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Inside

‘More Crop Per Drop’ in India

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Modifying the methods of plant establishment and water management, changing agricultural practices, and creating more favourable growing conditions for crops, both above and below the ground, farmers have begun producing more crop per drop of water, more crop per acre of land and more crop per unit of work

Prime Minister Modi’s recent challenge to India’s agricultural scientists and farmers to produce ‘more crop per drop’ is fully justified by the country’s economic, social and environmental conditions, both present and foreseeable. As the Prime Minister pointed out, when speaking at the Indian Council of Agricultural Research’s (ICAR’s) 86^{th} anniversary celebrations, India’s land resources are limited whereas the demand for food keeps growing. India, thus, needs to produce more crops per unit of land and also per day or hour of labour: *Kam zameen, kam samay, zyaada upaj.*

Meeting this challenge has been made more difficult and more urgent by the disruptive effects of climate change, which is making water supply less sufficient and less reliable. This constraint is magnified by the continuing degradation of land and water, and by the decline in soil health and water quality from the overuse of fertilizers and agro-chemicals.

Fortunately, farmers in many states of India, over the past decade, have already begun producing more crop per drop of water, more crop per acre of land and more crop per unit of work, by changing their agricultural practices. By modifying their methods of plant establishment and water management, farmers can create more favourable growing conditions for their crops, both above and below the ground. This is especially true for rice and is applicable to many other Indian crops also.

Modifications in crop management while using water more sparingly and carefully can lead to larger, better-functioning root systems and also to more beneficial soil organisms that live symbiotically around, on, and even inside plants’ roots and leaves. Complex microbial communities and the plant-soil micro-biome contribute positively to the growth and health of plants, in much the same way that the human micro-biome is proving to be essential for our own well-being.

The concern for roots and the soil biota was, unfortunately, entirely left out of the Green Revolution's strategy for crop improvement. Focussing just on water conservation for agriculture will not generate as much benefit for farmers or for the country as can be generated by more biological, less mechanistic thinking, which takes a more integrated approach to crop and water management.

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To give a specific example, ICAR researchers at the Directorate of Water Management in Bhubaneshwar have found that the integrated management of crops can produce rice plants that have quite a different capability for converting solar energy and nutrients into carbohydrates. For a given amount of water transpired, the processes of photosynthesis of rice plants can be made more than twice as efficient, enabling them to produce 'more crop per drop'. Rice plants grown using the System of Rice Intensification (SRI) methods discussed here can fix 3.6 micro-mols of carbon dioxide (CO_2) per milli-mol of water transpired, compared to just 1.6 micro-mols of CO_2 being transformed into photo-synthate by rice plants of the same variety grown conventionally. Attention to such physiological improvement in the performance of plants will become all the more important with the increasing water scarcity in India and elsewhere.

ALTERNATIVE SYSTEMS OF CROP MANAGEMENT

Our understanding of the important contribution that better root systems and more abundant and diverse life in the soil can make to crop production and efficiency is based on more than a decade of experience in India with SRI. This was developed in Madagascar some 30 years ago and was introduced in India about 15 years ago.

In recent years, Indian farmers have also begun adapting and extrapolating the ideas and methods of SRI to crops beyond rice. There is an expanded version of the SRI called the System of Root Intensification in Bihar, and a more encompassing System of Crop Intensification (SCI) that improves the productivity and resilience of crops such as wheat, *ragi*, sugarcane, maize, mustard, all the grams, and even some vegetables.

In Bihar, over 1,00,000 households are already benefitting from SRI and SCI practices, as documented in a 2013 World Bank/JEEVIKA report.

Crops with better-developed root systems and a more symbiotic relationship with soil organisms are more productive and more robust. Better root growth enables them to access the water available at lower depths in the soil and to take up more nutrients from the soil, making the plants better able to withstand pests, diseases and climatic stresses.

SCIENTIFIC EVALUATION

The first scientific evaluations of SRI in India began in 2000 at the Tamil Nadu Agricultural University (TNAU). Extensive on-farm comparison trials were conducted in the Thamirabarani river basin in 2004, with 100 farmers managing side-by-side rice plots, planted with SRI or using standard methods. SRI methods increased the average paddy yields by 28 per cent (7,227 vs. 5,657 tonnes/ha) while using 40–50 per cent less water and 80–90 per cent less seeds. Farmers' cost of production was 11 per cent less per hectare, with their labour requirements reduced by 8 per cent. (This contradicted the idea that SRI was more labour-demanding). The net income from the SRI crop was calculated as Rs 31,000 per ha, more than double the Rs 15,000 that was received from the rice crop that was conventionally managed.

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Among other things, TNAU researchers found that SRI-grown rice plants were more resistant to damage from wind and rain, during severe storms. In the *kharif* season 2006, researchers at the ANGRAU in neighboring Andhra Pradesh found that SRI plants could withstand colder temperatures than 'regular' rice plants. Despite temperatures remaining below 10°C continuously for five days during the season, SRI trial plots gave a paddy yield of 4.16 tonnes per ha. The cold snap, on the other hand, caused crop failure in the conventionally-managed plots, which produced just 0.21 tonnes per ha.

BROADER INDIAN EXPERIENCE WITH SRI METHODS

Since 2004, the practice of using the SRI method has been spreading to other states as well. In Tripura, the SRI method has been received well. It was first introduced in 2005–06 on 352 ha and was increased to 14,308 ha the next year, after the state government decided to promote new methods.

Last year, SRI use in Tripura reached 92,340 ha, approximately 36 per cent of the state's total rice area. The average paddy yields with the standard methods continue to be less than 2.5 tonnes per ha in Tripura whereas SRI yields have averaged almost twice as much, moving the state towards rice self-sufficiency. The additional income farmers got by using SRI methods (figuring a purchase price of Rs 10,000 per tonne) would have been at least Rs 3.3 crores in 2013–14, produced *with less cost and with less water.* The value of the additional rice produced with SRI methods in Tripura since 2006 has probably been over Rs 17 crores, giving both 'more crop per drop' and enhancing household income and food security as well.

