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(Received : July 97 Revised : February 98)

Madras Agric. J., 85(7-9): 442 - 446 July - September 1998
https://doi.org/10.29321/MAJ.10.A00781

INPUT USE EFFICIENCY IN PADDY WITH SPECIAL REFERENCE TO WATER - A TRANSLOG PRODUCTION FUNCTION APPROACH

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ABSTRACT

A study conducted in Krishnagiri Reservoir Project (KRP) in Tamil Nadu indicated that the water use efficiency in Navarai paddy was the highest in tail region with 32.85 kg/ha cm of water, followed by middle and head regions. Translog production functions were employed for each region to analyse the input use efficiency. The results clearly showed that labour and irrigation water were overused in the ayacut area whereas the inorganic fertilizers were underutilised and there is scope for increasing the productivity of navarai paddy through rational use of these scarce resources.

KEY WORDS : Translog, marginal product, elasticity, efficiency

Water is one of the crucial input in agriculture which is tending to become more scarce and costlier. The availability of water resource is getting fastly depleted, so conservation and efficient use of water have assumed greater importance. Evaluation of public irrigation system have shown that the benefits have declined due to many reasons like neglected maintenance and inefficient operation. (Anagol, 1969). Mitra (1984) observed that the factors contributing for the low efficiency of irrigation projects are inadequate project planning, excessive use of water, wastage of water, lack of conjuctive use of surface and ground water, inefficient distribution system and lack of infrastructural facilities.

The national average production of foodgrains per ha of irrigated land is around 1.7 tonnes as against 0.7 tonnes per ha of unirrigated rainfed land.. The rate of food production could be increased by about 2.5 times, if modernisation of the existing irrigation projects, improvement of on-farm development works, adoption of improved agronomic practice, followed by optimum water-land management techniques are undertaken (Mistry, 1987). To attain the increased production level, one specific area is increasing the productivity through efficient utilisation of critical inputs like fertilizer, water, etc. In this context, a study was conducted in Krishnagiri Reservoir Project (KRP) in Dharmapuri district, Tamil Nadu, with the specific objective to analyse the water use efficiency of Navarai Paddy (Nov-Apr) in the ayacut area.

MATERIALS AND METHODS

Multi stage sampling procedure was adopted for the study. In the first stage the ayacut area served by two main canals namely Right Main Canal (RMC) and Left Main Canal (LMC) were selected. At the second stage, based on the discussion with the KRP authorities, and total length of these canals, three regions namely head, middle and tail were selected. In the third stage, two revenue villages in each of the three regions in each canal were selected. At the fourth stage, the farmer-respondents in each village were listed out from the ayacut register / revenue records available, and ten respondents were selected in each village and thus a total sample of 120 respondents were selected at random and interviewed during 1991.

The collected data were subjected to percentage analysis and translog production function developed by Christensen *et al.*, (1972). This translog production function was preferred over the Cobb-Douglas type of production function. Since it helps to study the interaction effects of the independent variables and it is quite popular with the economists in recent times mostly because of its several possible interpretations, flexibility and mathematical simplicity.

The estimable form of the production function was as follows.

$$\ln Y = a_0 + a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_3 + 1/2\,(a_1 \log X_1^2) + 1/2\,(a_2 \log X_2^2) + 1/2\,(a_3 \log X_3^2) + (a_{12} \ln X_1 \ln X_2 + a_{13} \ln X_1 \ln X_3 + a_{23} \ln X_2 \ln X_3)$$

Where Y = Gross paddy output in kg/ha

X_1 = NPK nutrients in kg/ha

X_2 = Quantity of water used in ha cm.

