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Research Note

Estimation of Efficiency, Sustainability and Constraints in SRI (System of Rice Intensification) *vis-a-vis* Traditional Methods of Paddy Cultivation in North Coastal Zone of Andhra Pradesh

I.V.Y. Rama Rao

Cost of Cultivation Scheme, Regional Agricultural Research Station, Anakapalle, Visakhapatnam - 531 001, Andhra Pradesh

Abstract

The study has assessed the economics and sustainability of SRI (system of rice intensification) and traditional methods of paddy cultivation in North Coastal Zone of Andhra Pradesh for the period 2008-09, based on the data of costs and returns of crop. Apart from budgeting techniques, benefit-cost ratio (BCR), yield gap analysis, sustainability index and response priority index have been employed in the study. It has shown that BCR is higher for SRI (1.76) than traditional (1.25) methods. Further, there is a 31 per cent yield gap between SRI and traditional methods, in which cultural practices (20.15%) have shown a stronger effect than input use (10.85%). The most important constraint in SRI cultivation has been identified as 'nursery management'. The SRI method being more skill oriented, the study has observed that yields can be made sustainable if constraints are addressed on war-footing basis.

Key words: Paddy cultivation, Sustainability index, Nursery management, System of rice intensification

JEL Classification: Q13, Q15, Q16

Introduction

India is one of the leading rice producing countries of the world with cultivated area of 45.35 Mha and production of 99.15 Mt in 2008-09. The leading states in rice cultivation are: Andhra Pradesh, West Bengal and Uttar Pradesh. Andhra Pradesh ranked third with cultivated area of 4.39 Mha and production of 13.80 Mt with yield of 3.15 t/ha in 2008-09. In India, rice is an important ingredient of household food-basket, yet its yield level is low, stagnant and uncertain (Barah, 2009). The operational holding-size is shrinking, and land and water resources are getting degraded. And therefore, evolution of innovative production practices is needed to meet the growing demand of rice. Under such a scenario, system of rice intensification (SRI) has emerged as an important technology for rice production. SRI is amalgamation of refined and intensive management practices of rice production with advantages of production enhancement and cost reduction. The specificities of SRI are conservation of land, water and bio-diversity and utilization of biological power of plant and solar energy. Yield sustainability of SRI has both macro and micro economic importance. In other words, sustained yield levels among the community will ensure stable production and in turn food security, while economic sustainability would encourage the farmers to adopt the technology over time and space. On the other hand, the traditional method of paddy cultivation requires large quantities of inputs, particularly water, fertilizer and pesticides, contributing to high cost of cultivation. It leads to depletion of water levels, indiscriminate use of chemical fertilizers and pesticides, damaging the ecosystem equilibrium and reducing the quality of produce, leaving the residues behind.

* Email: ramarao_agrieco@yahoo.co.in

Andhra Pradesh had experienced a severe drought in 1999-2000, characterized by water shortages and falling groundwater levels. Under these circumstances, with dual objectives of reducing the demand for water and increasing the yields, the System of Rice Intensification (SRI) was introduced in Andhra Pradesh during *kharif* 2003 as an alternative technology. However, in spite of many advantages, farmers have their own difficulties for not adopting SRI at a rapid pace owing to SRI needing management of resources skillfully which requires high precision in handling of farm resources. With this background, present study was undertaken with the following objectives:

- To compare the costs and returns of paddy cultivation under SRI and traditional method of cultivation,
- To identify the important factors affecting production of paddy under SRI and traditional method of cultivation,
- To estimate the sources of yield gaps between SRI and traditional method of cultivation,
- To find the sustainability of SRI cultivation, and
- To identify important constraints in adoption of SRI technology.

Materials and Methods

The study was conducted in the districts of Srikakulam, Vizianagaram and Visakhapatnam in the North Coastal Zone (NCZ) of Andhra Pradesh, during 2008–2009. A brief description of selected districts is given below:

Srikakulam — It is spread over 5.8 lakh ha with 3.21 lakh ha (55.5%) net cultivated area in which 2.05 lakh ha (63.8%) was under paddy cultivation; rainfall was 825.3 mm and 48.9 per cent of cultivable area was under assured irrigation.

