An Economic Analysis of Modern Rice Production Technology and its Adoption Behaviour in Tamil Nadu

K. Sita Devi* and T. Ponnarasi

Department of Agricultural Economics, Faculty of Agriculture,
Annamalai University, Annamalai Nagar - 608 002, Tamil Nadu

Abstract

Rice is the staple food in Tamil Nadu and is grown in an area of 2.6 Mha with a production of 8.19 Mt and productivity of 3.2 t/ha. In the context of high water demand by rice farmers, any strategy that would produce higher rice yield with less water is the need of the day. One such system is "System of Rice Intensification" (SRI), which was developed by Fr. Henri de Laulanie in Madagascar in 1980. The general objective of the study is to find the economics and the farmer's adoption behaviour of the system of rice intensification. The study has revealed that the per hectare cost of cultivation is about 10 per cent lower in SRI than the conventional method. The logit framework has indicated that age, farm size, income of the farm, number of earners in the family and number of contacts with extension agencies are positive and highly influence the adoption behaviour of the farmers. Lack of skilled labour, awareness, training on new technology and experience have been opined as the main problems in adoption of this technology by the farmers. To sum-up, farmers have been vastly benefited by SRI technology and it has helped them in their socio-economic upliftment. The adoption of SRI technique has helped increase the rice production without increasing the area under its cultivation and has proved to serve as an alternative method for rice cultivation.

Introduction

Rice is one of the important food crops in the world and ranks second in terms of area and production. It is the staple food for about 50 per cent of the population in Asia, where 90 per cent of the world's rice is grown and consumed. Asia's food security depends largely on the irrigated rice fields, which account for more than 75 per cent of the total rice production (Virk *et al.,* 2004). Rice is a proliferate user of water, consuming half of all fresh water resources. In Asia, 17 million ha of irrigated rice area may experience "physical water scarcity" and 22 million ha may have "economic water scarcity" by 2025 (Tuong and Bouman, 2001). Water has become a scarce resource in the world as well as in India. Water needs of rice are two to four times more than that of the other crops of the same duration because of water loss by percolation, seepage, field preparation, etc. under submerged conditions.

In Asia, India has the largest area under rice occupying 29.4 per cent of the global area, but India has the lowest yield. The conventional paddy growing tracts are in worst crisis due to social, biological and technical setbacks. Well acclaimed rice bowls in several parts of the nation are facing a decline in area, production and productivity. In India, there is a growing demand for rice due to ever burgeoning population. It is estimated that rice demand by the year 2010 will be of 100 million tonnes. To assure food security in the rice-consuming countries of the world, rice production would have to be increased by 50 per cent in these countries by 2025 and, this additional yield will have to be produced on less land with less usage of water, labour and chemicals (Zeng *et al.,* 2004).

In Tamil Nadu, rice is the staple food and it is grown in an area of 2.6 Mha with a production of 8.19 Mt and

* Author for correspondence,
  Email: ksitadevi.in@gmail.com

productivity of 3.2 t/ha. During 2002 and 2003, drought reduced the area of irrigated rice production to less than 300,000 ha and incited a dispute over water allocation with the neighbouring Karnataka state. Therefore, a more efficient and fundamental approach is needed for reducing water requirements of rice for the economic rice production.

In recent years, several strategies, viz. direct sowing of rice, alternate wetting and drying, etc. have been tried (Tabbal *et al.,* 2002). However, the yield potential could not be matched with the irrigated lowland rice. Also, the main threats to the future food-security are: shrinking land, depleting water resources, declining trends in soil fertility and productivity, and depletion of groundwater table, The research and development activities in paddy have consistently been concentrated on new varietal improvement rather than development of a consolidated package that could make rice cultivation lucrative in certain states of the country. Average rice yields have increased considerably with the introduction of high-yielding varieties and improved crop management technologies. But, there is still a wide gap between the potential and actual yields of farmers. Increasing the productivity of rice remains to be the major challenge for the governments and researchers in all the rice growing countries.

System of Rice Intensification (SRI) is a new system of rice cultivation for increasing rice productivity with a comprehensive package of practices involving less seed, water, chemical fertilizers and pesticides. The system of rice intensification was first tried in Madagascar in 1999 and since 2000, it has spread to many countries with spectacular results. The rapid dissemination of this system lies in the fact that it increases rice yields dramatically without requiring extra seeds, chemical fertilizers or other external inputs.