SRI methods were introduced in Bihar in 2007 by the NGO PRADAN, working with 128 farmers on 30 ha in Gaya district. The SRI yield increase over the conventional methods that year was almost three-fold, and the use of the new methods began spreading rapidly, especially as Jeevika, the Bihar Rural Livelihood Promotion Society, began supporting SRI extension with World Bank (IDA) funding. By 2013, the area under SRI management, in full or in part, had expanded to 6,16,000 ha, cultivated by probably over two million farmers. Their yields with less water use (no more continuous flooding of paddy fields) have averaged over 4 tonnes per ha, compared with the usual yields about 2.5 tonnes per ha.

The additional income generated by SRI management in Bihar in 2013, with a lower cost of production and with less consumption of water, would be something over Rs 1,220 crores. A further consideration is that SRI crops have been more drought-resistant, an important factor for India. In 2010, a major drought year for Bihar farmers, crop cuttings were made from pairs of adjacent fields, where SRI methods were used on one, and the other continued with the standard practice. SRI yields averaged 3.22 tonnes per ha, more than the state's normal average of 2.4 tonnes. The yield for conventionally grown rice of the same variety was 1.66 tonnes per ha. These statistics help explain the growing acceptance of SRI methods by the farmers in Bihar.

CONTROVERSY OVER HIGH REPORTED YIELDS

SRI is perhaps best known in India for the controversy over certain 'super-yields' that have been reported, and welcomed in some circles while rejected in others. In the 2011 *kharif* season, Sumant Kumar, a farmer in Nalanda district, Bihar, had a yield of 22.4 tonnes per ha, measured by the standard methods used by the Bihar Agriculture Department personnel, with hundreds of observers watching.

TNAU researchers found that SRI-grown rice plants were more resistant to damage from wind and rain, during severe storms.

Subsequently, in 2013–14 in Tamil Nadu, a farmer in a village near Madurai achieved a yield of 23.4 tonnes per ha using SRI methods. This report however, hardly drew any notice.

Such high yields are outliers but they show the productivity that exists within our current rice varieties when the best conditions for plant growth and health are provided, enabling them to express their full potential. Such super-yields are not as important as the large differences in the average yield that are seen between SRI and conventional management, using less water. It is the averages rather than the outliers that feed the majority of the people and make farmers more prosperous. But we should be trying to understand how and why the outlying results are achieved so we can move the average in that direction.

IMPACTS AND BENEFITS

From the data supplied by Indian colleagues in different states, I have calculated that the average SRI yields across quite varying conditions in the country are about 5.6 tonnes per ha compared to 3.7 tonnes per ha produced through standard methods. The value of this increment, 1.9 tonnes per ha, will amount to, at common purchase prices, about Rs 3,230 crores for 2013, and is rising every year. This estimate does not take into account the lower cost of SRI production or the value of reduced water requirement, or the improvements being made in soil quality and soil health.

A study in four districts of Tamil Nadu found that SRI methods, even when not fully utilized, give farmers higher yields with lower costs of production, approximately 17 per cent lower expenditure per hectare. The economic return for farmers was thus increased by more than the gains in yield. The study also reported that SRI required 23 per cent to 39 per cent less water, and 92 per cent less seed.

A larger study across the 13 rice-growing states similarly reported higher yields with lower costs and more net income. Farmers, who followed all of the SRI recommendations, had 31 per cent higher yield on average whereas even the partial adoption of the method gave farmers more yield and higher earnings. Across all degrees of SRI adoption (high, middle or low), farmers' average cost per kilogramme of paddy produced reduced by 29 per cent because of their savings on seed, irrigation water, and the time required for weeding with mechanical hand weeders.

A meta-analysis conducted last year of the water savings, water productivity, and yield under SRI management looked at data from 251 comparison trials in 29 published evaluations across eight countries. It should be noted that 55 per cent of the trials were from the Indian research studies.

The analysis found that the total requirement of water for rice production, from both rainfall and irrigation, was 22 per cent less per ha with

SRI methods, and the amount of irrigation water required was 35 per cent less—all while reaping a higher yield!

Analysed in terms of the kilogrammes of rice produced per litre of water, the productivity of the total water applications (rainfall + irrigation) was 52 per cent higher, on an average, in SRI trials whereas in terms of irrigation water use, it was 78 per cent higher. These and other studies underscore that alternative management methods can produce 'more crop per drop' and give higher returns to land and to labour, to seed and capital.

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NEED FOR LINKING RESEARCH AND PRACTICE

A lot of research still remains to be conducted on these ideas and methods. Scientists at the ICAR and outside can be productively occupied in helping achieve the goals mapped out by the Prime Minister by working to understand and utilize better what SRI/SCI practices can achieve. There is already a fund of knowledge and experience in India that can move the agricultural sector very quickly toward these goals.

This knowledge and experience are, however, widely scattered and need to be assessed and consolidated through systematic efforts. Civil society, university, government and private sector actors, through the National Consortium for SRI (NCS), can advance both the knowledge and the practice of SRI. NCS can help to connect the pockets and reservoirs of expertise, much of it with farmers, to assist in a pooling of information. Such efforts could lead to both a fruitful research agenda and a plan of action for all parties to move more quickly towards achieving urgent progress in eco-friendly food production called for by the Prime Minister.

The references for this article are available on request from newsreach@pradan.net

Line-Sown Direct Seed Rice: A Climate Resilient Strategy for Food Security

ABDUL MANNAN CHOUDHURY AND ASHOK KUMAR

Introducing the line-sown DSR method of cultivation is proving to be viable and profitable because it is economical, labour friendly and assures a much greater yield to the farmers of EIP fighting against poverty, malnutrition and starvation

CONTEXT

The East India Plateau (EIP) comprises much of the state of Jharkhand and parts of adjoining West Bengal, Bihar and Orissa. EIP is characterized by high but variable rainfall (1,100–1,600 mm, 80 per cent of which is received from June to September), frequent and sometimes long dry spells within the monsoon, little irrigation, high run-off and soil erosion, infertile soil, terraced mono-cropped paddy lands and subsistence agriculture.

The area suffers low crop yield resulting in food-grain insecurity and endemic poverty. Rice is the staple food crop and the traditional cropping system is mono-crop, rain-fed rice production, which has high climate-related risk and is particularly vulnerable to subtle changes in rainfall distribution, associated with climate change. The pressure of the increasing population has pushed rice cultivation to the medium up-lands, but these lands are not suited for transplanted rice production systems. Cropping in the post-rain season *(rabi)* is limited due to the lack of irrigation resources and uncontrolled grazing by village cattle and goats. The main monsoon crop *(kharif)* is rice (overwhelmingly so for the poorer farmers) and usually very small areas are used for cultivating pulses, oilseeds and maize.