Vizianagaram — It is spread over 6.5 lakh ha with 3.01 lakh ha (46.5%) net cultivated area in which 1.31 lakh ha (43.19%) was under paddy cultivation, rainfall was 906.8 mm and 43.6 per cent of cultivable area was under assured irrigation.

Visakhapatnam — It is spread over 11.2 lakh ha with 3.08 lakh ha (27.5%) net cultivated area in which 1.02 lakh ha (33.12 %) was under paddy cultivation, rainfall was 837.8 mm and 36.9 per cent of cultivable area was under assured irrigation.

In the study, purposive random sampling was followed, as the farmers were not evenly distributed in any manner. From each district, 15 farmers were selected who were practising both SRI and traditional methods of cultivation. Thus, there were a total of 45 farmers with a sample size of 90 farms. The farmers were interviewed using pre-tested schedules. The farmers were also asked to prioritize the five most important constraints they were facing in SRI cultivation.

Analytical Tools

Apart from budgeting techniques, following analytical tools were employed:

Cobb-Douglas Type of Production Function — To identify the important factors affecting the production of paddy in both SRI and traditional methods of cultivation, following Cobb-Douglas type of production function was fitted seperately for cultivators using SRI and traditional method:

$$Y = a_o H^{a_1} M^{a_2} N^{a_3} P^{a_4} S^{a_5} I^{a_6} e_u \qquad \ldots(1)$$

where,

Y = Output of main produce (q/ha),

a_o = Intercept,

H = Human labour (human-days/ ha),

M = Quantity of manure (quintals/ha),

N = Quantity of nitrogen (kg/ha),

P = Quantity of phosphorus (kg/ha),

S = Quantity of seed rate (kg/ha),

I = Number of irrigations for the entire crop period,

e_u = Error-term, and

a_1 to a_6 are the elasticities of production.

Decomposition of Sources of Yield Gaps — To examine the structural break in production relations in traditional and SRI methods of paddy cultivation, the Equation (1) was estimated by the ordinary least square (OLS) technique for both the methods practising plots. The combination of different resources to yield gap was estimated with the Bisaliah (1977) model of decomposition. The following functional form was specified:

$\log (Y_2/Y_1)$ =

$[\log (b_o/a_o)] + [(b_1\text{-}a_1) \log H_1 + (b_2 - a_2) \log M_1 + (b_3 - a_3) \log N_1 + (b_4 - a_4) \log P_1 + (b_5 - a_5) \log S_1 + (b_6 - a_6) \log I_1] + [b_1 \log (H_2/H_1) + b_2 \log (M_2/M_1) + b_3 \log (N_2/N_1) + b_4 \log (P2/P_1) + b_5 \log (S_2/S_1) + b_6 \log (I_2/I_1)] + [U_2\text{-}U_1]$ …(2)

Equation (2) was used for decomposing the yield gap. The summation of 1st and 2nd square bracketed terms on the right hand side represented the yield gap, attributable to the difference in the cultural practices. The 3rd term represented the yield gap attributable to the difference in the input use (input gaps) between SRI and traditional methods. The last term represented the random disturbance.

Sustainability Index (SI) — For computing the Sustainable Index (SI), the method suggested by Kiresur *et al.* (1996) was employed.

Responses-Priority Index (RPI) — In the quantification of constraints expressed by the farmers, there was a problem, whether emphasis should be given for the number of responses to a particular priority or to the highest number of responses to a constraint in the first priority. But, both lead to different conclusions (Table 6). To resolve this, a Responses-Priority Index (RPI) was constructed as a product of Proportion of Responses (PR) and Priority Estimate (PE), where PR for the ith constraint gave the ratio of number of responses for a particular constraints to the total responses as per Equation (3):

$$(\text{RPI})_i = \frac{\sum_{j=1}^{k} f_{ij}.X_{[(k+1)-j]}}{\sum_{i=1}^{l}\sum_{j=1}^{k} f_{ij}} \quad 0 \le \text{RPI} \ge 5 \qquad \ldots(3)$$

where,

RPI_I = Response Priority Index for ith constraint,

f_{ij} = Number of responses for the jth priority of the ith constraint (i=1, 2……, l; j= 1,2,3 …..k),

$\sum_{j=1}^{k} f_{ij}$ = Total number of responses for the ith constraint,

k = Number of priorities, i.e. 5,

$X_{[(k+1)-j]}$ = Scores for the jth priority,

$\sum_{i=1}^{l}\sum_{j=1}^{k} f_{ij}$ = Total number of responses to all constraints, and

$\sum_{i=1}^{l} RPI_i$ = Summation of RP indices for all constraints.

