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Highlight

Impact of System of Rice Intensification (SRI) on Rice Yields:

Results of a New Sample Study in Purulia District, India

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Maximizing output with a given set of inputs has continued to be a matter of great interest and a technology that gives increased output with comparatively lesser inputs certainly draws a lot of attention.

This paper examines the case of one such highly debatable technology, popularly known as System of Rice Intensification (SRI) which promises to give more rice yields with lesser inputs. The study shows that there is a significant increase in paddy yields with this technology. The highest yield is of the order of 15 tons/ha.

SRI also leads to reduced input costs resulting from less seed requirement, 2.87 kg per acre compared to 27.17 kg per acre in the conventional method. With SRI there is an increase of about 67 percent on net returns compared to the conventional method of paddy cultivation, suggesting that SRI is pro poor.

Impact of System of Rice Intensification (SRI) on Rice Yields: Results of a New Sample Study in Purulia District, India[1]

Research Highlight Based on a Paper with the Same Title

Rice feeds more than half the people in the world but not well and may not do so for much longer. As the population rises, so does the demand for rice. Yet, yields of the crop are leveling out. Already, more than 400 million people endure chronic hunger in rice-producing areas of Asia, Africa and South America, and demand for rice is expected to rise by a further 38 percent within 30 years, according to the United Nations. Rice cultivation requires large amounts of water and in the wake of growing scarcity of water a gradual shift towards cultivation of less water-demanding crops is being witnessed. Moreover profitability of rice cultivation is low because of high input costs and low prices of rice. All these developments are accelerating farmers' withdrawal from rice cultivation, which may jeopardize future rice supply. So there is an imperative need to make paddy cultivation more efficient in terms of returns on farmer investments as well as in use of scarce resources such as water.

A package of practices for paddy cultivation, popularly known as the System of Rice Intensification (SRI), that has been tested in predominantly rice-growing countries such as China, Sri Lanka, Cambodia and Indonesia, and is claimed to have given stunning results in enhancing paddy output with lesser inputs, seems to have come as a solution. SRI was developed in Madagascar during 1980s and the package advocates use of less water, less seed, and less chemical fertilizers and pesticides, but claims to produce more grain. In SRI, the plants are bigger. This means more photosynthesis which in turn leads to more carbohydrate formation. The unutilized portion of carbohydrate comes out as root exudates, thereby supporting microbial growth. Agro-ecology is supposed to be the basic foundation for soil health and SRI helps in enriching it. At times, yields of up to 17 ton/hectare have been reported which is dismissed by many agricultural scientists as a physiological impossibility. Of late, SRI has generated a lot of heat and experimental trials are going on in many countries to test the validity of the claims.

What is SRI?

The System of rice intensification (SRI), developed by Fr. Henri de Laulanie in the 1980s in Madagascar and later tried in other rice-growing countries, is fast emerging as one of the best alternative rice production systems to increase rice yield. It has brought radical changes in the current way of following agronomic practices in terms of managing soil, water, plant and nutrient to create a synergistic effect to produce higher rice yield. The Madagascan farmers established key practices, which form the core of the SRI:

1.Transplanting 8 to 12 day old seedlings, one per hill, at 25x25 or 30x30 up to 50x50 cm spacing in a square pattern.

2.The soil is kept moist to the point of surface cracking but not inundated during the vegetative growth phase. In the reproductive phase, 1-3 cm

[1]The research covered by this IWMI-Tata Research Highlight was carried out with generous support from Sir Ratan Tata Trust, Mumbai under IWMI-Tata Water Policy Program. The research paper can be downloaded from the IWMI-Tata Website http://www.iwmi.org/iwmi-tata.

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of water is kept continuously on the field so that water is continuously available to the plant. Fields are drained 25 days before harvest.

3. Mechanical weeding should start about 10 days after transplanting. At least 2 weedings are necessary, but 3, 4 or even 5 are recommended until the canopy closes and weeding is no longer possible or necessary.

