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Research Note

Does the System of Rice Intensification make a difference to resource use efficiency? evidence from Tripura, India

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Abstract Using data from 120 rice farmers in Tripura, this paper compares resource use efficiency in rice production under the System of Rice Intensification (SRI) vis-à-vis conventional methods. The results show that the SRI uses less seeds and irrigation without adversely affecting rice yield, leading us to conclude that the SRI is more efficient than the conventional method of rice cultivation.

Keywords System of Rice Intensification (SRI), resource use efficiency, Tripura

JEL classification C80, D24, D61, P52, Q00, Q19

Among the north-eastern states of India, Tripura is the second largest producer of rice. Rice occupies over 78% of the state's total cultivated area. It is grown in the seasons of aus (April to June), aman (July to November), and boro (December to March). Aman rice shares about 62% of the total rice area, followed by boro (27%) and aus (11%). The average yield of rice in the state is slightly over 2 tonnes per hectare, but there is huge potential for raising it through the use of modern agricultural practices like the System of Rice Intensification (SRI).

The SRI in Tripura is an interesting example of the local adaptation of a global practice involving several technological and institutional innovations. In 1999, the State Agriculture Research Station at Arundhatinagar started experiments to adapt the SRI to the state's agro-climatic conditions. During 2015–16, primarily to combat the water shortage, more than 109, 000 hectares of rice area was covered by the SRI, benefiting about 350,000 farm households in eight districts of Tripura (GoT 2016).

The SRI has several advantages over traditional practices: it saves precious inputs like seed and water, reduces the infestation of pests and diseases, and improves the crop yield (Nath and Das 2017). But no systematic evaluation has been done to quantify the benefits of SRI in Tripura, especially in terms of improvements in resource use efficiency. This paper does exactly that.

Data and methods

Data

A multi-stage random sampling technique was used to select the respondents for the study. At the first stage, Sepahijala district was purposively selected, as it has the highest area under SRI practices. At the second stage, four blocks—Boxanagar, Bishalgarh, Nalchar, and Mohanbhog—were randomly selected from these districts. At the third stage, two villages were randomly selected from each block. Finally, 15 farmers practising both SRI and conventional techniques in rice cultivation were selected randomly from each village. This process resulted in 120 sample respondents for the study. The selected farmers were post-stratified into three groups by landholding size—marginal (1 ha or less), small (1.01–2.00 ha), and medium (2.01–4.00 ha) (Table 1). Data on various aspects of rice cultivation were collected for kharif rice pertaining to the year 2016–17 from the selected farmers by means of a pre-tested questionnaire through personal interviews.

Table 1 Distribution of sample households by farm size

Farm size	Number of respondents	Percentage of total (%)
Marginal	69	57.5
Small	40	33.33
Medium	11	9.17
Total	120	100

Analytical technique

Two separate Cobb–Douglas production functions—one for SRI, and another for conventional cultivation—were fitted and estimated. A general form of the function is

$$Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + ... \beta_n \ln X_n$$

where Y is the gross return per hectare and X_is are the various inputs used (in monetary terms) per hectare. We included seed, human labour, machine labour, chemical fertilizers, farm yard manure (FYM), plant protection chemicals, and irrigation as explanatory variables.

The estimated coefficients only of the significant variables were used to compute the marginal value product (MVP) and the resource use efficiency using the formula

r = MVP/MFC,

where r is the efficiency ratio, MVP is the marginal value product of the concerned input, and MFC is the marginal factor cost or price per unit of input.

MVP was calculated as $MVP_i = \beta_i \frac{\bar{Y}}{\bar{X}_i}$, where $\bar{Y}$ is the geometric mean of the value of output and $\bar{X}_i$ is the geometric mean of the ith input.

A firm maximizes profits with regard to a resource when the ratio of the marginal return to opportunity cost equals 1. If r is <1, then the resource is over-utilized; hence, a decrease in quantity is suggested to maximize profits till r becomes equal to 1. If r >1, the resource is under-utilized, and an increase in inputs will raise the profit to the level when r falls to 1.