The SRI efficiently uses scarce land, labour, capital and water resources, protects soil and groundwater from chemical pollution, and is accessible to poor farmers. It is spreading fast because it is versatile and can more than double farmers' net income. The SRI has been adopted in the Tamil Nadu state of India, as this methodology is particularly suited to the local conditions in the Cauvery delta region. In the light of the importance of SRI, this study has been undertaken with the general objective of analyzing the performance of emerging technologies and their potential over the existing technologies and the pattern of adoption of new technologies by the farming community. The specific objectives were:

- To estimate the cost and returns of paddy in the System of Rice Intensification and their comparison with those in conventional method.

- To identify the factors influencing the adoption of SRI and problems in its adoption.

Methodology

Sampling Design

A multi-stage stratified random sampling procedure was adopted for the study. In the first stage, Cuddalore district of Tamil Nadu was purposively selected. In the second stage, taluks were selected from the Cuddalore district, based on the talukwise data on the number of farmers adopting SRI method and blocks were selected in the third stage. The list of farmers adopting SRI was obtained from the Department of Agriculture. The farmers adopting system of rice intensification were selected randomly from the selected blocks. Also, to compare the impact of SRI adoption, a matching sample of conventional rice cultivating farmers from the same area was also selected. Thus, the ultimate sample consisted of 50 SRI and 50 conventional rice cultivators.

The data were collected from both primary and secondary sources. The primary data collected from the sample rice growers included the general particulars like age, farming experience, educational level, landholding pattern, occupational pattern, employment level, income level, reasons for cultivating SRI and the reasons for not cultivating SRI.

Analytical Approach

Descriptive statistical analyses such as mean, percentage, etc., were carried out for making a comparison of general characteristics of sample farms and in other analyses wherever necessary. Conventional farm management analysis and efficiency measures were carried out to examine the resource productivity in rice farming.

Logistic Regression Model

Farmers' adoption of SRI was studied using logit model. This study utilised a logistic regression model to empirically quantify the relative influence of various factors in the decision of the respondents to adopt SRI

method or conventional methods of rice cultivation. This study has postulated that the probability of a farmer adopting SRI method (L_i) depends on the attributes like age, literacy level, farm size, income, number of earners in the family and number of contacts with extension agencies (per month). The index variable Z_i indicating whether a farmer is adopting SRI method or not has been expressed as a linear function of the independent variables. Thus, the logit regression model has been specified as Equation (1):

$$L_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + u_i$$
$$\dots(1)$$

where,

X_1 = Age of the respondent (years),
X_2 = Literacy level of respondents (years),
X_3 = Farm size (ha),
X_4 = Income of households (Rs),
X_5 = Number of earners in the family,
X_6 = Number of contacts with extension agencies (per month),
β_0 = Constant,
$\beta_i s$ = Parameters to be estimated, and
u_i = Error-term.

Garrett Ranking Technique

The Garrett ranking technique was used to study the opinions of the farmers regarding the adoption of SRI. It was also used to study the reasons for not adopting the SRI technology by other farmers. The per cent position of each rank was found out by Equation (2):

$$\text{Per cent position} = \frac{100\left(R_{ij} - 0.5\right)}{N_j} \qquad \dots(2)$$

where,

R_{ij} = Rank given for the ith items by the jth individual, and

N_j = Number of items ranked by the jth individual.

Results and Discussion

Cost and Returns of Paddy

Simple percentage analysis was used to analyze the structural changes in the cost of cultivation of paddy. Cost structure of the crop was analyzed by working out the share of each item in the total cost of cultivation. The cost of production was also worked out. The cost of cultivation was computed for the paddy crop separately for the two categories, viz. SRI and conventional methods and are presented in Table 1.

It could be seen from the Table 1 that the total cost of cultivation per hectare was lower by about 10 per cent in SRI method (Rs 21655) than conventional method (Rs 25914). Among the components of the total cost, human labour occupied the highest share in both, viz. 43.61 per cent in SRI method and 41.87 per cent in conventional method.

