Production function analysis of irrigation water and nitrogen fertiliser in swamp rice production*1/

M. R. IRUTHAYARAJ**, Y. B. MORACHAN**

COMPENDIO

Se condujo un experimento en la Tamil Nadu Agricultural University, en Coimbatore India, durante 1971 a 1973, con las variedades de arroz 'Kannaki', 'Bala', en los períodos de monzón (húmedo) y verano (seco), con cinco tratamientos de manejo de agua y cinco niveles de nitrógeno. De los modelos de producción probados, se encontró que el cuadrático tenia el mejor ajuste, indicando que estas variedades requieren menos cantidad de agua y una cantidad mayor de nitrógeno para un rendimiento mayor de grano.

Introduction

IRRIGATION is the prime requisite for successful crop production, particularly in rice, the staple food of Tamil Nadu. Out of the 3.6 m.ha of cultivated land in Tamil Nadu, 2.5 m.ha, or 69.3 per cent are under rice. This area under rice utilises approximately 87 per cent of the available irrigation sources of the State. Due to the low storage position in the dams and also to pressure for water for other purposes, agriculture has to compete for water on the basis of its productivity and efficiency. Nitrogenous fertilisers have contributed significantly in recent years to the increases in rice yields but nitrogen requirements differ with the different water management practices. The maximising or economically optimum water and nitrogen input rates require a knowledge of the production function for water and nitrogen. The main object of this study is to determine which production function model is best suited for fertiliser and water use, improving water and fertiliser management and in planning future research in water and fertiliser use.

Materials and Methods

The experiment was conducted at the wet land farm of the Tamil Nadu Agricultural University, Coimbatore, India during the years 1971 to 1973. Coimbatore is situated at 11°N and 77°E, at an altitude of 498 m above mean sea level. The average annual rainfall of 613.6 mm was obtained in 49.8 rainy days.

The treatments were:

(I) water management treatments: I_1 – maintaining a 5 cm water depth daily throughout the crop growth; I_2 – maintaining a 5 cm water depth daily thoughout the crop growth with stoppage of water for five days only at the end of tillering stage; I_3 – maintaining saturation daily throughout the crop period; I_4 – maintaining a 5 cm water depth daily for four days followed by stoppage of water for four days; and I_5 – maintaining a 5 cm of water depth daily for eight days followed by stoppage of water for eight days.

(II) The varieties tested were V_1 - 'Kannaki' (IR 8 x TKM 6) and V_2 - 'Bala' (N. 22 x T. [N_1]).

(III) The nitrogen levels were N_0 - 0 kg, N_1 - 60 kg, N_2 - 120 kg, N_3 - 180 kg and N_4 - 240 kg per hectare. A common dose of 60 kg P_2O_5 and 60 kg K_2O per hectare were applied uniformly to all the plots.

The experiment was laid out in a split plot design with water management and varieties allotted to the main plot and the nitrogen levels allotted to the subplots, with three replications. In all, two monsoon (wet)

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** Associate Professor of Agronomy, and Director of Research respectively Tamil Nadu Agricultural University, Coimbatore-641 003, India.

and two summer (dry) crops were harvested. The crops were transplanted on 30.7.1971, 18.2.1972, 13.7.1972 and 5.2.1973.

The experimental data obtained during two summers and two monsoons with two varieties, were utilised for this purpose. Of the several productions functions available the linear, the square root, quadratic and Cobb-Douglas functions (equation 1, 2, 3, 4) below were chosen for consideration as suggested by Kloster and Whittlesey (3). Each of the equations was fitted to the data, using least square multiple regression analysis.

(1) $Y = a + b_1N + b_2W + b_3NW$ (Linear)

(2) $Y = a - b_1N - b_2W + b_3N^{1/2} + \frac{3}{4}W\frac{1}{2} + b_5N^{1/2}W^{1/2}$ (Square root)

(3) $Y = a + b_1N - b_2W - b_3N^2 + b_4W^2 + b_5NW$ (Quadratic)

(4) $Y = aN^{b1}\ W^{b2}$ (Cobb-Douglas)

Where:

Y = is the grain yield of rice in kg per hectare

N = is the nitrogen applied in kg per hectare

W = is the total water applied in cm per hectare

b_1 to b_5 = are the regression coefficients

a = is a constant derived from regression.