Most villagers achieve only 50–60 per cent of their food-grain requirement, forcing migration in the non-monsoon season to earn some off-farm income at the cost of social upheaval. The outcome of this is widespread malnutrition, limited medical care and low levels of literacy. Perhaps, not surprisingly, the region is a stronghold for left-wing extremist groups.

EIP is one of the poorest regions of India, with a high population of tribal farmers who do not have a long farming tradition. They practice mono-cropping and cultivate crops such as paddy, millet and pulses under rain-fed conditions. The average land-holding per family is less than one hectare and the people cultivate rice mostly in the low-lands and the medium low-lands in scattered plots, which bring down the average size of land-holding to only 0.3 ha per household. Because farming is done under variable rain-fed conditions, the average rice productivity in the region is only 1.96 tonnes per ha.

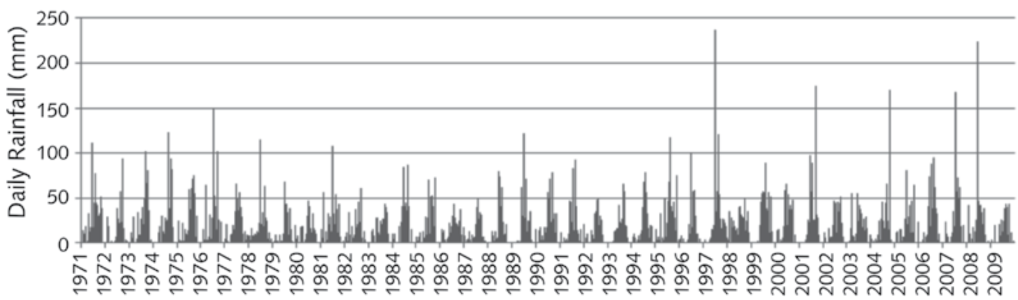
PREVALENT PRACTICES OF PADDY PRODUCTION

Broadcasting and transplantation of rice, mostly in the low-lands and medium low-lands, are very common practices across the EIP, including the Kolhan region of Jharkhand (Kolhan division is one of the five divisions in Jharkhand, comprising three districts, namely, Seraikela Kharsawan, East Singhbhum and West Singhbhum).

The average rainfall in the Kolhan region is about 1,400 mm; however, the pattern of rainfall over the last 40 years shows that rain in the monsoon periods (July to September) is very erratic and uncertain (Figure 1). Because of so much variability and uncertainty, farmers use the traditional broadcasted paddy because this method can withstand dry spells of 10–15 days and it results in some assured yield.

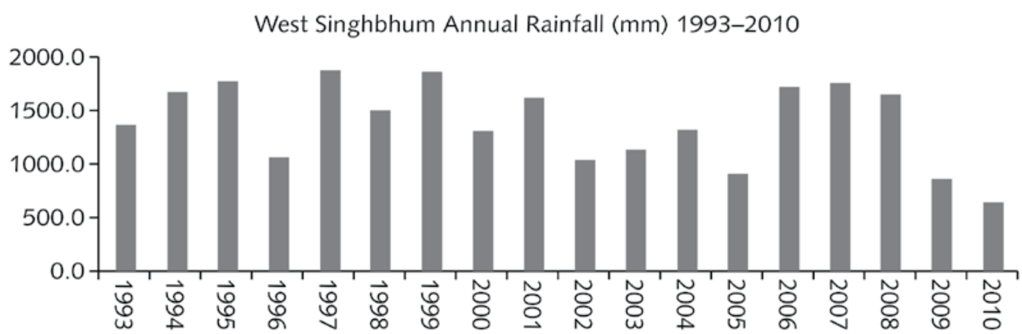
Farmers broadcast paddy seeds in their fields from the beginning of June to mid-July, after one or two showers of rain when the soil is moist enough to be ploughed.

Figure 1: Rainfall Pattern (1971–2009)



Source: Skymet and Indian Meteorological Department (IMD)

Figure 2: Rainfall Pattern (1993–2010)



Source: Skymet and Indian Meteorological Department (IMD)

The traditional broadcasting method of rice cultivation requires a high seed rate (seed rate @ 80–120 kg per ha) and is also very labour intensive. After 45–50 days of broadcasting when the field accumulates standing water, the farmers plough down the standing crop for the thinning and weeding operations (the process is traditionally called *karhan* in the Kolhan region). Half-an-acre of land requires 10–15 labour for weeding and thinning. The remaining weeds are pulled out by hand. These weeding and thinning practices, usually done by women, are very strenuous and involve prolonged working in muddy water, often leading to finger and toe infections.

Because the crop is planted randomly, there is no scope for using any kind of small tools or implements, and the operation of any kind of machine is almost impossible. And because household labour is also limited during this peak period, manual weeding operations become lengthy and delayed, which increases the weed competition and adversely affects the growth of the crop. Even after such an intense operation in the traditional broadcasted paddy, the end yield result is very low—less than one-sixth of the transplanted paddy.

However, because it does not require transplantation or waiting for enough rains to raise nurseries and the puddling of fields, this traditional system of paddy cultivation is much more resilient to the vagaries of the weather and assures the farmers at least some yield. The crop survives in the low or below average rainfall, especially during erratic rainfall, dry spells or poor monsoon.