4. Using compost instead of chemical fertilizer to maintain soil health.

All these practices challenge assumptions and practices that have been in place for hundreds, even thousands, of years. The convention is to transplant fairly matured, 25-30 day old seedlings and to keep the field flooded with water all the time giving little scope for the weeds to grow.

It is very difficult for the farmers to follow the entire set of practices of SRI perfectly, as a great amount of effort is required in managing water in the plots and in weeding and hoeing operations . The issue is whether imperfect use of these practices—that is farmer adaptations—confers significant benefits on the rice farmers. PRADAN, an NGO working in many states of India, thought of conducting trials on SRI in Purulia district of West Bengal, where farmers could ill afford "Green Revolution" recipe. They were surprised at the potential benefits of SRI and the farmers' faith in the package went up. Against such a backdrop this paper is an attempt to validate or falsify claims made about SRI using a systematic survey of adopters of this package in Purulia. In particular, the objectives of this study are to assess the impacts of SRI adoption on: [1] cultivation practices; [2] the output of paddy and straw; and [3]economics of paddy cultivation.

The Actual Practice of SRI in Purulia, West Bengal

Even with partial adoption of SRI practices in Purulia, we found our sample of SRI plots got on average 32 percent higher paddy yield (output/ha) as compared to conventional plots.

There has been only partial adoption of standard practices of SRI in Purulia. Farmers are following the practices of early transplantation and wide spacing of saplings, but have performed poorly in the management of water, fertilizer, hoeing and weeding. We found little attention was paid to preparing drainage channels, which is crucial to facilitate alternate wetting and drying. However, even with such partial adoption of SRI practices in Purulia, we found our sample of SRI plots got on average 32 percent higher paddy yield (output/ha) as compared to conventional plots. This gives an indication of the unexploited potential on the output front. Plots where SRI

Methodology

The data used for the analysis came from 110 farmers contemporaneously practicing both SRI and conventional method of rice cultivation in kharif 2004. Data collection was an ongoing process and a close watch was kept all the time to record various farming operations in the SRI farms. For every farmer data were collected at an interval of 8-10 days. In addition to collecting data on labour and input use we kept recording data on various agronomical practices under the two methods as difference in agronomical practices is hypothesized to bring all the difference in the output.

Sampling Plan: A two stage convenience sampling was followed to select 110 farmers from Jhalda and Balrampur blocks of Purulia district of West Bengal.

Measurement of plots: Given the fact that most of the farmers in our sample were not sure about the actual dimension of the plots and were giving only an approximate size we got 40 plots measured completely with the help of a qualified land surveyor. The aim was to avoid any extrapolation error.

Measurement of output: To avoid any measurement error, we got total output measured for all the farmers both for the SRI and conventional plots with the help of spring balances.

package was followed in a better manner produced higher output, especially those plots where more number of hoeing and weeding was done, indicating that possibilities exist for many farmers to increase the average output further.

Results and Discussion

Effect of SRI on Cultivation Practices

All farmers religiously followed the two practices of SRI namely, wide spacing and single seed per hill transplanting in their SRI plots (with the exception of three who planted two to three seedlings per hill). Even under conventional method farmers are gradually shifting towards line sowing to avail the benefits of easy hoeing and weeding, though the spacing is less. Most of the farmers, however, did not bring in any significant changes in water and soil management practices. For the first 10 days most of the plots were saturated with water and farmers did nothing to dry out the field. This trend, however, changed from the second week and 13 farmers drained out water completely from their SRI plots. All the farmers, though in varying proportions, applied fertilizer on both SRI and conventional plots. Very few farmers took active interest in timely hoeing and weeding as it required more labor. Only one from our sample of 110 farmers, did four hoeing and weeding (output was 9.02 tons/ha), six farmers did 3 hoeing and weeding and the rest of the farmers did only one or two hoeing and weeding in their SRI plots. Table 1 summarizes the extent of change witnessed in cultivation practices in Purulia with respect to standard SRI practices.