Results and discussion

The socio-economic details of the selected respondents revealed that 9.44% were illiterate, 51.85% were educated up to the primary level, 33.15% were educated up to Class 10, and 5.56% were graduates or better educated. The main occupations of the respondents were found to be agriculture activities (64.17%) and secondary activities (35.83%). The operational landholding size was found to be 0.74 ha in the marginal category, 1.21 ha in the small category, and 2.99 ha in the medium category. All the sample respondents (120) were male, though there were several female members in the households. Table 2 details the cropping pattern of the sample respondents. The cropping intensity was recorded to be 172.30% for marginal farmers, 169.23% for small farmers, and 180.22% for medium farmers.

During the rabi season, out of the total gross cropped area in the study area, marginal farmers used 12.50% of the SRI rice area, small farmers 6.06%, and medium farmers 14.49%. Similarly, during the kharif season, marginal farmers used 19.64% of the SRI rice area, small farmers used 26.77% and medium farmers used 25.25%. The mean and standard deviation of the variables utilized in the Cobb–Douglas production functions were calculated (Table 3). Farmers in the study area provide additional inputs for SRI rice—fertilizers, plant protection chemicals, FYM—than in the conventional technique of rice cultivation. The SRI has more outputs than does the conventional technique; therefore, the returns of SRI are much higher.

Table 4 presents the factors of rice production under the SRI and the conventional method. It shows a positive relation of all the factors considered under the SRI. This positive relation may be attributed to the scope for increasing the use of these inputs to improve production.

The regression coefficient for seeds was 0.031—considering all other factors constant, a 1% increase in seed cost would increase gross returns by 0.031%. The regression coefficient for human labour was (0.447) and for machine labour (0.020); keeping other inputs constant, a 1% increase in human labour would raise production by 0.447% and a 1% increase in machine labour would raise it by 0.020%. Similarly, the regression coefficient was 0.133 for fertilizers, 0.575 for plant protection chemicals, 0.016 for irrigation, and 0.009 for FYM; keeping the other factors constant, a 1% increase in each would increase the yield of fertilizers by 0.133%, plant protection chemicals by 0.575%, irrigation by 0.016%, and of FYM by 0.009%.

Table 2 Cropping pattern of various size groups per farms (ha)

Size group	Kharif crops			Rabi crops						Total rice	Total vegetables	Gross cropped area	Net cropped area	Cropping intensity
	SRI rice	Traditional rice	Kharif vegetable	SRI rice	Traditional rice	Potato	Oilseeds	Other vegetables	Legumes					
Marginal	0.22	0.24	0.10	0.14	0.14	0.07	0.01	0.19	0.01	0.73	0.36	1.12	0.65	172.30
	(19.64)	(21.42)	(8.92)	(12.50)	(12.50)	(6.25)	(0.89)	(16.97)	(0.89)	(65.17)	(32.14)	(100)		
Small	0.53	0.24	0.20	0.12	0.04	0.12	0.13	0.40	0.20	0.93	0.73	1.98	1.17	169.23
	(26.77)	(12.12)	(10.10)	(6.06)	(2.02)	(6.06)	(6.57)	(20.20)	(10.10)	(46.97)	(36.87)	(100)		
Medium	1.22	0.64	0.14	0.70	0.38	0.25	0.27	0.82	0.41	2.94	1.21	4.83	2.68	180.22
	(25.25)	(13.25)	(2.89)	(14.49)	(7.86)	(5.17)	(5.59)	(16.97)	(8.48)	(60.86)	(25.05)	(100)		
Average	0.41	0.28	0.14	0.18	0.13	0.10	0.07	0.32	0.11	1.00	0.56	1.74	1.01	172.27
	(23.56)	(16.09)	(8.05)	(10.34)	(7.47)	(5.75)	(4.02)	(18.39)	(6.32)	(57.47)	(32.18)	(100)		

Source Authors' calculations
Note Figures in parentheses indicate percentage to total respondents

The farmers in the study area were using very little of plant protection chemicals (the regression coefficient was 0.575). Therefore, raising their use by a comparatively small amount would raise the gross returns by 0.575%. The rice farmers using the SRI method in the study area were practising the alternate wetting and drying technique of irrigation; therefore, irrigation facilities were easily available. Farmers were using a good quantity of manure that would help in higher gross returns.

