	3.12935**
5	Human labour (Mandays ha^{-1}) X_5	-0.04038	0.0497527	0.8116744 NS
6	Irrigation water (Ha.cm) X_6	0.07909	0.0321562	2.4596269*

Sum of elasticities : 1.2416, Intercept (a) : 1.5965, R^2 value : 0.857, Number of observations : 30

Table 3. Production elasticities of inputs, returns to scale and coefficient of multiple determination of average farm for paddy - *kharif*

S.No.	Item	Regression coefficients (b_i)	Standard errors (SE b_i)	Statistic 't' values
	Gross output (kg ha^{-1}) Y			
1	Nitrogen (kg ha^{-1}) X_1	0.0900918	0.0638146	1.4117744NS
2	Phosphorus (kg ha^{-1}) X_2	0.52952	0.0982612	5.38890**
3	Potassium (kg ha^{-1}) X_3	0.08036	0.0504901	1.5917059 NS
4	Pesticides (kg ha^{-1}) X_4	0.30476	0.1131566	2.6932657**
5	Human labour (Mandays ha^{-1}) X_5	0.09373	0.0406950	2.3032184*
6	Irrigation water (Ha.cm) X_6	0.09853	0.0378357	2.6041443*

Intercept 1.9274, Sum of elasticities 1.1970, R^2 value : 0.946 Number of observations: 60

** Significant at 1% level * Significant at 5% level NS – Non significant

Table 4. Production elasticities of inputs, returns to scale and coefficient of multiple determination of small farm for paddy - *rabi*

S.No.	Item	Regression coefficients (b_i)	Standard errors (SE b_i)	Statistic 't' values
	Gross output (kg ha^{-1}) Y			
1	Nitrogen (kg ha^{-1}) X_1	0.3183	0.1304158	2.4406898*
2	Phosphorus (kg ha^{-1}) X_2	0.1825	0.0872343	2.0925632*
3	Potassium (kg ha^{-1}) X_3	0.00832	0.0311929	0.2669416 NS
4	Pesticides (kg ha^{-1}) X_4	0.07341	0.1125275	0.6524031 NS
5	Human labour (Mandays ha^{-1}) X_5	0.38287	0.0777732	4.92290**
6	Irrigation water (Ha.cm) X_6	0.12500	0.0465119	2.6875353*

Intercept : 0.7955, Sum of elasticities : 0.87909, R^2 value : 0.8736, Number of observations 30

Table 5. Production elasticities of inputs, returns to scale and coefficient of multiple determination of large farm for paddy - *rabi*

S.No.	Item	Regression coefficients (b_i)	Standard errors (SE b_i)	Statistic 't' values
	Gross output (kg ha^{-1}) Y			
1	Nitrogen (kg ha^{-1}) X_1	0.864212	0.5142462	1.6805 NS
2	Phosphorus (kg ha^{-1}) X_2	-0.01658	0.1236133	0.1341765 NS
3	Potassium (kg ha^{-1}) X_3	0.01622	0.0540592	0.3000609 NS
4	Pesticides (kg ha^{-1}) X_4	0.06570	0.1130089	0.5813833 NS
5	Human labour (Mandays ha^{-1}) X_5	0.321988	0.0966732	3.3306842**
6	Irrigation water (Ha.cm) X_6	0.11346	0.0801434	1.4157379 NS

Intercept : 1.210303, Sum of elasticities : 1.3650, R^2 value : 0.75144, Number of observations : 30

Table 6. Production elasticities of inputs, returns to scale and coefficient of multiple determination of average farm for paddy - *rabi*

S.No.	Item	Regression coefficients (b_i)	Standard errors (SE b_i)	Statistic 't' values
	Gross output (kg ha^{-1}) Y			
1	Nitrogen (kg ha^{-1}) X_1	0.43131	0.1896553	2.2742*
2	Phosphorus (kg ha^{-1}) X_2	0.07634	0.0707527	1.0789548 NS
3	Potassium (kg ha^{-1}) X_3	0.02793	0.0437464	0.6384339 NS
4	Pesticides (kg ha^{-1}) X_4	0.20704	0.1027795	2.0144041*
5	Human labour (Mandays ha^{-1}) X_5	0.25345	0.0692028	3.66242**
6	Irrigation water (Ha.cm) X_6	0.23793	0.0467286	5.0917020**