Results and Discussion

The multiple determination coefficient (R^2) and the 'F' statistics for the linear, square root, quadratic and Cobb-Douglas equations for both varieties in two seasons are furnished in Table 1. The R^2 values for the quadratic function were higher than for the other functions. It was recognised that the R^2 values for the Cobb-Douglas equation were not directly comparable with the others because these values were estimated in logarithmic form. The quadratic function was chosen, since the magnitude of the multiple determination coefficient (R^2) was greater than others; the logic being that it would fit the data and the degree of significance of its terms.

The regression coefficients are presented in Table 2, with b_1 and b_2 values being the regression coefficient of linear terms of nitrogen and total quantity of water respectively, and b_3 and b_4 being the quadratic terms. The interaction of nitrogen and total water requirement was expressed by the b_5 (N x W) term. This model accounted for the effect of nitrogen and total water requirement in explaining yield variations from season to season and variety to variety. The improved varieties showed a stronger nitrogen response in all the seasons and in both the varieties by having a positive regression coefficient for nitrogen (b_1 values) showing that the

Table 1.—Coefficent of multiple determination (R^2) and 'F' statistics for linear, square root, quadratic and Cobb-Douglas equation for two varieties of rice in different seasons.

Variety	Season	Particulars	Equation			
			Linear	Square root	Quadratic	Cobb-Douglas
Kannaki (V_1)	1972 summer	Coefficient of multiple determination (R^2)	0.59	0.86	0 88	0.69
		'F' statistics	10 24	23 91	27 61	24.84
	1973 summer	Coefficient of multiple determination (R^2)	0 58	0.71	0 72	0.49
		'F' statistics	9 56	9 16	9.89	10 57
Bala (V_2)	1972 summer	Coefficient of multiple determination (R^2)	0 63	0 82	0 91	0 67
		'F' statistics	11.70	16.80	39 79	22.68
	1973 summer	Coefficient of multiple determination (R^2)	0 62	0.82	0.85	0.68
		'F' statistics	11 20	17.06	21.54	23.68
Kannaki (V_1)	1971 monsoon	Coefficient of multiple determination (R^2)	0 72	0.92	0 96	0.94
		'F' statistics	17.64	42.03	81 66	183.99
	1972 monsoon	Coefficient of multiple determination (R^2)	0 69	0 73	0 71	0.51
		'F' statistics	15 34	10.44	9 40	11 46
Bala (V_2)	1971 monsoon	Coefficient of multiple determination (R^2)	0.91	0 94	0.97	0 83
		'F' statistics	69 92	57 70	121.32	52 65
	1972 monsoon	Coefficient of multiple determination (R^2)	0.72	0.73	0.78	0 59
		'F' statistics	17.85	10.26	13.22	15.74

Table 2.—Regression coefficients for grain yield on nitrogen and water requirement in two varieties of rice in different seasons under quadratic model.

Variety	Season	Constant	$b_1(N)$	$b_2(W)$	$b_3(N^2)$	$b_4(W^2)$	$b_5(NW)$	Nº of observations	Coefficient of determination
Kannaki (V_1)	1972 summer	36884 89	79.73	—772 65	0 03	4.29	—0.77	25	0 88
	1973 summer	32695 87	64 96	—676 73	0 01	3.74	—0 60	25	0 72
Bala (V_2)	1972 summer	22276 74	50 00	—522.72	—0 02	3.23	—0 39	25	0 91
	1973 summer	26829.81	62 30	—655 89	—0 04	4 08	—0 50	25	0.85
Kannaki (V_1)	1971 Monsoon	4087 46	31.85	— 28 06	—0 09	0 14	—0 001	25	0 96
	1972 Monsoon	13878 53	39 62	—233 58	0 004	1 20	—0 28	25	0.71
Bala (V_2)	1971 Monsoon	172 36	25 23	+ 24 53	—0 06	—0 18	0 05	25	0 97
	1972 Monsoon	6289 32	41 63	—162.08	0 03	1.24	—0 44	25	0.78

grain yield increase was due to nitrogen. High nitrogen application tended to increase the plant characters with a high positive correlation in increasing grain yield. High nitrogen levels encourage greater root development which expands the volume of soil from which plants can extract moisture.

Considering the total water applied or water requirement on the yield, a negative regression coefficient (b_2) was obtained indicating that these high yielding varieties showed a negative relationship in that, large amounts of water lower down the yield. This had also been pointed out under I_3 treatment, where the water use efficiency was maximum in all the seasons and varieties studied under this experiment. Ghildyal and Jana (2) reported that saturated moisture regime gave the higher yield during the June to September season. Enyi (1) reported maximum yield under saturated conditions. The interaction of nitrogen and quantity of water applied (N x W) regression coefficients also showed a negative trend in almost all cases. Hence it is evident that these varieties do not require large quantities of water but they require higher doses of nitrogen so as to increase yields. The best suited prediction model is the quadratic equation which provided a satisfactory basis for assessing the impact of nitrogen and total quantity of water applied on grain yield for the two varieties in each of the seasons.