Similar results were reported by Parasar et al. (2016) for seed, chemical fertilizers, plant protection chemicals, and human labour. The coefficient of multiple determinations (R^2) was found to be 0.84—84% of the variation in rice production was explained by the variables considered in the study. It shows that the variables considered were more crucial in the SRI than in the conventional method. However, the intercept (2.709) was found to have a positive and significant relation with the production of rice. There was still scope for the farmers in the study area to improve rice production by increasing the inputs considered in the study.

Similar results are reported by Rao (2011): the R^2 value in the SRI was 0.84, which suggests that the various factors considered jointly explained as high as 84% of the variation in yield in the SRI. Parasar et al. (2016) report that the coefficient of multiple determinations (R^2) was 0.85, which shows that the various factors considered jointly explained 85% of the variation in rice production in the SRI method. Basorun and Fasakin (2012) report that the quantity of rice harvested is significantly impacted by the status of farmers, area used for cultivation, labour, market, and agrochemicals. The returns to scale Σb_i under the SRI, $\Sigma b_i > 1.23$, indicate an increase, or that the output increases when inputs are increased.

Under the conventional method of rice cultivation, production is positively and significantly affected by seeds (0.032), human labour (0.023), machine labour (0.353), chemical fertilizers (0.221), plant protection chemicals (0.231), irrigation (0.084), and FYM (0.308) (Table 4). The coefficient of both irrigation (0.084) and FYM (0.308) indicates that farmers were using more irrigation in conventional rice cultivation than in the SRI. However, FYM was under-used in the conventional method.

Table 3 Mean and standard deviation of variables used in the Cobb–Douglas production functions (INR per ha)

Particulars	System of Rice Intensification		Conventional method	
	Mean	Standard deviation	Mean	Standard deviation
Seed	1756.88	267.81	10022.50	971.91
Human labour	18535.00	457.18	14870.83	491.25
Machine labour	2233.33	309.33	1018.33	163.98
Fertilizers	1356.59	59.92	627.49	41.66
Plant protection chemicals	246.67	23.54	127.21	10.96
Irrigation	274.58	13.84	372.25	16.83
Farm yard manure	2031.67	119.51	1023.33	109.03

Source Authors' calculations

Table 4 Cobb–Douglas production function estimate for the System of Rice Intensification and conventional methods of rice cultivation

Sl. No.	Particulars	Method of cultivation	
		SRI	Conventional
1.	Seed *(X_1)*	0.031	0.032
		(0.055)	(0.124)
2.	Human labour *(X_2)*	0.447***	0.023
		(0.131)	(0.330)
3.	Machine labour *(X_3)*	0.020	0.353**
		(0.020)	(0.132)
4.	Fertilizers *(X_4)*	0.133*	0.221
		(0.064)	(0.144)
5.	Plant protection chemicals *(X_5)*	0.575***	0.231*
		(0.094)	(0.112)
6.	Irrigation *(X_6)*	0.016	0.084
		(0.058)	(0.498)
7.	Farm yard manure *(X_7)*	0.009	0.308*
		(0.048)	(0.153)
8.	Intercept	2.709*	3.126
		(1.397)	(3.387)
9.	R^2	0.84	0.48
10.	*F* value	86.73	14.94
11.	Number of observations	120	

Source Authors' calculations
Notes Figures within parentheses indicate standard errors
*Significant at 10% probability level
**Significant at 5% probability level
***Significant at 1% probability level

Even by using less FYM, farmers were able to increase the gross returns. This positive relation between the factors and production reveals that there is still scope for increasing these inputs and improving the production of rice. The coefficient of multiple determinations (R^2) was found to be 0.48, which indicates that 48% of the variation in the rice production was explained by the variables considered in the study for the conventional method. The intercept (3.126) had a positive relation with the production of rice. Farmers have the scope for improving rice production even in the conventional method of rice cultivation, and it would be beneficial if they increased their use of inputs in the SRI. The returns to scale, $\Sigma b_i > 1.25$, are increasing, or increasing inputs will increase the outputs.