Intercept : 0.1767, Sum of elasticities 1.234, R^2 value : 0.8985, Number of observations : 60

** Significant at 1% level * Significant at 5% level NS – Non significant

Table 7. Marginal Value Product to Opportunity Cost for paddy-small farmers – *kharif*

S.No.	*Item*	MVP	OC	MVP/OC	Input use
1	Nitrogen (X_1)	27.10	6	4.52	Under – use
2	Phosphorus (X_2)	15.705	7	2.24	Under – use
3	Potassium (X_3)	21.39	2	8.56	Under – use
4	Pesticides (X_4)	0.3747	1	0.3747	Over – use
5	Human labour (X_5)	0.1870	1	0.1870	Over – use
6	Irrigation water (X_6)	0.5188	1	0.5188	Over – use

Table 8 . Marginal Value Product to Opportunity Cost for paddy-Large farmers – *kharif*

S.No.	*Item*	MVP	OC	MVP/OC	Input use
1	Nitrogen (X_1)	0.1486	6	0.025	Over – use
2	Phosphorus (X_2)	1.5239	7	0.2177	Over – use
3	Potassium (X_3)	-0.2982	2	-0.1491	Over – use
4	Pesticides (X_4)	2.3190	1	2.3190	Under – use
5	Human labour (X_5)	-0.0518	1	-0.0518	Over – use
6	Irrigation water (X_6)	0.4595	1	0.4595	Over – use

Table 9. Marginal Value Product to Opportunity Cost for paddy-Average farmers – *kharif*

S.No.	*Item*	MVP	OC	MVP/OC	Input use
1	Nitrogen (X_1)	0.2266	6	0.0378	Over – use
2	Phosphorus (X_2)	1.7348	7	0.248	Over – use
3	Potassium (X_3)	0.2389	2	0.11945	Over – use
4	Pesticides (X_4)	0.4757	1	0.4757	Over – use
5	Human labour (X_5)	0.1197	1	0.1197	Over – use
6	Irrigation water (X_6)	0.5745	1	0.5745	Over – use

Table 10. Marginal Value Product to Opportunity Cost for paddy-Small farmers – rabi

S.No.	*Item*	MVP	OC	MVP/OC	Input use
1	Nitrogen (X_1)	69.99	6	11.47	Under – use
2	Phosphorus (X_2)	47.57	7	6.61	Under – use
3	Potassium (X_3)	2.49	2	0.996	Over – use
4	Pesticides (X_4)	0.1068	1	0.1068	Over – use
5	Human labour (X_5)	0.8733	1	0.8733	Over – use
6	Irrigation water (X_6)	0.6202	1	0.6202	Over – use

Table 11. Marginal Value Product to Opportunity Cost for paddy-Large farmers – *rabi*

S.No.	*Item*	MVP	OC	MVP/OC	Input use
1	Nitrogen (X_1)	4.5097	6	0.7516	Over – use
2	Phosphorus (X_2)	-0.0416	7	-0.00594	Over – use
3	Potassium (X_3)	0.0473	2	0.02365	Over – use
4	Pesticides (X_4)	0.0956	1	0.0956	Over – use
5	Human labour (X_5)	0.4123	1	0.4123	Over – use
6	Irrigation water (X_6)	0.5954	1	0.5954	Over – use

Table 12. Marginal Value Product to Opportunity Cost for paddy-Average farmers – *rabi*

S.No.	*Item*	MVP	OC	MVP/OC	Input use
1	Nitrogen (X_1)	1.8215	6	0.3036	Over – use
2	Phosphorus (X_2)	0.1953	7	0.0279	Over – use
3	Potassium (X_3)	0.0824	2	0.0412	Over – use
4	Pesticides (X_4)	0.3012	1	0.3012	Over – use
5	Human labour (X_5)	0.5805	1	0.5805	Over – use
6	Irrigation water (X_6)	1.2146	1	1.2146	Under – use

