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An economic evaluation of system of rice intensification in Odisha

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ABSTRACT

Seventy five rice farm families of Odisha practising system of rice intensification (SRI) were personally interviewed during 2011. Data envelopment analysis (DEA), a nonparametric technique was employed for technical efficiency estimation using computer software DEAP ver. 2.1. The investigation shows that farmers allocated a little more than 25% of the total rice area to SRI. Pooja was the most preferred variety both in the SRI and conventional system of cultivation. The study further indicated that the SRI package was not being followed in its entirety. However, even with partial adoption of SRI practices the average grain and straw yield on SRI plots was 25 and 13% higher than the conventional plots. Farmers who followed the SRI packages in a better manner produced higher output, indicating that possibilities exist for many farmers to increase average output further. Evidence from the study suggests that though the cost of cultivation was 3.2% higher, the cost of production was almost 19% lower in SRI due to higher grain yield. Gross and net returns were higher in SRI by more than 30% and 69% respectively. Technical efficiency (TE)analysis indicated that the average TE was about 88% in SRI and 75% in conventional. Further, farmers had positive perception about the SRI.

Key words: *rice, SRI, technical efficiency, economic impact, perception*

India's population is projected to reach around 1.59 billion by 2050. Yet, today there are about 200 million underfed people and 50 million on the brink of starvation. Therefore, the food situation is far from secure (Gujja and Thiyagarajan. 2009). For the growing Indian population 130 mt of rice will be required by 2025. To achieve this target the rice yield has to grow @ 1.8% per annum (CRRI, 2009). However, rice yields in India are stagnating and new solutions are required to keep ahead of the food demands of a growing billion. The existing system of paddy production, particularly green revolution technology is input intensive and favours cash rich farmers. Moreover, water availability in the near future will be under severe threats. Further, increasing prices of agricultural inputs prevent poor farmers from completely adopting modern production technologies. Excessive use of agrochemicals have negative social and environmental externalities (Stoop *et al*., 2002). Hence, there is an urgent need to find ways to produce more rice, but with less water and fewer inputs.

In these situations system of rice intensification popularly known as SRI cultivation may be a potent option for the farmers. SRI is not a single technology, rather it involves a number of technologies or a complete package. It aims at managing plant, water and soil in a cordial relationship rather than as a mere technology. Contrary to the green revolution strategies, in SRI tremendous grain yields are achieved with few external inputs, while reducing environmental externalities and improving sustainability (Karthikeyan and Jacob, 2008).Today rice farmers in nearly 40 countries are reported to be practicing it, while in India, more than one million farmers are practicing SRI (Gujja and Thyagarajan, 2009). By adopting this system of cultivation, rice farmers could save water, protect soil productivity, and save environment. Bring down the input cost, besides increasing the production for providing food to the growing population (Krishna *et al.*, 2008). Grain yields reported from field experiments carried out in different parts of India showed that SRI cultivation could enhance the yield (Reddy, 2002). Higher grain and straw yields leave farmers with higher net income. Today SRI is being adopted in many states in India and the response from farmers has been overwhelming seeing the benefits of the method (http://www.sri-india.net/). However, despite several studies, farmer surveys, and theoretical arguments, debate over the merits of the SRI continues. Therefore, the present study tried to analyze empirically the performances of the SRI vis a vis conventional management in Odisha state of India where the Government is encouraging the rice farmers for adopting SRI system.

MATERIALS AND METHODS

To assess the performance of SRI in Odisha, Cuttack district was selected purposively. The department of agriculture, Government of Odisha conducted SRI demonstration in 200 acres of paddy field in each block of this district. A minimum stretch of 10 acres was chosen for this purpose by the department. From the 14 blocks of the district three blocks, namely Tangi-Choudwar, Salepur and Barang were selected randomly. Subsequently 4 villages from each block were visited randomly to collect the data during April 2011. The villages included under the study were Birala, Berhampur, Guali, Jaripada of Tangi-Choudwar; Laxminarayanpur, Mahajanpur, Sisuah and PurvaKachh of Salehpur and Ramdaspur, Arilo, Andhuti and Usuma of Barrang block. The total sample size was 75 farm families. For assessing the impact of SRI, a comparative analysis was carried out between SRI and conventional cultivation. To remove the farmer bias, samples were drawn from the same group of farmers who practice SRI as well as conventional methods.