Summary

An experiment was conducted at Tamil Nadu Agricultural University, Coimbatore, India during 1971-1973 with Kannaki and Bala varieties of rice in monsoon (wet) and summer (dry) seasons with five water management treatments and five nitrogen levels. Of the production models tried it was found that the quadratic model is the best, indicating that these varieties require less water and higher amounts of nitrogen for increased grain yield.

Literature cited

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Reseña de Libros

DEMERATH, N J. III, LARSEN, O. y SCHUESSLER, R.F. eds. Social policy and sociology New York, Academic Press, 1975. 365 p

El volumen aborda un problema que desde el principio del siglo ha analizado la sociología: la relación existente entre el análisis sociológico y la política social, y esto no se discute en el vacío La discusión emerge de una serie de análisis críticos relacionados con algunos casos de investigación sociológica.

Gran parte de su contenido fue presentado en la Conferencia sobre "Investigación aplicada y estudios de post-grado" tenida en 1972 en Carmel, California.

La primera parte del volumen, y la más larga, se concentra sobre los más recientes estudios sociológicos relacionados con la toma de decisión y la política de acción de organismos públicos La segunda parte está dedicada a la metodología empleada en los cursos de post-grado de las escuelas de sociología de Estados Unidos para que el estudiante se familiarice con el problema del análisis y decisión política Finalmente en el Epílogo, se muestran las conclusiones a que han llegado los editores.

Los artículos y comentarios de la primera parte se articulan un poco arbitrariamente bajo tres subtítulos: A. Desigualdad social y sus efectos; B. Presión individual en el círculo familiar; C. La juventud americana y sus problemas.

Los artículos de Rossi, Alford, Schuman, Kasarda y Preston tienen un sabor maltusiano: todos tocan la desadecuación entre población y disponibilidad de bienes y servicios de una parte, y de otra los efectos de esa desadecuación. Los demás artículos de la primera sección describen en forma clásica diversos problemas de la sociedad norteamericana. ¿Por qué estas descripciones y análisis causal de variables en sentido matemático han sido inoperantes para formular políticas eficientes y operacionales? En forma reducida una respuesta crítica podría ser:

1. Los sociólogos se preocupan mucho de estudiar variables relevantes dentro de una teoría, pero no tienen mucha preocupación en saber si sus resultados encontrados son aplicables o no.
2. Se preocupan mucho más de las variables causales y no de saber si esas variables son controlables por una decisión política.
3. Los políticos presionan a los sociólogos para que hagan estudios rápidos con muestras o muestreos inadecuados.

Estas observaciones que se encuentran en muchos estudios están a la base de la inoperancia de gran parte de los estudios sociológicos

La segunda parte del libro es un conjunto misceláneo de diversos artículos. R. J. Hill ofrece, en forma condensada, la formación recibida por los estudiantes en varias facultades de sociología de Estados Unidos. Otros autores tratan la historia de los diversos tipos de capacitación sociológica dentro de las ciencias sociales.

Un hecho relevante es que hasta los años 60 los sociólogos fueron mucho más profesores que investigadores dedicados a estudiar las condiciones bajo las cuales se puede mejorar la situación socio-económica de los grupos sociales marginados. Los diversos artículos no ofrecen ningún consenso en proponer algunas soluciones para mejorar el sistema de estudio de los departamentos de Sociología de las Universidades norteamericanas.

En resumen, ni los estudios analizados por los autores, ni el análisis de los *curricula* de las facultades norteamericanas ofrecen una pista sólida a los autores para indicar a los lectores algunos aspectos fundamentales de la relación existente entre análisis sociológico y política social.

A nuestro juicio, el título del libro es mucho más ambicioso que su contenido. El problema de la relación existente entre el análisis sociológico y la política social fue a principios del siglo analizado por Max Weber. Los artículos del libro ignoran la tradición alemana e inglesa sobre el tema. Ignoran también los aspectos que ha hecho resaltar G. Myrdal sobre variables causales y variables controlables. El libro deja en evidencia que un "symposium" de "hombres de ciencia" no siempre aclara los problemas en torno a los cuales discuten esos mismos hombres.

EDUARDO SALVADO
INSTITUTO INTERAMERICANO
DE CIENCIAS AGRICOLAS
PORT-AU-PRINCE, HAITI