The elasticity coefficient for nitrogen (X_1) was found positive and significant at 5 per cent level. This would indicate that for every increase in one per cent of this input, the gross value of crop out put increase by 0.43 per cent. The coefficient of phosphorus (X_2) was positive and non-significant. It did not significantly contribute to increase in the value of output.The estimated coefficient of potassium (X_3) was positive and non-significant. It would indicate that it did not significantly contribute to increase in the value of output.The coefficient of pesticides (X_4) was positive and significant at five per cent level. It can be inferred that for every increase in one per cent of this input the gross returns increase by 0.207 per cent.The coefficient of human labour (X_5) was positive and significant at one per cent level. This would indicate that for every increase in one per cent of this input the gross value of crop output increase by 0.253 per cent.

The elasticity coefficient for irrigation (X_6) was positive and significant at one per cent level. This would indicate that for every increase in one per cent of this input the gross value of crop output increase by 0.238 per cent.

The sum of regression coefficients ($\sum b_i$) was greater than one indicating increasing returns to scale.

Sum of elasticities of resources in Cobb-Douglas production function gave an indication of returns to scale. The results of the 't' test revealed that for small, large and average groups of both *kharif* and *rabi* were more than unity significantly indicating increasing returns to scale.

Resource use efficiency

The production function analysis was used to determine the efficiency of resource, which requires the estimation of marginal value products of resources. The marginal value products (MVP) derived from Cobb-Douglas production function, indicates the addition to gross value of farm production for a unit increase in the resource with all other resources fixed at their geometric mean levels. The estimated marginal value productivity (MVP), opportunity costs (OC) and their ratios are presented in the tables 7,8,9,10,11 & 12.

Kharif

Small farms

The MVP to OC ratio was positive and more than one for nitrogen, phosphorus and potassium. This indicates further scope for increasing the use of these inputs to realize higher profits. For the variables Pesticides, human labour and irrigation, MVP to OC ratio was less than one indicating that increases in use of inputs result in returns less than the additional expenditure. Hence, the expenditure on these inputs needs to be reduced as they yielded decrease additional returns.

Large farms

The MVP to OC ratio for variable pesticides was positive and more than one indicating under use of the inputs. There is scope for increasing the use of these inputs to realize higher profits. The ratio for variables nitrogen, phosphorus, potassium, human labour and irrigation are below unity and negative for potassium and human labour. This indicates that the expenditure on these inputs needs to be reduced as they result in decreasing returns.

Average farms

For all the variables the MVP to OC ratio was less than unity indicating that use of inputs result in returns less than the additional expenditure. So, the costs on these input needs to be decreased as they result in decreasing additional returns.

Rabi

Small farms

The MVP to OC ratio for inputs nitrogen and phosphorus was positive and more than one. This shows that there is a scope for increasing the use of these inputs to realize higher profits. The ratio for variables potassium, pesticides, human labour and irrigation was below one indicating that the expenditure on these inputs need to be reduced as they decrease the returns.

Large farms

The MVP/OC ratio for all the variables i.e., nitrogen, phosphorus, potassium, pesticides, human labour and irrigation was less than unity and for phosphorus, it was negative. This shows that the expenditure on these inputs needs to be reduced as they yielded decreasing additional returns.

Average farms

The ratio for variables nitrogen, phosphorus, potassium, pesticides and human labour was less than one. Increasing use of inputs result in returns less than the additional expenditure. Hence, the expenditure on these inputs needs to be reduced as they result in decreasing additional returns.

CONCLUSIONS:

It can be concluded that the farmers are using fertilizers on unbalanced manner and they are overusing the inputs. This should be reduced to optimum level. Extensive research on balanced use of fertilizers and integrated nutrient management should be carried out. The Government should take a forward step to set up sub-depots of fertilizers in each village at each panchayat to make fertilizer available in the village itself. Proper extension services should be enhanced in the district for dissemination of information on the benefits of balanced use of fertilizers and the adverse affects that would be caused due to the indiscriminate use of fertilizers.

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