Technical efficiency is the ability of a farm to achieve maximum possible output with the available resources. In India most of the studies of technical efficiencies have been done in the recent past. Most of the efficiency analysis studies employed stochastic frontier production function, which requires some assumptions. In this study, similar to Kumar *et al.* (2005), Pandit*et al.* (2009) Data Envelopment Analysis (DEA), a nonparametric technique of technical efficiency estimation was employed. It uses a mathematical program to estimate the efficiency frontier. It does not need the pre-specification of the production function coefficients. Unlike parametric approaches, DEA makes no assumption of the distribution of the underlying data, and all deviations are assumed to be due to inefficiency (Banker *et al.*, 1989). DEA analyzes farms separately while measuring its efficiency relative to all the observations in the sample. Let X be the input matrix of order k x n and Y the output vector. Here k is the number of inputs. Thus, for i^{th} farm, X_i and Y_i represent the respective inputs and output. Now the problem reduces to obtaining a ratio measure $\mu' Y_i / \nu' X_i$ where μ and ν are the output and input weights, respectively. Optimal weights are obtained by solving the following mathematical program:

$$\text{Max}_{\mu,\nu} (\mu_i' Y_i / \nu_i' X_i)$$
$$\text{Subject to } \mu' Y_j / \nu' X_j < 1, \quad j = 1, \ldots, n$$
$$\mu, \nu > 0$$

In order to avoid infinite number of solutions, imposing a constraint $\nu' X_j = 1$, we get

$$\text{Min } \theta, \lambda^{\theta} \text{ subject to } \begin{array}{l} -y_i + Y\lambda > 0 \\ \theta x_i - X\lambda > 0 \\ \lambda > 0 \end{array}$$

Here, θ is a scalar and λ is an n x 1 vector of optimal weights. θ represents the technical efficiency (TE) corresponded to constant return to scale (CRS). Imposing an additional constraint $1'\lambda=1$ gives the technical efficiency under variable return to scale (VRS). Efficiency measurements by the DEA model can be used to determine both pure technical and scale efficiencies (TE_{CRS}/TE_{VRS}). The product of these two gives the overall technical efficiency. In the present study the output is gross return (includes grain + straw) and the nine inputs costs are: seed, nursery raising, tillage, transplanting, nutrients, weeding, harvesting, bundling + carrying, threshing + cleaning. The analysis was carried out in computer software DEAP ver. 2.1 as described by Coeli (1996).

RESULTS AND DISCUSSION

Majority of the sampled SRI farmers were literate with nine years of schooling. They were middle aged and on an average had seven members in their family (Table 1). Above poverty line households were more and farming was the major occupation to 96% households while business was the preferred option for secondary occupation. On an average every household had 4.5 acres of land of which 57% were irrigated.

It was found that only 26% of the respondents were members or office bearers of any social institutions (Table 2). Gram panchayat and credit cooperative society were the two major intuitions where

Table 1. Socio-economic status

Particular	Unit	Value
Age	Years	45.8
Literacy	% of sample	90.00
Years of schooling	Years	9.26
Above poverty line	% of sample	60.00
Below poverty line	% of sample	40.00
Family size	Number	7.12
Operational holdings	Ac	4.56
Irrigated land	Ac	2.61
Un-irrigated land	Ac	1.95
Crop farming	% of main	96.00
Others	% of main	4.00
Business	% of secondary	66.67
Crop farming	% of secondary	13.33
Labourers	% of secondary	13.33
Poultry	% of secondary	6.67

farmers were members or office bearers. Farmers may be encouraged to take membership of different social institutions. Because social institutions are the good place where they can share their knowledge and knowhow of the improved farming practices.

Table 2. Social participation (26%)

Institution	% of participation
Gram *Panchayat*	38.46
Credit cooperative society	46.15
Self help group	7.69
Pani Panchayat	7.69
School education committee	7.69
Fishery society	7.69

Farmers allocated a little more than 25% of the total rice area to SRI and rest 75% to the conventional method of cultivation. Among the adopters, some farmers were doing SRI for the first time, some for the second time. Once the farmers are convinced about the benefits of SRI they are likely to allocate more area under SRI. Pooja was the most preferred variety in both SRI and conventional system of cultivation (Table 3). CR-1018 was second most popular variety in conventional plots, it covered about 21% of the rice area. In case of SRI, Swarna occupied second place with more than 25% of the rice area. In conventional system it occupied third position. The other popular varieties were Naveen, Lalat for SRI and Sarala, 7575 for conventional system.

Table 3. Varietal preferences under SRI and conventional method of cultivation.