Table 1: SRI practices in Purulia (N=110)

SRI practices	No. Of following farmer the practice
Early transplant (<14 days)	53
Single seedling per hill	107
Wide spacing (25x 25 cm or 30x 30)	110
Alternate wetting and drying	13*
weeding (2 or more)	59
Mechanical weeding	0

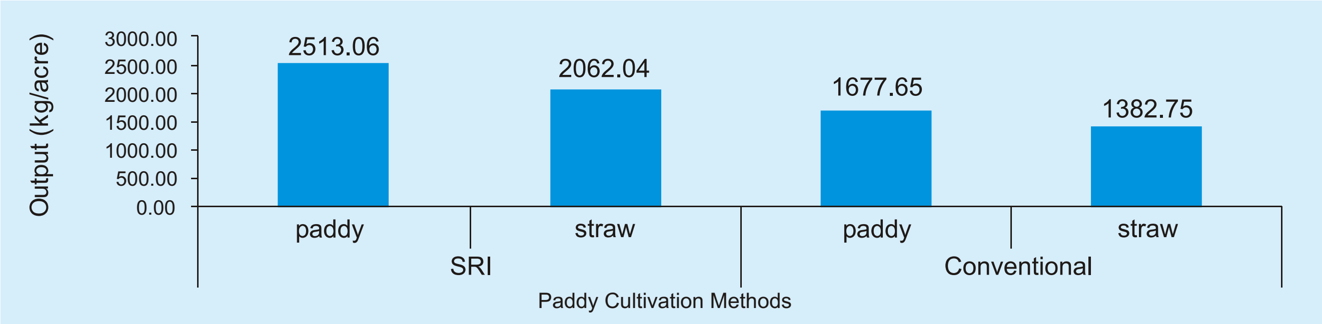
* Farmers did not follow this practice consistently.

Comparison of Yield under SRI and Conventional Method

SRI significantly increases rice yield, *ceteris paribus*. There is 49.8 percent increase in output per hectare in SRI plots as compared to the conventional plots in Balrampur, whereas the increase is 11.9 percent in Jhalda

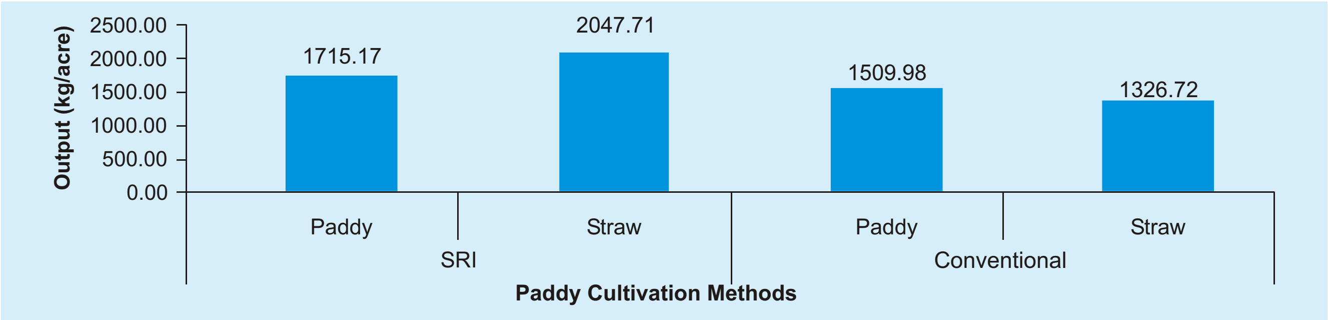
Our data confirm that SRI significantly increases rice yield, *ceteris paribus*. There is 49.8 percent increase in output per hectare in SRI as compared to the conventional method in Balrampur, whereas the increase is 11.9 percent in Jhalda. Lower yield increase in Jhalda can be partially attributed to three dry spells in this region leading to dry condition in the fields at the grain filling

Figure 1: Output of Paddy and Straw Per Acre in Balrampur (Sample Size = 59)



Source: Authors' analysis based on primary data.