X_3 = Number of mandays of labour per ha.

a = regression constant

a_{ij} = parameters to be estimated

From the estimated function, the marginal products (MP_i) were estimated as follows.

$$MP_i = \frac{\Delta Y}{\Delta Xi} = \frac{\Delta \ln Y}{\Delta \ln Xi} \cdot (Y/Xi)$$

The Marginal Value Product (MVP) and Elasticities of Production (EP) were estimated as follows.

$$MVP = MPP.\ P_x$$

$$EPI = \frac{\Delta \ln Y}{\Delta \ln Xi}$$

The Elasticities of Substitution (ES) were also estimated as below.

$$ES = MRS_{12} \frac{X_1}{X_2}$$

RESULTS AND DISCUSSION

The study indicated that the average yield of navarai paddy was highest in middle region with 4114.25 kg/ha, followed by tail region 3779.10 kg/ha and head region 3603.63 kg/ha (Tables 1 & 2) indicating that water use efficiency was higher in tail and middle regions rather than head region inspite of the fact that the per hectare application of

Table 1. Average yield of paddy vis-a-vis irrigation distance (Kg/ha)

Distance	Head	Middle	Tail	Average
0-1.00	4231.93	3952.00	4248.40	4144.11
1.01-2.00	4087.85	3450.74	3630.90	3723.16
2.01-3.00	3130.73	-	3458.00	3294.37
3.01 and above	2964.00	4940.00	-	3952.00
Average	3603.63	4114.25	3779.10	

fertilizers was higher in head region. Obviously, middle region used highest level of fertilizers, which has helped to higher yields. The salinity of the soil and poor fertilizer response in the head region might be the reasons for low yield. The average yield was the highest at 4144.11 kg/ha in the category of upto one km irrigation distance followed by 3723.16 kg/ha in 1-2 km category and 3294.37 kg/ha in 2-3 km category. It was observed as the irrigation distance increased, productivity of paddy decreased, except in the last category where a single farm's productivity in the middle region was the highest and so the average productivity was higher for that category as a whole. It was more pronounced in the head region where the productivity of paddy gradually decreases as the irrigation distance increases. Similar trend was observed in the tail region also.

The distance wise water use efficiency of paddy in terms of productivity of paddy per unit quantity of water i.e., productivity per ha cm of water is presented in Table 2. It could be seen from the table that the water use efficiency is highest in tail region with 32.85 kg/ha cm of water followed by middle region with 25.88 kg/ha cm and head region with 22.59 kg/ha cm. This showed that water use efficiency and irrigation distance are positively related. The water use efficiency in 0-1 km category was 25.77 kg/ha cm and it declines marginally to 24.76 kg/ha cm in 1.01-2.00 km

Table 2. Distancewise water use efficiency of paddy (Kg/ha cm)

Distance (Km)	Water use efficiency (i.e. productivity / ha cm of water)			
	Head	Middle	Tail	Average
0-1	23.43	23.22	32.27	25.77
1.01-2.00	23.80	21.11	24.14	24.76
2.01-3.00	20.66	-	34.45	26.45
3.01 and above	21.70	34.45	-	28.23
Average	22.50	25.88	32.85	

Table 3. Summary of Translog Production Function - Head Region

Particulars	Variables	Regression coefficient (bi)	Standard error (SE bi)	't' value	Significance level
Gross paddy output in kg/ha	Y				
NPK nutrients in kg/ha	X_1	-2.287	0.465	-4.920	xx
Quantity of water used in ha cm	X_2	17.934	4.265	4.205	xx
Number of mandays of labour per ha	X_3	0.497	0.256	1.936	NS
Square terms :					
NPK nutrients	X_1^2	0.259	0.043	6.065	xx
Quantity of water	X_2^2	-0.244	0.066	-3.665	xx
Labour	X_3^2	1.441	0.778	1.850	NS
Interaction terms :					
Fertilizer x quantity of water	X_1X_2	0.054	0.134	0.402	NS
Fertilizer x Labour	X_1X_3	-0.047	0.135	-0.348	NS
Quantity of water x labour	X_2X_3	-1.242	0.568	-2.188	x

$R^2 = 0.90$ a = -45.290 xx Significant at 1% level
N = 39 N = Number of samples x Significant at 5% level
NS Non-Significant

category and it again increased to 26.45 kg/ha cm in 2.01 to 3.00 km category and it was highest in 3.01 km and above with 28.23 kg/ha cm, confirming that water use efficiency increases as the irrigation distance increases eventhough the trend was not clear. It also indicates that the farmers in the head region are not efficiently managing the irrigation water in the context of salinity as compared to those farmers in tail and middle regions.