The *r* values for seed, human labour, machine labour, chemical fertilizers, plant protection chemicals, irrigation, and FYM were computed under the SRI method based on the estimated parameters in the rice production function (Table 5). The *r* value was more than unity for seed (2.27), human labour (3.11), machine labour (1.15), chemical fertilizers (12.61), plant protection chemicals (300.40), and irrigation (7.51) but less than unity (0.54) for FYM. The results indicate that farmers had the opportunity to increase the output per hectare by increasing their use of human labour, machine labour, chemical fertilizers, plant protection chemicals, and irrigation. However, farmers need to reduce their use of FYM. Similar results are reported by Parasar et al. (2016) for seeds, chemical fertilizers, plant protection chemicals, and human labour; MVP values for all the variables were greater than 1, indicating that there was still scope for increasing the use of the strategic resources under SRI for increasing rice yields.

Majumder et al. (2009) present similar findings: for landowners and tenant operators, the MVP of seedlings,

Table 5 Estimated resource use efficiency for system of rice intensification and conventional methods of rice production

Sl. No.	Farm inputs	Production elasticities		MVP		MFC (INR)		MVP/MFC (*r*)	
		SRI	Conventional	SRI	Conventional	SRI	Conventional	SRI	Conventional
1	Seed	0.031	0.032	2.27	0.25	1	1	2.27	0.25
2	Human labour	0.447	0.023	3.11	0.12	1	1	3.11	0.12
3	Machine labour	0.020	0.353	1.15	26.81	1	1	1.15	26.81
4	Fertilizers	0.133	0.221	12.61	28.57	1	1	12.61	28.57
5	Plant protection chemicals	0.575	0.231	300.40	147.83	1	1	300.40	147.83
6	Irrigation	0.016	0.084	7.51	18.08	1	1	7.51	18.08
7	Farm yard manure	0.009	0.308	0.54	23.79	1	1	0.54	23.79

Source Authors' calculations

and insecticides was higher than 1, which indicates that more of these resources can be used; for cash tenants, the MVP of seedlings, insecticides, and fertilizers was greater than 1, which indicates the scope for increasing output by spending more on these inputs. The analysis of the MVP-to-factor cost ratio also shows that the MVP of each of the factors was found to be higher than its respective price, which indicates further scope of increasing the use of these inputs for maximizing rice production. The MVP-to-MFC ratio for fertilizers, labour and land is reported to be greater than 1 (Sani et al. 2010).

The *r* value for seed, human labour, machine labour, chemical fertilizers, plant protection chemicals, irrigation, and FYM under the conventional method was computed: < 1 for seed (0.25) and human labour (0.12) and > 1 for machine labour (26.81), chemical fertilizers (28.57), plant protection chemicals (147.83), irrigation (18.08) and FYM (23.79) (Table 5). If the *r* value > 1, it indicates the under-utilization of inputs. Similar results are reported by Parasar et al. (2016) for seeds, chemical fertilizers, plant protection chemicals, and human labour.

Conclusions

From the study, it was observed that resource utilization is more efficient under the SRI than in the conventional method of rice cultivation. An analysis of the impact of the production variables on rice productivity revealed that under both the SRI and conventional method, the gross return of rice production is significantly and positively impacted by human labour, machine labour, fertilizers, plant protection chemicals, irrigation, and FYM. Farmers in the study area still had scope for improving rice production by increasing their use of inputs. Farm yard manure was over-utilized in the SRI method and human labour in the conventional method. Overall, resource utilization was more efficient under the SRI than in the conventional method. To improve the adoption of SRI techniques in Tripura and to optimize input use for rice cultivation, appropriate policy measures like awareness camps and capacity building programmes are needed.

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