Here, larger the RPI, higher was the importance for that constraint.

Results and Discussion

Comparative Costs and Returns in SRI and Traditional Cultivation of Paddy

A comparison of costs and returns in SRI and traditional methods of paddy cultivation, given in Table 1, revealed that there was not much difference in the total cost of cultivation, but variable cost was higher in the traditional method (₹ 28,525/ ha) than SRI method (₹ 26,115/ ha). Out of the total operational cost, under SRI method 59 per cent (₹ 15,400/ ha) was incurred on labour charges and 41 per cent (₹ 10,715/ ha) was spent on materials, whereas under the traditional method 65 per cent (₹ 18,540/ ha) was incurred on labour charges and 35 per cent (₹ 9,985/ ha) was spent on materials. This shows the labour-intensive nature of the traditional method. A higher material cost in SRI than traditional method was due to the cost involved on manure. Now-a-days farm yard manures have become dearer. Among the operational costs, expenditure on manure and fertilizers was highest at 19.6 per cent (₹ 8,780/ ha), followed by seed material and land preparation 9.8 per cent (₹ 4,390/ ha), harvesting charges 9.6 per cent (₹ 4, 300/ ha) in SRI method. In the traditional method also, expenditure on manure and fertilizers was highest at 13.5 per cent (₹ 5, 960/ ha), followed by 9.5 per cent (₹ 4,195/ ha) each on plant protection and harvesting charges, and 9.1 per cent (₹ 4,020/ ha) on irrigation. A comparison showed that higher costs were incurred on land preparation, manures and harvesting in SRI and nursery management, transplanting, intercultivation, plant protection and irrigation in the traditional method.

Kumar *et al.* (2004) have reported that the operational cost of paddy cultivation in North Coastal Zone was ₹ 4,580 / acre in 2001-02. In the present

Table1. Comparative cost of cultivation in SRI and traditional methods of paddy cultivation in Andhra Pradesh

(₹/ha)

Operations	Method of cultivation			
	SRI	%	Traditional	%
Operational costs				
1. Land preparation	4,390	9.8	3,974	9.0
2. Nursery management	490	1.1	1,455	3.3
3. Transplanting	1,920	4.3	2,290	5.0
4. Manures/Fertilizers	8,780	19.6	5,961	13.5
5. Intercultivation	1,970	4.4	2,515	5.7
6. Plant protection	2,060	4.6	4,195	9.5
7. Irrigation	2,195	4.9	4,020	9.1
8. Harvesting & threshing	4,300	9.6	4,195	9.5
Cost A_1	26,115	58.3	28,525	64.6
Interest on working capital	815	1.8	890	2.0
Cost A	26,930	60.1	29,415	66.6
Fixed costs				
Imputed (Rental) value of own land	13,800	30.8	10,725	24.3
Cost B	40,730	90.9	40,140	90.9
Supervision (10 % of cost B)	4,073	9.1	4,014	9.1
Cost C	44,803	100	44,154	100
Returns				
Yield (quintals)	64.0		49.0	
Total revenue (₹)	46,000		35,758	
Net revenue (over cost A_1)	19,885		7.233	
Net revenue (over cost C)	1,198		- 8.399	
Returns over costs				
Benefit - cost ratio (over cost A_1)	1.76		1.25	
Benefit - cost ratio (over cost C)	1.03		0.81	

study, the cost of paddy cultivation has been found as ₹ 6,780/ acre. Thus, there was an increase of ₹ 2,200/ acre, i.e. 48 per cent in 7 years. The major contributor for this increase was labour cost. Between this period per day labour wages increased from ₹ 40/- to ₹ 120/-, i.e. three-times.

Resource-Use Pattern in SRI and Traditional Methods

The productivity was higher by about 31 per cent in SRI (6.4 t/ha) than traditional (4.9 t/ha) method of cultivation (Table 2). It was accompanied by lower cost of cultivation in SRI (Table 1) owing to the lesser requirement of inputs, except manure. This may be because of organic nature of the SRI method. Further, manure improves the soil health which makes the soil productivity sustainable.