Production function analyses

An attempt was made to evaluate the use efficiency of different crucial inputs in the output of navarai paddy. This was done through translog production function for each region. The results of the estimated translog production function for head, middle and tail regions are presented in Tables 3 to 5. The estimated equations in all the three cases have reasonable R^2 (coefficient of multiple determination) of 0.90, 0.87 and 0.89 for head, middle and tail regions respectively, which confirms the appropriateness of the specification of production function and selection of functional form.

It could be seen from the table that the calculated marginal physical product for NPK nutrients were 7.212, 11.288 and 7.173 kgs, respectively for head, middle and tail regions (Table 4). The MVP of output in the three regions were Rs. 18.03, Rs. 28.22 and Rs. 17.93 and it indicates that the farmers could get additional income of Rs. 18.03, Rs. 28.22 and Rs. 17.93 in head, middle and tail region by incurring an expenditure of Rs. 13.45 being the cost of one kg of

Table 4. Summary of Translog Production Function - Middle Region

Particulars	Variables	Regression coefficient (bi)	Standard error (SE bi)	't' value	Significance level
Gross paddy output in kg/ha	Y				
NPK nutrients in kg/ha	X_1	-1.875	0.412	-4.553	xx
Quantity of water used in ha cm	X_2	8.992	3.083	2.917	xx
Number of mandays of labour per ha	X_3	0.186	0.890	0.209	NS
Square terms :					
NPK nutrients	X_1^2	0.225	0.038	5.958	xx
Quantity of water	X_2^2	-0.880	0.309	-2.846	xx
Labour	X_3^2	0.068	0.064	1.078	NS
Interaction terms :					
Fertilizer x quantity of water	X_1X_2	0.088	0.135	0.654	NS
Fertilizer x Labour	X_1X_3	-0.104	0.133	-0.785	NS
Quantity of water x labour	X_2X_3	-0.045	0.063	-0.713	NS

$R^2 = 0.87$ a = -12.255 xx Significant at 1% level
N = 39 N = Number of samples NS Non-Significant

Table 5. Summary of Translog Production Function - Tail Region

Particulars	Variables	Regression coefficient (bi)	Standard error (SE bi)	't' value	Significance level
Gross paddy output in kg/ha	Y				
NPK nutrients in kg/ha	X_1	-1.899	0.400	-4.746	xx
Quantity of water used in ha cm	X_2	11.220	3.269	3.432	xx
Number of mandays of labour per ha	X_3	0.113	0.853	0.133	NS
Square terms :					
NPK nutrients	X_1^2	0.226	0.036	6.193	xx
Quantity of water	X_2^2	-1.100	0.239	-3.343	xx
Labour	X_3^2	0.066	0.062	1.069	NS
Interaction terms :					
Fertilizer x quantity of water	X_1X_2	0.091	0.131	0.689	NS
Fertilizer x Labour	X_1X_3	-0.105	0.128	0.815	NS
Quantity of water x labour	X_2X_3	-0.037	0.061	-0.612	NS

$R^2 = 0.89$ a = -17.642 xx Significant at 1% level

N = 33 N = Number of samples NS Non-Significant

NPK nutrients, keeping all other inputs at their mean level. The estimated elasticity of production for NPK nutrients were 0.463, 0.651 and 0.353 for head, middle and tail regions, respectively. It implies that the output of paddy is expected to increase by 0.463, 0.651 and 0.354 percent for one percent increase in NPK nutrients in head, middle and tail regions respectively, assuming all other inputs at constant levels.

The MPP for water is -12.062 kgs and the MVP was Rs. 30.16 in head region. The negative sign indicates that the water is overused and it might be due to excessive use of irrigation water, competition among the farmers to use more water, poor water management practices, low productivity, low fertility status of the soil and problem soils like alkalinity and salinity. The elasticity of production for water in head region was -0.536 and it implies that one per cent increase in the quantity of water would decrease the gross paddy output by 0.536 percent, when all other variables are kept at their mean levels.