In the SRI method, the cost of seeds occupied a meager amount (0.63 per cent) as compared to the conventional method (6.99 per cent). Also, the share of irrigation cost was also very little in SRI method (9.84 per cent) as against 19.30 per cent in the conventional method. It is due to the fact that there is a drastic reduction in seed rate from about 30-60 kg/ha to 10 kg/ha in the SRI technology. Also, there is 40-50 per cent water saving from planting to harvesting. However, the cost of machine labour was higher (20.99 per cent) in SRI than conventional method (9.19 per cent) due to frequent weeding using a rotary weeder.

It could also be noted that the lowest share of cost on plant protection chemicals was low in both the methods of cultivation, viz. 2.77 per cent and 4.41 per cent in SRI and conventional methods, respectively. The cost incurred on fertilizers was more or less the same in both the methods of cultivation.

Further, it could be seen that the net returns were higher in SRI (Rs 27009) than conventional (Rs 14499) method. It was mainly due to the higher productivity of paddy in the SRI method. The gross returns were also higher in SRI (Rs 48665) than conventional (Rs 40413) method. Also, the costs of production per tonne of paddy were lower in SRI (Rs 3937) than conventional method (Rs 7403) of rice cultivation. It could be inferred that the cost of production was almost double in the conventional method of paddy cultivation, as the productivity of rice was low in this method. It was also observed that the benefit-cost ratio was higher in SRI (2.25) than in conventional (1.56) method.

The respondents in SRI method had realized increased productivity and thereby the returns in paddy crop were comparatively high. The increased grain yield under SRI was mainly attributed to more number of

Table 1. Cost on cultivation of paddy

(Rs/ha)

S. No	Particulars	SRI method		Conventional method	
		Expenditure	Percentage	Expenditure	Percentage
1	Seeds	136	0.63	1812	6.99
2	Human Labourers	9444	43.61	10850	41.87
3	Machine Labourers	4545	20.99	2380	9.19
4	Fertilizers	4798	22.16	4726	18.24
5	Irrigation	2131	9.84	5001	19.30
6	Plant protection chemicals	600	2.77	1143	4.41
I	Cost of cultivation	21655	100.00	25914	100.00
a.	Land revenue	500	-	500	-
b.	Interest on working capital	2838	-	3110	-
II	Cost A_1	24994	-	29523	-
III	Cost A_2	29860	-	29523	-
IV	Cost B	36230	-	31623	-
V	Cost C	39185	-	33123	-
VI	Gross return	48665	-	40413	-
VII	Net return	27009	-	14499	-
VIII	Yield (t/ha)	5.4	-	3.5	-
IX	Cost of production (Rs/t)	3937	-	7404	-
X	Benefit-cost ratio	2.25	-	1.56	-

lengthy productive tillers with increased number of filled grains per panicle. Thus, the cumulative effect of SRI technology was higher returns compared to conventional method due to less seed rate, irrigation and labour requirement in weeding.

Returns over Cost

The returns over cost were calculated for the paddy cultivation in both the methods and the results are presented in Table 2.

A perusal of Table 2 revealed that the gross returns were higher in SRI (Rs 48665) than conventional method (Rs 40413). Also, the other measures of returns over different costs, namely, farm business income, family labour income, net income and farm investment income were higher in SRI than conventional method of rice cultivation. It could be inferred that in SRI method the efficiency of production was high, which may be due to higher yield obtained by practising improved technology.

Partial Budgeting in Paddy Farms

The additional costs and returns incurred in the paddy farms were analysed and are presented in

Table 3. It was revealed form Table 3 that increment in the profit realised in paddy cultivated through SRI method was Rs 16968/ha. From the components of partial budgeting, the added returns in paddy were attributed mainly through the increased productivity obtained in the SRI technique. The reduction in cost incurred in SRI method was due to the value of seeds, human labour, irrigation and plant protection chemicals. However, the cost on machine labour and fertilizers contributed to the increase in cost of SRI technology. It is concluded from the partial budgeting analysis that the adoption of SRI technique would provide an additional profit to the farmers.