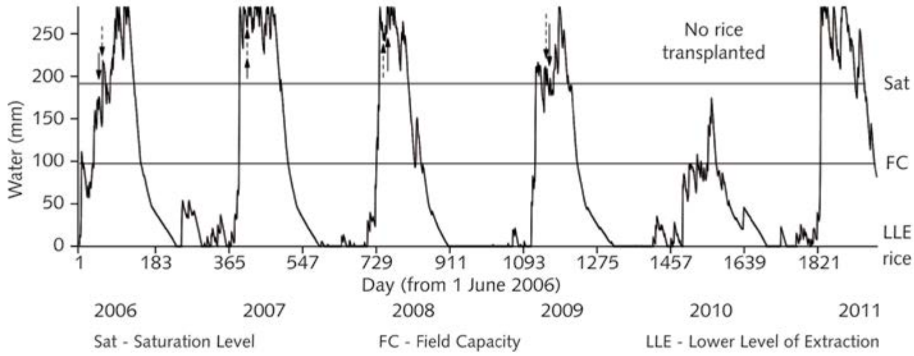
Farmers have adopted transplanted rice practices in some medium up-land and medium low-land areas that have access to irrigation. In traditional rice transplantation, rice is sprouted in a nursery and the sprouted seedlings are then transplanted in standing water; it is dependent, therefore, on assured standing water in the field for puddling (ploughing or harrowing of land with standing water). Seedlings need to be transplanted in time or else they become over-age. Often, however, due to limited irrigation facilities (less than 6–8 per cent of the area is under irrigation) and unpredictable rainfall, the process of transplantation gets delayed.

During the dry spell period, the soil becomes cracked, resulting in the drying-off of paddy in the fields. This is a common feature and is experienced at least every alternate year. The chances, thus, of the paddy crop failing in the transplanted conditions are high. Farmers transplant over-aged seedlings; usually three or four seedlings are used per hill; and the transplantation process stretches until the end of August although the seedlings were raised much earlier (in the beginning of July). Late sowing of long duration (140–150 days) varieties (for example, Swarna Mansuri) results in fewer tillers and small panicle development. The over-mature seedlings quickly go into the flowering stage and these become more pre-disposed to pest attacks. All these factors lead to a low yield.

The harvesting of the transplanted paddy starts by late November or December, by which time the farmers fail to tap the opportunity of using soil residual moisture for the second crop with partial irrigation. Most of the transplanted rice fields then remain fallow for the next six months and the farmers face economic losses and the loss of opportunity for better utilization of resources.

Clearly, in both the methods of rice cultivation, transplanting (which is inherently risky due to climatic variations) or traditional broadcasting (which is labour intensive as well as low yielding) are not very suitable for the farmers in Kolhan or the EIP region. An alternative approach is needed.

Figure 3: Rainfall and Duration of Ponding (2006–11)



RAINFALL AND SOIL MOISTURE

Understanding about soil moisture and rainfall is important because the moisture in the soil determines the planting of crops and their subsequent growth. Rainfall data (2006–11 collected by PRADAN in Purulia) and the corresponding soil moisture conditions in the medium up-lands during the period show that there is huge variation in the ponding duration in the medium up-lands. Ponding of water in the fields is essential to ensure transplantation and further growth of transplanted paddy.

Between 2006 and 2011, the ponding duration varied from 0–106 days (Figure 3). There was no water available for ponding and rice was not transplanted in the medium up-lands in 2010, which was a drought year. Farmers kept waiting for the puddling of soil, and the paddy crop failed, especially the transplanted crop in the medium up-lands.

A critical look at the data of these years reveals that although there was not adequate water for puddling, there was enough water every year for a non-flooded crop to grow. As seen in the Figure 3, there was enough soil moisture between the soil at field capacity (FC) and the saturation level (Sat) in all the years from 2006 to 2011, even in the so-called drought year, 2010. There were possibilities of growing crops that are not dependent on flooding, including the short duration rice of 100–120 days variety, under direct seeding, and vegetables in the medium up-lands.

DIRECT SEEDED RICE

Line-sown direct seeded rice (DSR) is an innovative and modified method (direct seeded broadcasting method) of paddy cultivation, in which sorted and treated seeds of short-to-medium duration are used. Seeds are hand sown in lines made with a ‘multi-teeth marker’ under dry land conditions at the end of June with a 10″ line-to-line spacing and 6–9″ spacing from seed to seed. This way of sowing rice requires urgent weeding and thinning after 15–20 days of sowing, followed by a second weeding at 25–30 days. Weeding can be done using the ‘wheel hoe’ in dry-land conditions and the ‘cono-weeder’ in wet-land conditions. In case of a delayed monsoon, the line-sown DSR crop gets established easily whereas transplanted rice often fails or yields poor results.

Line-sown DSR rice may have huge scope/advantage in the EIP region by adding value to the traditional method of broadcasting of paddy. It has the potential to produce more yield in transplanted rice (conventional), is at

DSR paddy field matures earlier than a transplanted paddy field. Early harvesting of the crop creates scope for the second crop, using the available residual moisture.

par with the SRI method of rice cultivation, and has many advantages over transplanted and traditional broadcasting methods of paddy cultivation. In DSR, the rice seed is sown and sprouted directly in the field, eliminating the laborious process of planting seedlings by hand and greatly reducing the crop's water requirements. It is resilient to the changes in the climate; with no dependency on the rains for puddling, it involves the least soil disturbance and there are minimal chances of the soil cracking during dry spells. Line-sown DSR can allow a rice crop to be established in seasons when transplanted rice often fails or yields poorly due to late sowing. The additional advantages include:

- Reduced labour requirement (no nursery phase, no puddling or no transplanting)
- No dependence on the onset of monsoon because sowing can be completed in partially dry soil after the pre-monsoon showers
- Effective and efficient weed management, using mechanical weeders, made possible and easy because of line sowing
- Earlier sowing and earlier harvest, creating opportunities for early sowing of a *rabi* crop, and accessing soil residual moisture with partial irrigation if required
- Less quantity of seeds (by 50 per cent) required as compared to broadcasted paddy
- Reduced drudgery for women because there is no nursery, no transplantation and no manual weeding

EXPERIENCE WITH DSR

The experimentation with DSR started in Purulia in 2007–08 under the Australian Centre for International Agricultural Research (ACIAR) project, wherein the attempts were to secure food production for families that only had up-lands, where the paddy crop failed often. In the beginning, we had mixed experiences. Timely weeding and planting are critical for the success of DSR. The average yields were around 4 tonnes per ha; however, ensuring timely weeding was a challenge. Manual weeding with spades or pulling out

Table 1: Yield Comparison in Kalpana Hasda Fields, Talaburu Village, West Singhbhum, 2012