Production Function Estimates in SRI and Traditional Methods

The Cobb-Douglas type of production function was fitted to the observations for the estimation of elasticities of important variables contributing to the yield of paddy in both SRI and traditional methods of cultivation. The analysis of variance in respect of the production function showed a significant variance, indicating the overall significance of the estimated production function (Table 3). The value for the coefficient of multiple determination (R^2) in SRI was 0.84, which suggested that the six resources included in the production function had jointly explained as high as 84 per cent of total variation in the SRI method, whereas it was 72 per cent ($R^2 = 0.72$) in the traditional method. It showed that the variables taken into consideration were more crucial factors in SRI than in the traditional method.

Table 2. A comparison of use of resources across SRI and traditional methods of paddy cultivation in Andhra Pradesh

(per ha)

Resources	Method of cultivation	
	SRI	Traditional
Human labour (hours)	190	288
Manure (q)	50	25
Nitrogen (kg)	115	155
Phosphorus (kg)	100	105
Seed Rate (kg)	6.5	8.0
Irrigations (No.)	10	18
Productivity (q)	64	49

Table 3. Cobb-Douglas production function estimate for SRI and traditional methods of paddy cultivation in Andhra Pradesh

Sl.	Particulars	Method of cultivation	
No.		SRI	Traditional
1	Human labour (X_1)	1.5693	1.4195***
		(0.3122)	(0.3345)
2	Manure (X_2)	-0.1100	0.4180***
		(0.1440)	(0.1134)
3	Nitrogen (X_3)	0.1683	0.1710
		(0.2266)	(0.1655)
4	Phosphorus (X_4)	-0.2005*	-0.1698
		(0.1210)	(0.3188)
5	Seed rate (X_5)	-0.2221***	-0.4570**
		(0.0694)	(0.2092)
6	Number of irrigations (X_6)	-0.1934**	-0.1291
		(0.0915)	(0.0942)
7	Intercept	-1.1596	-1.1596
		(0.7558)	(1.1840)
	R^2	0.84	0.72
	F Value	17.10****	18.24***

Notes: *, ** and *** indicate significance at 10 per cent, 5 per cent and 1 per cent levels, respectively

Figures within the parentheses are standard errors for the respective regression coefficients

In the SRI method, phosphorus, seed rate and number of irrigations were negatively significant. This means that usage of more than the recommended dose of these inputs would result in a decrease in production. In traditional method, human labour and manure were positively significant and seed rate was negatively significant. Thus, the traditional method is more labour-intensive and exhaustive as it responded more to labour usage and manure application.

Decomposition of Sources of Yield Gap between SRI and Traditional Methods

Barah (2009) in his study in Tamil Nadu during 2006-07, has concluded that SRI has potential to increase rice production by 26 per cent or even more depending on the extent of adherence to its basic principles. More importantly, SRI saves water by 30-40 per cent due to its alternate wetting and drying system. In the present study, the yield gap between SRI and traditional methods was to the tune of 31.0 per cent (Table 4).

Table 4. Decomposition of yield gap between SRI and traditional methods of paddy cultivation

Sources of difference	Difference (%)
Yield	31.00
Cultural practices	20.15
Input usage	10.85
Human labour (X_1)	75.95
Manure (X_2)	8.14
Nitrogen (X_3)	5.43
Phosphorus (X_4)	0.00
Seed rate (X_5)	-65.10
Number of irrigations (X_6)	-13.56

Among other sources of yield gap, cultural practices (20.15%) turned out to be the major contributor. Thus, without incurring extra expenditure on required inputs, only by adopting the recommended cultivation practices, the yield can be increased by 20.15 per cent in paddy. The appropriate usage of inputs can reduce the yield gap between SRI and traditional methods to the extent of 10.85 per cent. Among these inputs, human labour and manure have proved to be more important as per Tables 3 and 4. Patole *et al.* (2008) by using the Bislaih (1977) model of decomposition, had estimated that yield gap in chickpea in the Ahmednagar district of Maharashtra was 53 per cent, of which, input use (29%) had a higher role than cultural practices (24%).