Variety	% of area under SRI	% of area under conventional method
Pooja	31.07	22.94
Swarna	25.24	19.64
Naveen	15.53	-
Lalat	8.74	1.32
Rani	3.88	-
Sarala	4.85	7.92
Gitanjali	4.37	-
Kalashree	1.94	-
Others	3.41	17.68
CR-1018	-	20.63
7575	0.97	7.26
Durga	-	2.61

The study shows that in Odisha there has been only partial adoption of standard practices of SRI (Table 4). Although all farmers were following the requirements of early transplantation, less seedling per hill and wide spacing of seedlings, they were not doing SRI in exactly the way they were told. Therefore, the SRI package was not being followed in its entirety due to certain constraints and ignorance on the part of farmers.

Table 4. Farmers' cultivation practices: a comparison of SRI and conventional system

Parameter	Unit	SRI	Conventional
Age of seedling at planting	Days	14.88	26.91
Number of seedling $hill^{-1}$	Number	1.38	4.29
Line planting	% of farmers practiced	100	0
P-P distance	cm	25	Irregular
R-R distance	cm	25	irregular
No. of weeding operation	Number	2.30	1.61
Chemical fertilizer	Rupees	875	1050
FYM	q	10.26	5.5
Bio-fertilizer	Kg	0.49	0.12

They were skeptical of the good output of following the SRI in totality. On an average the age of seedling at planting was about 15days in SRI and 27 days in case of conventional. Number of seedlings per hill was three times more in conventional cultivation. All SRI farmers transplanted the seedlings in line but in conventional cultivation nobody followed line planting. They kept 25 cm x 25 cm space in transplanting in SRI. Most farmers had performed poorly in the management of irrigation.The crucial aspects of maintaining alternate wetting and drying was either not possible for them or farmers were unaware about its benefits. Weeding operations were more in SRI than the conventional cultivation. All the farmers, in varying proportions, applied fertilizers on both the SRI and conventional plots. Although the application was slightly more in conventional plots.

Even with the partial adoption, farmers were successful in achieving more tillers per plant, grain and straw yield (Table 5). The average number of tillers per plant was about 41 in SRI, whereas in conventional

Table 5. Yield impact of SRI

Parameter	Unit	SRI	Conventional	% higher in SRI
Avg. no of tillers plant^{-1}	Number	40.8	15.46	163.91
Grain yield	q ac^{-1}	22.57	17.98	25.56
Straw yield	Bundle ac^{-1}	5000	4430	12.87

it was only 15.5. There has been 25.5% grain and about 13% straw yield advantages in SRI. Studies conducted elsewhere also found significantly higher number of tillers plant^{-1} and higher grain and straw yield in SRI method of cultivation (Krishna *et al.* 2008, Sinha and Talati, 2007).

The evaluation of 167 on-farm trials in Andhra Pradesh reported average per ha yield obtained using SRI practices to be 8.1 t, compared with 5.67 t using conventional practices (Gujja and Thiyagarajan, 2009).

SRI has the potential of reducing the cost of production (Table 6). The analysis of cost of cultivation shows that in one acre of land, paddy farmers had to incur about ₹ 11,800 in SRI cultivation and about ₹ 11,400 in conventional cultivation. The expense in SRI was only 3% higher than the conventional cultivation. However in individual cost items there were wide differences. As for example, the seed cost was more than 7 times and nursery raising was just double in

Table 6. Cost of cultivation (₹ ac^{-1})

Items	SRI	Conventional	% higher in SRI
Seed	44	358	-713.64
Nursery raising	294	588	-100.00
Tillage	1973	1851	6.18
Transplantation	1944	1330	31.58
Irrigation	213	218	-2.35
Nutrients	1087	907	16.56
Plant protection	101	144	-42.57
Weeding	1712	1608	6.07
Harvesting	1071	1186	-10.74
Bundling + Carrying	870	832	4.37
Threshing + Cleaning	964	875	9.23
Land rent	1500	1500	0.00
Total	11772	11395	3.20

conventional plots. More seed rate and use of older seedlings for transplantation were the underlying reasons. Plant protection cost was less owing to less disease pest prevalence in SRI. This is in conformity with other studies (Karthikeyan *et al.* 2010). Line planting made harvesting easier in SRI and hence, harvesting cost was also less. However, the threshing and cleaning costs were more in SRI due to more grain and straw yield. Though farmers applied less chemical fertilizers, the overall nutrient cost in SRI was more. This was because application of more FYM and bio-fertilizers in SRI plots. Transplanting cost was also more in SRI. SRI farmers had to employ more labour for transplantation. Laboureres were not familiar with the practices of uprooting and transplanting very younger seedlings in square pattern and in a wider space. Hence, in due course of time this cost may get reduced when laboureres will get sufficient expertise in SRI transplanting. In fact experiences in other areas shows that transplanting cost is lower in SRI. Hence, in due course of time SRI cultivation will be requiring less expenses.