The MPP of water was 17.467 and 9.263 kgs and the MVP of water was Rs. 43.67 and Rs. 23.15 for the middle and tail regions, respectively. The coefficient of water was also significant at one percent level and the MPP and MVP could be interpreted in the same way as that of NPK nutrients. The elsticity of production was 0.675 and 0.282 for middle and tail regions, respectively. It indicates that for one percent increase in the quantum of water would increase the paddy output by 0.675 and 0.282 percent in middle and tail regions keeping other variables at constant levels.

The variable, labour in mandays, (X_3) was found to be statistically not significant in all the three regions. This might be due to the fact that the farmers in the ayacut area have already applied this labour input to a point beyond which the additional input of labour will not contribute additional output significantly. The negative sign indicates the overuse of labour in the project area.

Elasticity of substitution

From the estimated production function, marginal rate of substitution (MRS) was derived for a given level of gross paddy output and then elasticity of substitutions were calculated.

The MRS derived for the estimated function is as follows.

$$MRS_{X_1X_2} = \frac{(a_1 + b_{11} \log X_2 + b_{12} \log X_2 + b_{13} \log X_3)/X_1}{(a_2 + b_{22} \log X_2 + b_{12} \log X_1 + b_{23} \log X_3)/X_2}$$

$$ES_{X_1X_2} = MRS_{X_1X_2} \frac{X_1}{X_2}$$

The estimated elasicity of substitution of NPK nutrients with irrigation water was -0.212 in head region, -0.170 in middle region and -0.140 in tail region. The negative sign indicates that these two inputs are substitutes. This also indicates the substitution between these two inputs takes place for a given level of output. This may help to substitute the lower cost input to the higher cost

Table 6. Marginal Physical Product (MPP), Marginal Value Product (MVP) and Elasticity of Productin (EP) in the study area

Particulars	Head			Middle			Tail		
	NPK	Water	Labour	NPK	Water	Labour	NPK	Water	Labour
MPP	7.212	-12.062	-34.190	11.288	17.467	-33.278	7.172	9.263	-21.519
MVP	18.03	-30.16	-85.48	28.22	43.67	-83.20	17.93	23.15	-53.79
EP	0.463	-0.536	-1.659	0.651	0.675	-1.498	0.354	0.282	-1.049

input. In all the three regions, the degree of substitution possibilities was not high and it indicates that to a certain extent only these two inputs can be substituted beyond which they become complements. Since the variable, labour (X_3) was not significant in all the three regions, the substitution possibilities of X_3 with X_1 and X_2 were not calculated.

Conclusions

The study revealed that navarai paddy productivity and irrigation distance was negatively related and the average productivity in the study area was highest in the middle region, where as the water use efficiency was highest in tail region followed by middle region. The production function analyses showed that water and labour are being overused in the KRP ayacut area. There is a need to create awareness among the farmers on optimum use of scarce resources like water and education on water management practices are essential to achieve the goal of efficiency.

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(Received : February 97 Revised : June 99)

Madras Agric. J., 85(7-9): 446 - 450 July - September 1998

THE EFFECT OF THREE PESTICIDES AND PESTICIDE INTERVAL ON *Cinnamomum verum* galls in Southern Sri Lanka.

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ABSTRACT

Experiments performed to find a suitable pesticide and a pesticide interval to control a gall causing insect *Trioza cinnamomi* indicated that there was significant effect of all three insecticides monocrotophos, lannate and methamidophos on tested distribution of galls at 3 crown levels tested. There were no significant differences between the crown levels in respect of gall distribution. Monocrotophos (30ml/25L) was found to be the most effective pesticide and 4 days interval was found to be the best spraying interval to control gall causing insect *T. cinnamomi*.

KEY WORDS : Pesticide, galls, cinnamon

Cinnamon (*Cinnamomum verum* Presl.) (*Fam. Lauraceae* is an indigenous plant in Sri Lanka, with an area of 6749 ha (Department of Statistics, 1992) and the production was 10016.4 MT. The quills, cinnamon bark oil and leaf oil are the commercial products of cinnamon plant. Sri Lanka is the highest exporter of cinnamon trade in the world and contributes 60% of the world export market. The main centres of cultivated cinnamon in Sri Lanka are Colombo (300 ha), Galle (9200 ha) and Matara (5900 ha) districts (Agric. Stat. of Sri Lanka, 1992).