Figure 2: Output of Paddy and Straw Per Acre in Jhalda (Sample Size = 40)



Source: Authors' analysis based on primary data.

Table 2: Land Productivity

Parameter	Sample size		SRI		Conventional	
	SRI	Conventional	Paddy kg /acre	Straw kg /acre	Paddy kg /acre	Straw kg /acre
Purulia	106	106	2131.64	2051.07	1616.85	1362.76
Low land	83	41	2239.18	1974.00	1594.16	1370.19
Medium land	43	44	2064.03	2003.92	1605.80	1408.44
For Measured plots	40	40	2311.75	2239.89	1779.83	1514.91

Source: Authors' analysis based on primary data.

stage. Moreover, 26 farmers in Jhalda transplanted very old seedlings in their SRI plots aging more than 25 days. Of these, 10 farmers transplanted seedlings after 30 or more days in field. One more important reason is that all the farmers in Jhalda did only one hoeing and weeding under SRI. Besides increased paddy yield, output of straw per acre under SRI too increased significantly by 49.13 and 54.34 percent in Balrampur and Jhalda, respectively.

Table 2 shows average paddy and straw yields for both Balrampur and Jhalda pooled together, and for different types of land under the two methods. We observed that under SRI, there is an increase of 28.54 percent and 40.46 percent in paddy output for medium lowlands and lowlands respectively when compared to the conventional plots. Also there was an increase of 54.24 percent and 20.18 percent in paddy output under SRI for lowlands, and medium lowlands, respectively, for a set of 35 farmers contemporaneously practicing both the methods in the same type of land. There was an increase of 29.89 percent in paddy output under SRI for the 40 plots that were measured. This increase was 39.56 percent for Balrampur (sample size 30) and 50.62 percent for Jhalda (sample size 10).

Productivity of Agricultural Inputs

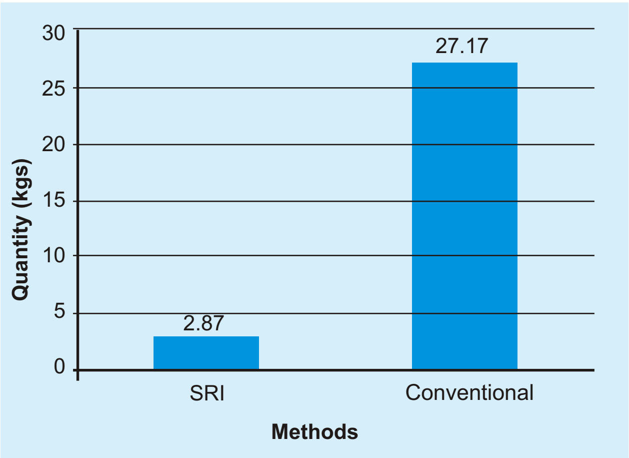
Several studies suggest that SRI not only increases paddy yields, but also helps improving the

Table 3: Input Productivity (N=110)

Parameter	SRI	Conventional Paddy
Paddy yield (kg) /kg of seed	845.61	61.35
Paddy (kg)/kg fertilizer applied	42.40	36.60
Paddy (kg)/man days	46.20	32.20

Source: Authors' analysis based on primary data.

Figure 3: Seed Requirement Per Acre



Source: Authors' analysis based on primary data.

productivity of labor and other inputs. We also observed that under SRI per acre productivity of applied agricultural inputs increased significantly (Table 3).

Can SRI Help Change the Economics of Paddy Cultivation?