It is evident that even with partial adoption of SRI practices the average grain yield of SRI plots was 25% higher than on conventional plots (Table 7). Farmers who followed the SRI packages in a better manner produced higher output, indicating that possibilities existed for many farmers to increase the average output further. In addition to paddy yield, the output of straw per hectare with SRI too, was higher by 13%.

Table 7. Economic analysis of SRI and conventional cultivation

Items	Unit	SRI	Conventional	%increase under SRI
Cost of cultivation	₹ ha^{-1}	29430	28488	3.20
Grain yield	t ha^{-1}	5.64	4.49	25.56
Straw yield	bundles ha^{-1}	12500	11075	12.87
Market price of paddy	₹ q^{-1}	1048	1000	4.80
Cost of production	₹ q^{-1}	455	560	-18.62
Gross return	₹ ha^{-1}	62890	48266	30.30
Net return	₹ ha^{-1}	33460	19779	69.17
B:C	Ratio	2.14	1.69	-

Evidence from the study suggests that SRI is economically attractive although the cost of cultivation was 3.2% higher, the cost of production was almost 19% less in SRI due to higher grain yield (Table 7). Gross and net returns were higher in SRI by more than 30% and 69% respectively. Accordingly the B:C ratio was 1.7 in conventional and 2.1 in case of SRI cultivation. Sinha and Talati (2007) found that in West Bengal the net return with SRI was 88% higher than the conventional method of paddy cultivation. The other studies on economics of SRI cultivation also indicated higher net return with this method (Prasad *et al.,* 2001; Sarath and Thilak, 2004). In the present investigation it was also found that the seed multiplication ratio was much higher in SRI. One kg of seed with SRI produced 768 kg of paddy versus 75 kg with the conventional method. Paddy output per man-day was 15% higher with SRI. These give farmers enough economic incentive to adopt this method. The analysis also suggests that SRI is scale neutral *i.e.* the yield per unit of land (1 ha) did not vary with changes in land holding size. In order to examine the effect of scale on the yield of paddy under SRI, the sample of 75 SRI adopters were categorized into two groups: one falling in the land holding category of 0 to <4ac and the others having 4 acres or more. Two groups of farmers were having almost identical yield (5.67 t ha^{-1} in former and 5.61 t ha^{-1} in later). Therefore, SRI technique is also socially acceptable because it does not discriminate the farmers based on their land holding size.

An attempt was made to assess the technical efficiencies in paddy cultivation under both SRI and conventional methods (Table 8). It indicated that no farm in SRI had less than 60% efficiency whereas in case of conventional plots 16% of them were having upto 60% efficiency. Majority of the plots in SRI were more than 90% efficient whereas in conventional plots it was 70-80%. The average TE was found to be about 88 in SRI and 75 in conventional and the minimum TE was 63.5 in SRI and 44.5 in conventional. 26% of the SRI farms were operating under optimum scale where as the corresponding figure for conventional method was only 10%. Similar to the findings of the present study Palaniasamy (2008) also reported higher technical efficiencies in SRI as compared to conventional system. Hence, the above analysis suggests that the SRI not only yielded better output but also the production system was more efficient than the conventional method. It is anticipated that SRI farmers will bring more area under SRI and more and more non-adopterfarmers will be coming for SRI cultivation in due course of time attracted by the higher economic benefits. Government should extend the irrigation facilities and technical knowhow to happen this transition.