Practices	Area (ha)	Variety	Date of Sowing/ Transplantation	Effective Tillers (Average Three Samples)	Grain Per Panicle	Date of Harvest	Crop Duration	Yield in Actual Area (Kg)	Yield/ Ha (Kg)	Second Crop
DSR	0.06	Abhishek	July 18, 2012	28	254	November 14, 2012	116	384	6,857	Chickpea
Transplanted paddy	0.14	Abhishek	July 30, 2012	DNA*	DNA*	November 18, 2012	133	624	4,333	Fallow
Broadcasted	0.22	Local	June 30, 2012	DNA*	DNA*	July 11, 2012	119	150	670	Fallow
SRI	0.15	Abhishek	DNA	DNA*	DNA*	DNA	DNA*	810	5,506	Fallow

**DNA- data not available*

Table 2: DSR in 2013–14

Participating Farmers	FY	Areas (ha)	Paddy Variety	Yield (kg/ha)*	Land Category	DOS**	DOH***	Rabi Crop
Babli Doraiburu	2013	0.044	Abhishek	5,964	Medium low-land	23 Jun	31 Oct	Tomato, chickpea
Kalpana Hasda	2013	0.051	Abhishek	6,426	Medium low-land	23 Jun	01 Nov	Chickpea
Gurbari Hasda	2013	0.031	Abhishek	5,568	Medium low-land	22 Jun	29 Oct	Green gram
Gita Kunkel	2013	0.114	Abhishek	5,228	Medium low-land	23 Jun	24 Oct	Chickpea
Pelong Kunkel	2013	0.049	Abhishek	5,254	Medium low-land	28 Jun	30 Oct	Chickpea
Sarswati Surin	2013	0.024	Abhishek	5,722	Medium low-land	8 Jul	21 Nov	Chickpea
Average				5,694				

** Converted from dried total field yield; **DOS: Date of Sowing; ***DOH: Date of Harvesting*

Table 3: Labour for Different Operations (in Person Days, PDs) Per Hectare

No.	Name of Farmer	Area (ha)	Practices	Sowing	Nursery management	Transplantation	Karhan	Thinning and Weeding	Total PDs**	Average
1	Kalpana Hasda	0.28	DSR	11.4	NA	NA	NA	15.2	26.5	61.9
2	Gurbari Hasda	0.32	DSR	9.8	NA	NA	NA	63.7	73.5	
3	Babli Doraiburu	0.19	DSR	21.5	NA	NA	NA	40.3	61.8	
4	Gita Kunkel	0.71	DSR	13.2	NA	NA	NA	78.9	92.1	
5	Pelong Kunkel	0.31	DSR	13.6	NA	NA	NA	27.2	40.8	
6	Sarswati Surin	0.15	DSR	31.3	NA	NA	NA	45.1	76.4	
7	Surin Hansda*	0.88	SRI	NA	12.2	95.2	NA	25.0	132.4	115.2
8	Kalpna Hansda*	0.88	SRI	NA	15.8	57.1	NA	25.0	97.9	
9	Colye Hansda*	0.50	Broadcasting	5.0	NA	NA	10	90.0	105.0	105
10	Babali Hansdas*	0.25	Broadcasting	5.0	NA	NA	10	90.0	105.0	

** Interactive data, 1 PD (Person Day) = 6 hours, ** Includes sowing/nursery management, transplantation, weeding, thinning only.*

by hand were cumbersome during the busy monsoon months. The attempt, therefore, was to find some affordable mechanical tools for efficient line planting and weeding.

PRADAN has been working in line-sown DSR in West Singhbhum and Bokaro districts of Jharkhand since 2012, with the support of scientists from the ACIAR, the Asian Vegetable Research and Development Centre (AVRDC) and the Advanced Centre for Water Resources Development and Management (ACWADAM).

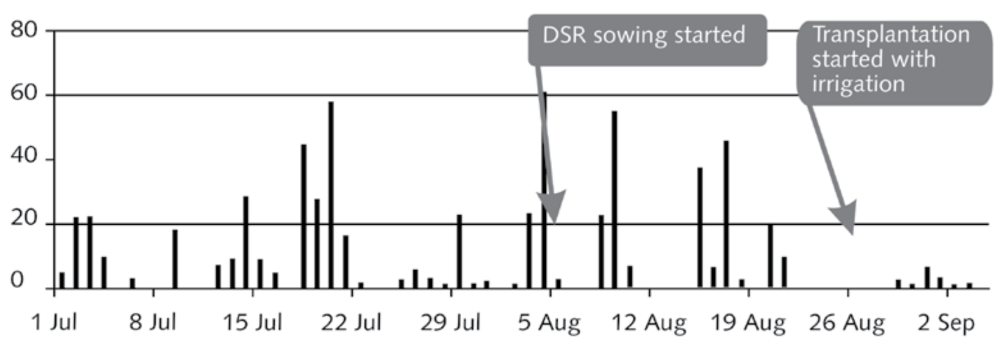
The promotion of line-sown DSR was initiated at the hamlet level with concept seeding in the SHGs, the main focus being on current issues and concerns about the traditional way of broadcasted as well as transplanted—puddled paddy—cultivation and the scope and potential for line-sown DSR in the region. SHG members have been encouraged to try line-sown DSR cultivation on an experimental basis in the beginning to observe the results—the pros and cons—so that in subsequent years, more families may take up the technology.

In 2012, only three famers—Babli Doraiburu, Kalpana Hasda and Guruwari Hasda—participated in line-sown DSR cultivation in their medium low-lands in Talaburu village, Tonto block, West Singhbhum. Babli, Kalpana and Guruwari harvested 5,166 kg, 6,695 kg and 7,813 kg per ha, respectively.

In an experiment, Kalpana cultivated paddy in four adjacent plots applying four different methods, namely, traditional broadcasting, transplanting, DSR and SRI. She used the local variety of 140 days duration in the broadcasting method; for the other three methods, she used the high-yielding Abhishek variety of 120–125 days duration. The yield comparison (as seen in Table 1) was quite significant with DSR showing at par results with SRI paddy. And because the crop was harvested early, the same field was utilized for a second crop.