Evidence from field suggests that SRI is economically more attractive and can help in improving the factor productivity of land, capital and labor. Some of the direct economic benefits under SRI are lower seed rate, lower expense on labor and higher output of paddy and straw. Under SRI seed rate reduces drastically (Figure 3) which gives farmers enough economic incentive to adopt this method even if it gives as much output as under the conventional method. This has implications for viability of paddy cultivation, especially in years which experience monsoon failure, and when farmers have to plant seedlings for a second time. In such situations SRI farmers can save a lot of money going down the drain in the form of wasted seeds. For our sample farmers, on average, there is a saving of Rs. 292 per acre, assuming that all the farmers were using same type of seed.

SRI is supposed to be highly labor intensive. However, our sample data from Purulia farmers suggest that for all the farming operations taken together it takes less labor per acre under SRI (369.12 hours) when compared to Conventional system (401.75 hours), implying a saving of Rs. 184 per acre on labor. The biggest reward under SRI comes in terms of the higher yield leading to higher income, an average of Rs. 2059 per acre more under SRI when compared to conventional method (Table 4). For poor farmers this higher yield is significant as even if they do not sell their produce they will have greater food sufficiency.

Table 4: Value of Output Per Acre

Parameter	SRI	Conventional paddy
Paddy yield (kg)/acre	2131.64	1616.85
Value of paddy/acre (Rs.)	8526.58	6467.4

Source: Authors' analysis based on primary data.

Table 5: Net Return Under SRI and Conventional Paddy

Method	Value of output/ acre (A)	Value of straw/ acre (B)	Expense on seed/ acre (C)	Expenses on labor (D)	Expense on fertilizer (E)	Net Return (A+B-C-D-E)
SRI	8526.58	1025	34.44	2076	389	7052.14
Conventional	6467.4	681	326.04	2260	339	4222.96

Source: Authors' analysis based on primary data.

The gross return per acre is Rs. 3341 if we take only the Balrampur block. This in fact gives us a more realistic picture because the rainfall condition in this area in kharif 2004 was more or less normal.

The net return estimated by deducting major expenses on labor, fertilizer and seeds from output value of paddy (valued at Rs. 4 per kg) and straw (valued at 50 paisa per kg) per acre is even more impressive. With SRI there is an increase of about 67 percent on net return compared to the conventional method. The break ups of estimates are shown in Table 5.

We also found that land productivity under SRI increased by 32 percent.

Labor Issues

In addition to the debate on output there also exist divergent views on labor use under SRI. The general impression is that SRI requires more labor because greater care and effort is required in transplanting young seedlings, and for more frequent hoeing and weeding. Proponents of SRI contend that initially SRI may be more labor intensive but the technique can be mastered and it may eventually even require less labor as compared to conventional paddy cultivation. From our study it is not possible to make a conclusive statement about labor use between the two methods since the SRI package is not being followed completely. Our data suggest that actual transplantation time per acre for SRI is less compared to the conventional method, (148 hours for SRI as against 175.25 hours per acre for conventional method). This is because fewer seedlings are transplanted in SRI plots. The actual transplantation time is even less for plots having their seedbeds closer to or within the plot itself. The overall analysis of labor use on hoeing and weeding in the two blocks reveals that it takes more time under SRI (57.12 hours per acre in SRI as against 49.9 hours per acre in conventional) but it must be noted that this increase is due to more number of hoeing and weeding done in SRI plots.

In order to have a better understanding of the hoeing and weeding time taken under SRI for a single operation, when we multiplied the plot size with the number of hoeing and weeding done on it to arrive at the effective area of operation we found that it took less time for hoeing an acre of SRI plot when compared to conventional paddy plot. For all the farming operations taken together, it actually took less labor for SRI per acre, a finding which corroborates with that of SRI proponents. Line sowing and wide spacing in square pattern facilitates easy movement of laborers during inter-culture operations, thereby reducing the time taken for weeding and hoeing in SRI plots. Table 6 summarizes the labor requirement for both the methods for every farming operation.