Table 2. Returns over cost in SRI and conventional methods

(Rs/ha)

Particulars	SRI method	Conventional method
Gross returns	48665	40413
Farm business income	23670	10889
Family labour income	12435	8789
Net income	9480	7289
Farm investment income	14670	9389

Table 3. Partial budgeting of paddy farms

	Debit	Amount, Rs		Credit	Amount, Rs
(a)	Increase in costs		(a)	Decrease in cost	
	i) Machine labour cost	2164		i) Seed cost	1675
	ii) Fertilizer cost	72		ii) Human labour cost	206
				iii) Irrigation cost	2869
				iv) Plant protection chemicals cost	543
	Total	2236		Total	5295
(b)	Decrease in returns	-	(b)	Increase in returns	13910
	Total debits	2236		Total credits	19205
	Profit	**16969**			

Adoption Behaviour Model for SRI

The logit framework discussed has postulated that the probability of a respondent to adopt SRI technology was dependent on the socio-economic characteristics of the respondents, such as age of the respondent, literacy level, farm size, income of the farm, number of earners in the family, and number of contacts with the extension agencies. The index variable Z_i is a dichotomous variable, i.e., it takes the value of one if a respondent is adopting SRI technology ($Z_i = 1$) and takes the value zero otherwise ($Z_i = 0$); Z_i has been shown to be logarithm of odds ratio. The maximum likelihood estimate of the coefficients of the logit model for the respondents is presented in Table 4.

It could be noted from Table 4 that the specified logit model was significant at one per cent level of probability. The level of count R^2 obtained was 0.61; which indicated a good predictive ability of the model. The estimation yielded the expected signs for the coefficients of all the independent variables, except the literacy level. The results clearly indicated that age, farm size, income of the farm, number of earners in the family and number of contacts with extension agencies were positive and highly significant, whereas the literary level of respondents was negative and not significant. It could be inferred that one unit change in the positive and significant slope coefficient would increase the probability of a respondent to adopt SRI technology by the appropriate percentage.

The results of this analysis would imply that the choice to adopt SRI would be influenced by the factors considered in this model. Further, out of the six variables subjected for analysis, the variable "number of earners" in the family was found to be influencing the adoption decision on a high degree tending to increase the rate

Table 4. Parameter estimates for logit model

Sl No.	Variables	MLE co-efficient	Exp β
1.	Intercept	2.8233 (1.4189)	
2.	Age	0.1734*** (0.0619)	1.490
3.	Literacy level	-0.1643* (0.7244)	1.459
4.	Farm size	0.1785*** (0.0740)	1.508
5.	Income of the farm	0.1667** (0.0906)	1.467
6.	Number of earners	0.9341** (0.4670)	8.593
7.	Number of contacts with extension agencies	0.3449*** (0.0355)	2.212
	log likelihood	58.0965	
	Chi-square	22.43	
	Count R^2	0.61	
	Number of observations	100	

Note: ***, ** and * indicate significance at 1 per cent, 5 per cent and 10 per cent probability levels, respectively.

of adoption by 8.5-times for a unit increase in the variable, followed by the variables number of contacts with extension agencies, farm size, income of the farm, literacy level and age. Every contact with extension agency has influenced the rate of adoption by 2.2-times and a unit increase in each of the variables farm size, income of the farm and age, had tended to increase the adoption behaviour by one and a half times. The negative sign for the literacy level indicated that respondents who were less educated were more likely to adopt SRI technology.

Table 5. Reason for adoption and non-adoption of SRI technology

Particulars	Mean score	Rank
Reasons for adoption		
Higher grain and straw yield	78.91	I
Reduced requirement of seeds	67.80	II
Less requirement of water	59.55	III
Increased returns to labour	52.10	IV
Higher seed quality	49.80	V
Reasons for non-adoption		
Lack of skilled labour	67.21	I
Lack of awareness	64.66	II
Lack of training	56.50	III
Lack of experience	51.65	IV
Lack of extension service	42.43	V

Opinions of the Respondents

Reasons for Adoption of SRI

The reasons for adoption of SRI technology, as reported by the respondents, were analysed using Garrett ranking technique and the results are presented in Table 5. The reasons for practising SRI technology were: higher grain and straw yield, reduced requirement of seed and other inputs, increased returns to labour, and high seed quality.