In 2013, seven new farmers, besides the original three, tried the DSR method in an average area of 0.05 ha. The yield realized in 2013 was quite significant and very exciting for the farmers. The sowing and harvesting were completed by the end of June and October, respectively. Line-sown DSR performed at par even with the SRI crop in the neighbouring field. Due to the late transplantation of the SRI crop and other transplanted rice, harvesting was late and the farmers failed to take advantage of the residual soil moisture

Figure 4: Rainfall (in mm) and Field Operations in DSR and Transplanted Rice in West Singhbhum during *Kharif* 2014



for the second crop. In the line-sown DSR fields, however, they could cultivate a second crop. Yields from two neighbouring traditional broadcasting fields were recorded as 1,812 and 2,370 kg per ha, respectively, as compared to 5,228 and 6,426 kg per ha. The yield from the neighbouring SRI field was 7,123 kg (HYV Lalat, 120 days), which was 11 per cent more than line-sown DSR. Table 2 gives the details of the yield data for the FY 2013–14.

Another remarkable factor is the investment in labour use (Table 3), which was 36 per cent less in line-sown DSR as compared to traditional broadcasting and transplanted rice and even SRI rice (labour considered for this comparison includes sowing/transplantation, weeding and thinning only).

Figure 4 represents the rainfall and field operations in DSR and transplanted rice in *kharif* 2014. That DSR operations start one month earlier than transplantation operations, even before the farmers start raising the nurseries is clear. DSR, therefore, uses the soil moisture more efficiently than transplanted rice in medium low-lands.

UP-SCALING DSR

During the team's review meetings, it was evident that in spite of its intensive intervention in promoting SRI paddy, only 30–40 per cent of the farmers used SRI out of the total plan. The reason was the late and erratic monsoon. Because of the late monsoon, soil puddling does not occur and the seedlings become over-age, etc. Only 10–12 per cent of the farmers in Jharkhand have access to irrigation, used mainly for other crops and mostly for the *rabi* crops. Far better it is, therefore, to facilitate planning for the paddy cultivation after taking into consideration the weather history, rainfall pattern, farmers' interests and irrigation infrastructure in the paddy land.

During the livelihood planning meetings this year (2014), almost 40–50 per cent of the paddy area from the medium up-lands to low-lands have been under traditional broadcasting. Farmers started sowing very early in June or even earlier. Quite late, the team realized that it could have facilitated line-sowing for the community. Although the team planned for 2,000 families, only 729 farmers finally decided to use line-sown DSR. This was mainly due to the team's untimely planning. Farmers had sown seeds after the first showers, with little or no soil moisture. Paddy germinates even with very little or no soil moisture. This was a great learning for the team members, who realized that they had to move with the farmers' time-table so that a greater number of families could adopt the line-sown DSR technology.

SCALING-UP STRATEGY ADOPTED BY THE TEAM

1. Field exposure visits-cum-group discussions were organized among SRI and DSR farmers at the Cluster level.
2. Orientation was held for various stakeholders around this initiative, including the *panchayati raj* institution (PRI) representatives, the Agricultural Technology Management Agency (ATMA) staff, and the tool suppliers/vendors at the Cluster-level *melas* to reach more families.
3. Exposure visits-cum-interactions were held with DSR host farmers in the field from new areas.
4. Field-level guidance and support were sought from experienced farmers and expert service providers for SHG members in new areas.
5. Awareness was created through the introduction of IEC (Information, education and communication) material such as flex boards, leaflets, photographs

Table 4: Details of the Operational Procedure in DSR

Timeline	Major Activities	Remarks
Second to third week of May	• Ploughing of field begins after receiving one or two pre-monsoon showers	• Easy to plough • Ploughing reduces the clods • Reduces pests and diseases in the coming crops
Beginning of June	• Final field preparation with levelling	• Field preparation should match with farmers' traditional broadcasting calendar.
Beginning June to mid-July	• Major interventions: • Seed sorting and treatment • Marking line using 'litho-markers' • Seed sowing, and covering of seeds • Application of farmyard manure (FYM), *ghana jeevamrutha* at the rate of 75 kg for 30 decimals of land as basal, followed by the same dose during the first weeding and the second weeding, or chemical fertilizers at the rate of N=70, P=42 and K=30 kg per ha in the soil.	• Optimum time for sowing depends on receiving 10–15 mm rain • Soil should have 8–15% moisture for better germination, usually after receiving one pre-monsoon rain. • Beginning of June is good for sowing. • Seed rate—6 kg per hectare • Spacing row-to-row of 20–25 cm (9–10″) with continuous dropping, or drop two seeds at a distance of 6–9″ in the line
By 15–20 days after sowing	• Thinning and first weeding operations	• Manual thinning and mechanical weeding is done. • Thinning of seedling is done to maintain proper seed-to-seed spacing. Thinning is ensured manually, where the seed is dropped continuously.
July–August	• Second weeding mechanically in 1–2″ of standing water, application of nutrients (as recommended)	• Weeding with the 'cono-weeder'
Late August	• Application of nutrients as per recommendation	• Based on crop status/growth
October	• Harvesting of paddy	• For variety of 100–120 days duration
Mid to end-October	• Rabi crops (legumes, pulses and other short-duration vegetables)	• To utilize residual soil moisture

and videos, to create awareness.

6. Linkages were established with tool fabricators/suppliers, to ensure availability of implements.
7. Mobilization of resources and training of people were organized for SHGs, Clusters and Federations.
8. Focus was on SRI promotion in low-land areas where puddling is more predictable.