Proponents of SRI contend that initially SRI may be more labor intensive but the technique can be mastered and it may eventually even require less labour as compared to conventional paddy cultivation.

Impact of SRI Practices on Output

Regression analysis with fertilizer, age of seedling, number of hoeing and plot size as independent variables and output as dependent variable shows that 29.7 percent variation in output can be explained by these four independent variables. Frequency of hoeing has significant impact on output with a Beta value of 0.515 followed by

Table 6: Labor Requirement/Acre (Hours)

Parameter	SRI	Conventional
Seedbed preparation	6.58	7.84
Seed treatment	0.52	0.95
Seed sowing	0.35	0.59
Fertilizer/manure on seedbed	0.80	1.08
Ploughing	33.45	34.30
Land leveling	7.03	6.42
Field bund dressing/drainage channel	4.13	2.63
Application of fertilizer as basal dose	0.75	0.68
Application of manure	2.49	2.57
Transplantation	148.07	175.25
Hoeing and weeding	57.12	49.90
Successive application of fertilizer	0.80	0.83
Harvesting	63.15	71.88
Threshing	44.40	46.83
Total	369.12	401.75

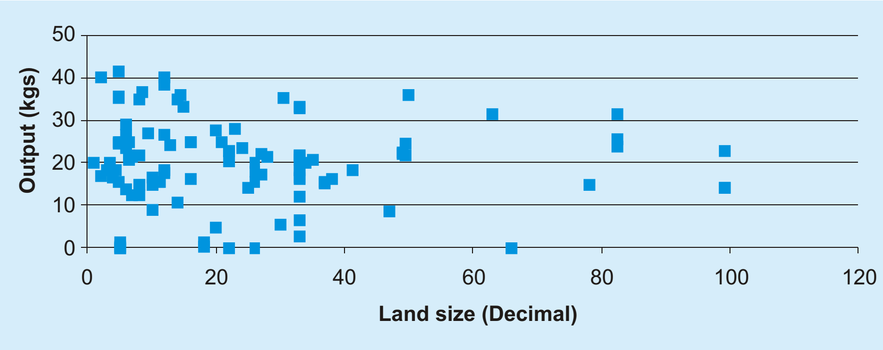
Source: Authors' analysis based on primary data.

Table 7: Coefficients and Significance Level of Independent Variables

		Un-standardized coefficients		Standardized coefficients	t-ratio	Signifi-cance level
Model		B	Std. Error	Beta		
1	(Constant)	1.648	4.836		.341	.734
	No. of hoeing	7.828	1.620	.515	4.831	.000
	Land size	3.595E-02	.040	.083	.892	.374
	Seedling age	.171	.144	.123	1.186	.239
	fertilizer/decimal	4.739	2.179	.213	2.175	.032

Source: Authors' analysis based on primary data.

Figure 4: Paddy Output as Influenced by Plot Size



Source: Authors' analysis based on primary data.

quantity of fertilizer (Table 7). Our analysis does not seem to suggest that SRI is scale neutral (Figure 4) as argued by some scientists. In order to examine the effect of scale on the yield of paddy under SRI, we have categorized our sample of 110 SRI adopters into two groups: one falling in the land holding category of 0-25 decimals (1 decimal = 0.01 acre), and the other having more than 25 decimals of land under SRI. The statistical analysis of yields shows that the farmers in the smaller holding category obtained higher yield (20.4 kg/decimals) than those in the larger holding category (19kg/decimal). Further yield variation was more for smaller holding category indicated by the coefficient of variation of 51 percent against 45 percent for larger holding category. Higher yield in the case of smaller holders can partly be explained by the higher doze of fertilizers farmers apply (0.88kg/decimal against 0.38 kg/decimal for larger holding category), given the effect of fertilizers on yield. The variation in yield for the small holding category needs to be further investigated.