In the course of investigation it has been found that farmers were enthusiastic about SRI and they wanted to continue with this practice. Farmers appear convinced that SRI produces more tillers $plant^{-1}$ and grains $panicle^{-1}$. They were of the view that the SRI

Table 8. Technical Efficiency(TE) impact

Parameter	Unit	SRI	Conventional
Overall Efficiency level			
<50%	No. of farms	0	2 (4.00)
50-60%	No. of farms	0	6 (12.00)
60-70%	No. of farms	5	11 (22.00)
70-80%	No. of farms	10 (20.00)	12 (24.00)
80-90%	No. of farms	7 (14.00)	10 (20.00)
>90%	No. of farms	28 (56.00)	9 (18.00)
Average TE	%	87.87	75.30
Minimum TE	%	63.50	44.50
Number of farms operating under optimum Scale	Number	13 (26.00)	5 (10.00)

Figures in the parentheses indicate % of respective total farmers

plants were healthier and disease pest problem was less. They rightly felt that all the varieties do not give same return under SRI. Hence, the departments should arrange for the location specific and SRI friendly varieties for the farmers. Overwhelming majority of the farmers stated that SRI gives more return. More grain and straw yield can help them rise out of their

Table 9. Farmers' perception about SRI

Particulars	% of the farmers say		
	Yes	No	Can't say
All the varieties give same return under SRI	8	78	14
SRI requires less water	60	18	22
Number of tillers are more plant^{-1} in SRI	90	4	6
Number of grains panicle^{-1} is more in SRI	80	2	18
Weed is a problem in SRI	64	18	18
Insect/pest is more in SRI	2	60	38
SRI requires more labour	34	26	40
SRI gives more return	92	0	8

misery and provide greater food security. They were inconclusive whether SRI requires more labour or not. However they thought that weed is more problematic in SRI than conventional cultivation. In general farmers reported favourable opinion about the SRI.

Farmers were convinced about the yield advantage of SRI. However, in due course of investigation farmers expressed certain constraints in adopting and practicing SRI method of paddy cultivation (Table 10).

Among all the constraints, more weeds in SRI tops the chart. Forty four per cent of the farmers reported this constraint. When weeds were more farmers should be made available with the mechanical weeder. However, they felt difficulties in acquiring this

Table 10. Farmers' responses on constraints in SRI cultivation

Constraints	% of farmers quoted (multiple responses)
Weeds are more	44
Unavailability of weeder	30
Less suitable for rain-fed conditions	22
Required more labour	20
Difficulty in carrying of seedlings	12
Required good drainage facilities	14
Lack of knowledge about POP of SRI	16
Requirement of good control over irrigation	12
Required more personal attention	8

(30% farmers). Twenty two per cent of the farmers felt the constraint of unsuitability of SRI in rain-fed conditions. It is very difficult to manage the irrigation and water regime under rainfed conditions. Secondly farmers have to transplant very younger seedlings. But filed may not be prepared in the absence of rains. One-fifth of the farmers felt that SRI requires more labour. They experienced the difficulty of engaging labourers at right point of time. Difficulty in carrying the tender and small seedlings was another constraint to the farmers, 12% of the farmers expressed this problem. SRI needs good water management. For proper water management good drainage facility is required. However, all the plots may not have good drainage facilities. Farmers also felt they did not have sufficient knowledge and expertise for practicing SRI. Since, SRI entails comparatively new methods, farmers have to acquire sufficient knowledge about it. Irrigation facility is a must for SRI practice. In addition to irrigation facilities, the timing of irrigation is also an important issue in SRI. However, farmers had hardly any control over timing of irrigation when it is managed by others. Under canal irrigation system also the water availability was uncertain. Some farmers also felt that SRI requires more personal attention which they could not devote always.

It has been argued that the SRI has the potential to save water, protect soil productivity due to less use of inorganic fertilizers, save environment by checking methane gas emission from water submerged paddy cultivation practices, bring down the input cost besides increasing the paddy production providing food for the growing population. The present study showed that SRI gave more economic benefits to the farmers. Moreover, SRI was more efficient system then the conventional cultivation system. It has been shown that the grain yield advantage was around 26% in SRI. This may be an underestimate of the true impact of SRI as there was considerable diversity in how individual farmers adopt and implement the SRI packages, which made correct assessment of impacts difficult. Hence, there exists scope of further enhancing the benefits of SRI when it will be adopted in its entirety. Studies conducted elsewhere in India found more yield advantage than the present study. However, with this modest yield advantage also India could harvest an extra amount of about 8 million tonnes of rice from its 2007-08 level if it can cover its 50% of the irrigated rice area with SRI. This extra production will come without any extra investment. Thakkar (2011) concluded that if SRI were to be applied on all the rice area, we would be able to increase our irrigated area by at least 50%, using the saved water now being used for paddy irrigation. It would also lead to a 50% increase in rice production. It has been seen that farmers in Odisha were enthusiastic about SRI and chances are that the number of adopters will be increased,because the early adopters will be the proponents of SRI.

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