IMPLEMENTS ESSENTIAL FOR DSR

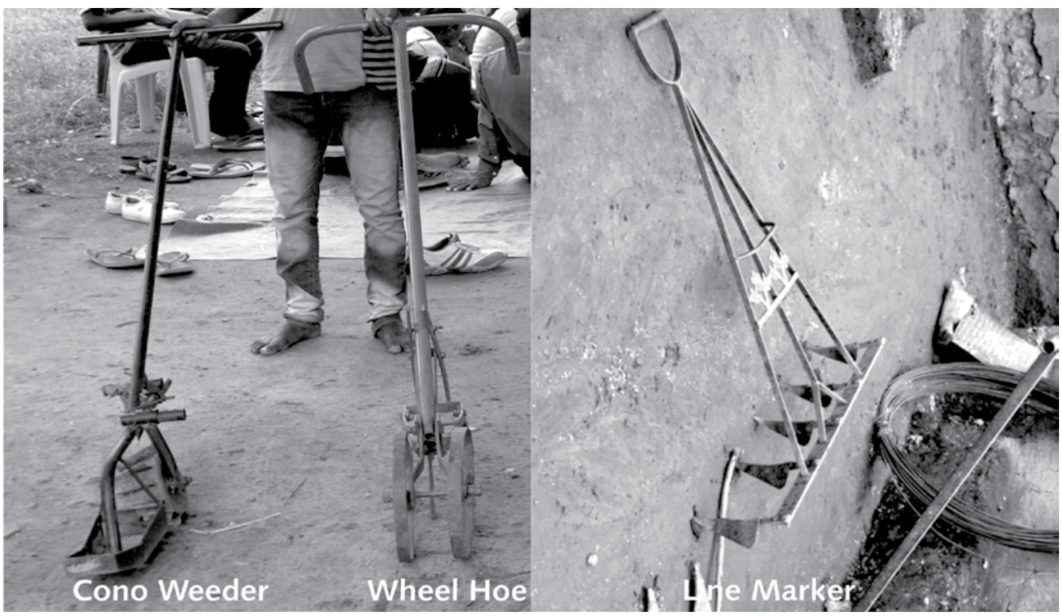
Line marker: This is used for row marking after the final field preparation and levelling, for sowing the seeds in line.

Wheel hoe: This is a three blade hoe, fitted with a wheel and shaft and is used for weeding and loosening the soil, 15–20 days after sowing in dry soil conditions, for young tender weeds. During this operation period, the thinning of seeding is also ensured. It is also used to maintain proper seed-to-seed spacing.

Cono weeder: This tool is used after 25–35 days of sowing in 1–2″ of standing water in the paddy field.

LEARNINGS

1. Early sowing and early harvesting help the family overcome the hunger period. The rice arrives at home in October when the reserves at home are near depletion and the new harvest from the transplanted fields is still two months away.
2. Farmers get an opportunity to sow second crops, for example, chickpea, mustard and vegetables, using the residual soil moisture and supplemental irrigation, if required. It leads to better resource utilization, additional crops and income.
3. The use of tools and implements save time, reduce drudgery for women, especially in transplantation and weeding. With the utilization of tools and implements, there is better task-sharing in the family because men and grown-up children like to work with implements.
4. Soil structure improves, leading to better water infiltration and root growth. Puddling practices destroy the soil structure. Soil particles are dispersed, and



when the soil dries, it becomes very hard. It makes ploughing very difficult. DSR practices do not require puddling; the soil, therefore, slowly regains it structure and becomes granular, beneficial for root growth and water infiltration.

CHALLENGES

The challenges with DSR are to ensure affordable quality implements for line-seeding and weeding tools at the community level. Without ensuring the availability of these implements, the success of DSR will be difficult because of the weed load and the need for removal of weeds in time. Another issue is the risk of a wet harvest because sometimes there are storms and significant rainfall in East India during October, which can affect the mature rice crop in the fields or on the threshing floor. Protection of harvested rice may be required in October. Birds and rats also cause damage to the plants, especially when only a few farmers adopt DSR. The few maturing fields in the whole area attract all the birds, rats and squirrels and this may require special measures to ward them off. Once the practice is adopted on a larger scale, the damage from birds and rodents will be reduced significantly. Getting good quality short and medium duration (90–120 days) varieties of seeds too might be a challenge in some of the areas.

If these challenges can be overcome, DSR cultivation will prove more effective because it is a more climate-resilient and predictable method of rice production than transplanted rice in the medium up-lands under rain-fed conditions. At the same time, it is more woman-friendly because the back-breaking tasks of carrying the seedlings, transplantation and pulling out of weeds by hand, mainly done by women, are eliminated. With the introduction of tools and implements, the tasks become easier and are shared by men.

We are very grateful to the women farmers of West Singhbhum, Ramgarh and Purulia districts, who took the risk of experimentation and contributed to our learning. We are also sincerely thankful and acknowledge the contributions of Prof. Peter Cornish from the UWS, who helped us to think through and work with the challenges of agriculture in EIP. We are beneficiaries of his wisdom. All the knowledge, evidence and data presented above are the outcome of the hard work of the whole research team of two ACIAR research projects and we are enormously thankful to them. We are also thankful for the support and guidance provided by the AVRDC and the ACWADAM.

Adoption and Dis-adoption of SRI: A Study of the Dynamics

BC BARAH, SHIPRA SINGH AND AMIT KUMAR

Quantifying the benefits and analysing the factors that encourage farmers to adopt or dis-adopt SRI methods in the four major rice-producing states in India, this study offers policy recommendations for up-scaling in order to attain agricultural sustainability

Rice is the most important staple food in India. The demand for rice has been growing every year and it is estimated that, to meet the projected demand by 2050, the yield of rice has to increase by more than three per cent every year between now and then. However, India's rice yield has improved by only one per cent since early 2000 (Directorate of Economics and Statistics, 2013).

The recent Food Security Bill passed in India, geared to provide cheap food to the poor, will increase the pressure on the country's capacity to produce more food on its own. Estimates show that the country will require five to six million metric tonnes of additional food grains annually, to meet the demands of the growing population and to fulfill the commitment of the Food Security Bill. It has been proven and accepted that sustained technological change is the primary driver of growth in food production.

Among the recent technological changes in agriculture, the System of Rice Intensification (SRI) has been recognized as the innovation capable of achieving the target of producing 'more with less'. SRI is an agro-ecological innovation, appropriate for small and marginal farmers. It has gained popularity and wider acceptance among farmers and other stakeholders due to increased production with fewer inputs, reduced costs, and resilience to the vagaries of the climate.

In order to understand the dynamics of the adoption process, carefully designed longitudinal farm surveys were conducted during 2011–12, and 2012–13 among 715 SRI farmers in selected districts in Bihar, Odisha, Chhattisgarh and Jharkhand. The farmers were selected using the stratified random sampling procedure, representing three distinct groups, that is, practising SRI farmers, including the new adopters (the adopters), farmers who discontinued the use of SRI (the dis-adopters) and farmers who had never practised SRI (non-SRI farmers as control).

The study attempts to quantify the benefits and analyses the factors that encourage farmers to adopt or dis-adopt SRI methods in four major rice producing states in India, and provide policy recommendations for up-scaling in order to attain agricultural sustainability.