Estimation of Sustainability of SRI Method of Cultivation

The results on the computation of sustainability index for farmers adopting SRI method of paddy cultivation,

Table 5. Actual yield levels and sustainability index of SRI method of cultivation

Sl. No.	SRI yield (kg/ha)	Traditional yield (kg/ha)	Desired yield (D_i)	Sustainability Index (SI)
1	53	38	55	83.1
2	56	46	58	87.7
3	60	45	62	93.8
4	70	50	72	109.1**
5	67	50	69	104.4**
6	76	56	78	118.15**
7	60	46	62	93.7
8	68	47	70	105.56**
9	58	44	60	90.75
10	78	62	80	121.34**

Notes: D_s = 6.57 t/ha; Regression coefficient (β)= 1.084;
*and ** indicate significance at 5 per cent and 1 per cent levels, respectively

Table 6. Prioritization of constraints in SRI method of paddy cultivation in Andhra Pradesh

Sl. No.	Constraint	Numbers in respective priorities					Total (recorded) responses	RPI	Rank
		I	II	III	IV	V			
1.	Drudgery in using cono-weeder	10	1	30	5	5	51	0.71	II
2.	Skill in transplanting	25	1	5	3	1	35	0.67	III
3.	Nursery management	3	40	2	2	2	49	0.83	I
4.	Using of marker	2	1	3	18	3	27	0.28	IV
5.	Availability of farm yard manure	2	1	3	10	17	33	0.27	V
6.	Alternate wetting and drying	3	1	2	7	17	30	0.25	VI
	Total	45	45	45	45	45	225		

along with the values of D_i and D_s as well as yield levels of SRI and traditional methods have been presented in Table 5 for 10 farmers out of 45 farmers taken for study. The yield levels of SRI farmers were higher than those of traditional farmers as evidenced from the positive regression coefficient (β=1.084) and positive symmetry index. The yield levels of SRI method, adjusted for regression (D_i) were higher than their actual yield level. Hypothetical (or) standard yield level (D_s) of the SRI method, which determined whether the D_{-i} values were in fact sustainable was estimated as 6.57 t/ha. Out of the 45 farmers, 21 farmers had D_i values significantly higher than D_s values, thereby sustainability index for the yield of SRI method in the North Coastal Zone was worked out to be 46.7 per cent.

The results of sustainability indices revealed that even though the yields of SRI-adopters were higher than of traditional method adopters, the sustainability indices of SRI method against traditional method varied from 83.1 to 121.3. Whenever the symmetry of the site indices was closer to zero, irrespective of the regression coefficients of SRI method yields on site index, the mean yield of SRI was closer to the corresponding standard yield level (D_s), indicating that in such cases, the mean yields of SRI could be used for assessing the sustainability of SRI.

Rajendra Prasad (2008) has reported the value of sustainability index for yield of SRI technology in Andhra Pradesh as 52 per cent in 2006-07. In the present study, the SI index of SRI paddy for North Coastal Zone has been found as 46.7 per cent. The present lower value of sustainability index suggests the possibility of shortfalls in the implementation of package of practices and rise in some constraints in the implementation of basic principles of SRI.

Identification of Major Constraints

The farmers were asked to list priority-wise five major constraints they were facing in SRI method of cultivation. All these were sorted and screened and finally six major constraints were identified. A perusal of Table 6 revealed that the constraint 'Drudgery in using cono-weeder' was the biggest constraint, followed by 'Nursery management'. Also based on the maximum responses in first priority, it was concluded that the constraint 'Skill in transplanting' was the major constraint. To get unanimity across these two constraints, the Responses-Priority Index (RPI) was constructed (Table 6), wherein, the maximum value (0.83) was for the constraint No. 3, viz. 'Nursery management'. Therefore the most important constraint in SRI method of cultivation in North Coastal Zone was difficulties in 'Nursery management', followed by 'Drudgery in using cono-weeder' and 'Skill in transplanting'.

Conclusions

- There is a dual advantage in the SRI method, viz. reduction in cost of cultivation (Rs 2, 410/ha) (operational costs), and increase in yields (1.52 t/ha) (31 %). Thus, owing to its economic viability, SRI has potential for up-scaling of production.
- Cultural practices (20.15%) are major contributors to yield gap than input-use (10.85%) between SRI and traditional methods.
- SRI is more a skill-oriented method than a new technique, and requires clinical precision in management of farm resources.
- Yield improvement through SRI method can be sustainable provided the major constraint, viz. 'Nursery management', is addressed on war-footing basis, along with adherence to the basic principles of SRI and management of other constraints.

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