Results show that, out of the five reasons identified by the respondents, 'higher grain and straw yield' was ranked first, as the farmers in SRI method got higher yield from paddy crop. 'Reduced requirement of seeds' was ranked second as in the SRI technology the seed requirement is drastically reduced. The respondents ranked the 'less requirement of other inputs', especially water, as the third advantage, since the saving of water in rice cultivation was experienced by the farmers who adopted SRI technology. The fourth rank was given to 'increased returns to labour' as the SRI technology requires less labour for weeding, thereby increasing the efficiency. The last rank was given for higher seed quality.

Reasons for Non-Adoption of SRI

The respondents in the conventional method reported five main reasons for not adopting the SRI technology. They ranked 'lack of skilled labour' as the foremost reason for not adopting the SRI method in their farms, became SRI requires more skilled labours for carrying out various operations in the paddy cultivation.

The 'lack of awareness' was ranked second, as adequate information on the advantages of SRI method might lead to solve the other reasons given by the conventional farmers. Nearly 57 per cent of conventional farmers had expressed that lack of training, experience and extension service were the reasons for their non-adoption of SRI.

Conclusions and Implications

The net return has been found higher in SRI (Rs 27009) than the conventional method (Rs 14499). The cost of production per tonne of paddy was lower in SRI (Rs 3937) than the conventional method (Rs 7404) of rice cultivation. The cost of production is almost double in the conventional method because of low productivity of rice in this method. The measures of returns over different costs, namely, farm business income, family labour income, net income and farm investment income are comparatively higher in the SRI than conventional method of rice cultivation. The increment in the profit realised in paddy cultivated through SRI method has been found as Rs 16568/ha. The partial budgeting has revealed added returns in paddy due to the increased productivity and reduced cost in terms of value of seeds, human labour, irrigation and plant protection charges.

The probability of adoption shown by the logit model has yielded the expected signs and the odds ratio shows that the variables have influenced the rate of adoption by appropriate number of times for the unit increase in the corresponding variables. The respondents have reported 5 reasons for adoption and 5 reasons for non-adoption of SRI technology, the implication being that lack of training, experience and extension services be taken care to infuse shifting from conventional method to SRI technology.

The study has revealed that adoption of SRI technique would help increase rice production without increasing the area under cultivation. It has proved to serve as an alternative method for rice cultivation. The increased productivity and net profit would attract the farmers, and saving in water-use for rice cultivation is an important advantage for efficient water management.

References

Badawi, T.A. (2004) *Rice Based Production System for Food Security and Poverty Alleviation in the Near-East and North Africa: New Challenges and Technological Opportunities*, FAO Rice Conference Held at Rome, Italy. In: *http://www.fav.org/rice2004/en/pdf.badawi.pdf.*

Garrett, Henry E. and Woodworth, R.S. (1971) *Statistics in Psychology and Education*, Vakils, Feffer and Simons, Bombay.

Sunandini, G.P., Haffis, Shaik , Rama Rao, C.A. and Reddy, Y.V.R. (1992) Input use efficiency on paddy farms in West Godavari district of Andhra Pradesh, *Indian Journal of Agricultural Economics*, **47**(3): 574.

Tabbal, D.F., Bouman, B.A.M., Bhujan, S.I., Sibayan, E.B. and Saffar, M.A. (2002) Onfarm strategies for reducing water input in irrigated rice. Case studies in the Philippines. *Agricultural Water Management,* **56**(2): 93-112.

Tuong, T.P. and Bouman, B.A.M. (2001) Rice production in water-scare environments, Paper Presented at the *Water Productivity Conference*, Colombia, Sri Lanka.

Umadevi, K. and Prasad, Y. E. (2006) A logistic regression of risk factors for disease occurrence on coastal Andhra shrimp farms. *Indian Journal of Agricultural Economics,* **61**(1): 123-133.

Virk, P.S., Khush, G.S. and Peng, S. (2004) *Breeding to Enhance Yield Potential of Rice at IRRI*: *The Idotype Approach*, IRRI, p. 5-9.

Zeng, J., Lu, X., Tang, X. and Tang, Y. (2004) The system of rice intensification (SRI) for super-high yields or rice in Sichuan Basin, *4th International Crop Science Congress*, Brisbane, Australia. In: *hhtp://www.ciifad.cornell.edu/sri/countries.*