Field Observation on Phenotypic (Physiological) Characteristics

There was a visual difference in the growth of tillers, productive tillers, grain filling and overall vegetative growth between SRI and conventional plots. Productive tillers (effective tillers) ranged from 18 to 32 in SRI plots and from 8 to 14 in conventional plots. Maximum tillering of up to 85 was observed on a few SRI plots. However, panicle length did not seem to be any different in SRI plots from conventional plots. We also observed that the root color changed from white to brown for both SRI and conventional plots under inundated conditions thus leading to lower effective conversion ratio.

Constraints in Adopting SRI in a Rain-fed Condition:

Since ponding of water is not allowed under SRI method of paddy cultivation, it is very difficult to go for SRI if there is no facility available for protective irrigation in case of monsoon failure. SRI increases the vulnerability to the failure of timely rains. Dry spells at the time of grain filling stage can lead to heavy yield loss resulting from bad effective conversion ratio of tillers.

Delay in arrival of monsoon leads to delay in seedbed preparation which has negative implications for yield.

It is very difficult to drain the fields completely during the rainy season especially in places like Purulia where the average rainfall is 1200 mm or greater and it rains almost everyday in normal rainfall years. In bad rainfall years like 2004, farmers would not drain out water fearing delays in rainfall or no rainfall at all.

In case of heavy downpour it becomes very difficult to drain out water from lowlands thus making it difficult to achieve dryness in the fields, at times required under SRI.

Conclusion

The study in Purulia shows that SRI leads to higher yields. It is also worthwhile to mention that following SRI package in its entirety is not an easy task as it needs careful management of water and more labor because of more number of hoeing and weeding operations. Though our study suggests that for all the farming operations taken together SRI takes less time per acre compared to conventional method, the results might differ if all SRI practices are followed carefully. SRI plots produced more output for both lowlands and medium lands but there are topographical variations in the output. SRI is definitely pro-poor in nature, as it requires lower cost of inputs per acre of land. Our study, however, could not capture the effect on output with only organic manure, as all the adopters of SRI method applied chemical fertilizers. Promoting the use of only organic fertilizers and pesticides under SRI needs to be given serious thought as it can further help in reducing input costs, provided yields are not adversely affected.

Areas for Future Research

There is a substantial saving in applied water through SRI. But the actual saving in water comes only if there is reduction in depleted water (ET plus the water evaporated from the fallow land after harvesting of the crop).

Though advocates of SRI claim that it has tremendous potential for water saving there is dearth of scientific data on actual water saving potential of SRI. There is, however, definitely substantial saving in applied water through SRI. But the actual saving in water comes only if there is reduction in depleted water (ET plus the water evaporated from the fallow land after harvesting of the crop). Having said that it is important to remember that most of the saving in applied water (apparent saving) must be coming from reduction in deep percolation which occurs in rice fields under conventional method. But, this water is available for reuse. The actual saving can come from reduction in non-beneficial evaporation (E component of ET) from the inundated field, as the period of inundation is much lower under SRI. Some saving can also come from reducing the residual soil moisture in the field after harvesting.

Understanding the causes and effects of greater root growth in rice under SRI is an area where systematic research is needed.

There is a need to develop scientific explanation for degeneration of roots in flooded conditions and its impact on output.

Most of the SRI farmers apply chemical fertilizers. Hence, there is a need for systematic research to determine the standard dose of chemical inputs per acre in SRI plots. There is also need to test if organic compost alone has the capacity to provide all the nutrients to the plants in proper balance.

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IWMI-Tata Water Policy Program

The IWMI-Tata Water Policy Program was launched in 2000 with the support of Sir Ratan Tata Trust, Mumbai. The program presents new perspectives and practical solutions derived from the wealth of research done in India on water resource management. Its objective is to help policy makers at the central, state and local levels address their water challenges – in areas such as sustainable groundwater management, water scarcity, and rural poverty – by translating research findings into practical policy recommendations.

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The policy program's website promotes the exchange of knowledge on water-resources management, within the research community and between researchers and policy makers in India.

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