The study was conducted with the specific objectives of:

- Examining the trends in the adoption of SRI, and studying the causes and effects of dis-adoption of SRI in rain-fed areas
- Evaluating and assessing the performance of SRI, as compared to conventional methods
- Examining the impact of SRI adoption on household food security
- Analysing farmers' perceptions about SRI methods and their preference for it, the drivers of up-scaling

METHODOLOGY

A longitudinal survey of on-farm practice was planned for three agricultural seasons in 2011–12, 2012–13 and 2013–14, to generate the panel data at the disaggregate village level. The panel data used both the cross-sectional and the time-series data. A multi-layer stratified random sampling design was used to select 705 farmers from rain-fed areas in the eastern Indian states.

The survey was conducted in six districts, covering four important rice-producing states of India—Gaya and Nalanda in Bihar, Sarguja and Raigarh in Chhattisgarh, Khunti in Jharkhand and Keonjhar in Odisha. A total of 88 villages were selected, based on the intensity of adoption of SRI. The villages were distributed in three distinct categories—high, medium and low, as Table 1 shows.

The socio-economic dynamics of the adoption and the dis-adoption processes was analysed, using a survey questionnaire. The factors determining adoption and those constraining it were identified primarily, based on the farmers' perceptions and experiences. The resource-use pattern was also analysed, using the survey information. The Garrett ranking technique was used to examine the importance of the factors behind the dis-adoption of SRI among farmers.

The states and the districts were selected on the basis of the predominance of small farmers in rain-fed areas and the low productivity of rice. The presence of promoting organizations such

Table 1: Percentage of Farmers in Various Categories (High, Medium and Low)

District	No. of Sample Farmers	High Intensity (More than 10% Adopters)	Medium Intensity (5–10% Adopters)	Low Intensity (Less than 5 % Adopters)
Gaya	109	86	0	0
Keonjhar	199	12	12	66
Khunti	104	18	28	41
Nalanda	104	11	28	47
Raigarh	93	34	25	41
Sarguja	97	12	36	42

as NGOs and the state agriculture universities (SAUs) was also taken into consideration. As mentioned, 88 villages were selected based on the intensity of adoption of SRI. Intensity is defined as the percentage of SRI farmers in a particular block of a district.

In order to give a fair representation, the farmers were classified into three groups, that is, old SRI farmers and new SRI farmers, SRI dis-adopters, and non-adopter farmers. A dis-adopter is a farmer who did not continue the practice of SRI voluntarily. If a farmer started the SRI operation in the season but failed to continue it due to socio-economic conditions, a family situation and or sudden climatic variation, it would be not be considered as willful dis-adoption. To identify the causal factors of the adoption as well as the dis-adoption of SRI, a small sample of farmers were also selected from villages that had no access to information about SRI and where no promoting agency was present.

ANALYSES AND INTERPRETATIONS

The participation of women in agriculture was found to be wide and extensive across the sample districts. Barring Sarguja, in all the other districts, more than 50 per cent of the SRI farmers were women. In Keonjhar, 32 male- and 171 female-headed households adopted SRI in their fields whereas, in Raigarh, the adopters were all women.

Across the districts, farmers allotted their holdings under SRI to varying extents. The total area under SRI differed from 88 acres in Gaya to a maximum of 224 acres in Sarguja. The farmers used SRI in their own land, leased land and also in share-cropping. The regions being predominantly rain-fed, most of the farmers used SRI in rain-fed lands, specifically in Keonjhar district, where 207 of the 260 acres of land under SRI were rain-fed. However, in Nalanda and Gaya, farmers used SRI largely in irrigated areas that is, in 94 and 57 acres, respectively.

CULTIVATED AREA UNDER SRI AND CMP (CONVENTIONAL METHOD OF PADDY CULTIVATION)

The average operational area using SRI methods across the districts was 0.72 acres, as compared to 1.29 acres of CMP. Raigarh district reported the lowest area under SRI, that is, 0.42 acres, whereas in Sarguja district, the average land size was 1.05 acres under SRI. The farmers of Sarguja district practised both cultivation practices on almost equal areas of land (1.06 acres).

As far as the SRI practice on the basis of adoption intensity is concerned (Table 2), the average land, in acres, under high adoption intensity, medium adoption intensity and low adoption intensity was 0.72, 0.53 and 0.57, respectively, indicating farmers' increased interest in the SRI method.

Table 2: Average Operational Area under SRI in Different Intensity Categories (Acres)

District	High	Medium	Low
Gaya	0.48	0	0
Keonjhar	0.76	0.50	0.73
Khunti	0.74	0.95	0.80
Nalanda	0.87	0.49	0.75
Raigarh	0.50	0.47	0.29
Sarguja	1.12	0.79	0.84

Table 3: Yield Advantage with SRI

District	Yield with CMP (Quintals/Acre)	Yield with SRI (Quintals/Acre)	Actual Difference	Yield Advantage of SRI in %
Gaya	11.92	23.14	11.22	94.00
Keonjhar	7.90	21.74	13.84	175.00
Khunti	9.16	15.39	6.23	68.00
Nalanda	15.25	24.86	9.61	63.00
Raigarh	15.09	20.56	5.47	36.00
Sarguja	8.65	27.44	18.79	217.00
Average	11.33	22.19	10.86	108.83

YIELD OF PADDY UNDER SRI AND CMP

The average yield under the SRI method was found to be 22.19 quintals per acre (5.55 tonnes/ha) compared to the 11.3 quintals (2.83 tonnes/ha) under the conventional method, a 109 per cent yield advantage over conventional methods. With the yield difference of about 11 quintals per acre under SRI, over the conventional methods of paddy cultivation, the yield of CMP varied from 7.9 quintals/acre in Keonjhar to 15.25 quintals/acre in Nalanda. It varied from 15.39 quintals/acre in Khunti to 27.44 quintals/acre in Sarguja for SRI.

Although Nalanda achieved the second highest yield, the farmers in Keonjhar achieved a higher yield advantage of 175 per cent over CMP. Such a yield advantage may indicate that where the yield is normally low under the conventional practice, the relative advantage of SRI is higher. This is seen in rain-fed districts such as Sarguja and Raigarh. This also shows the wide inter-regional variation in the rice yield.

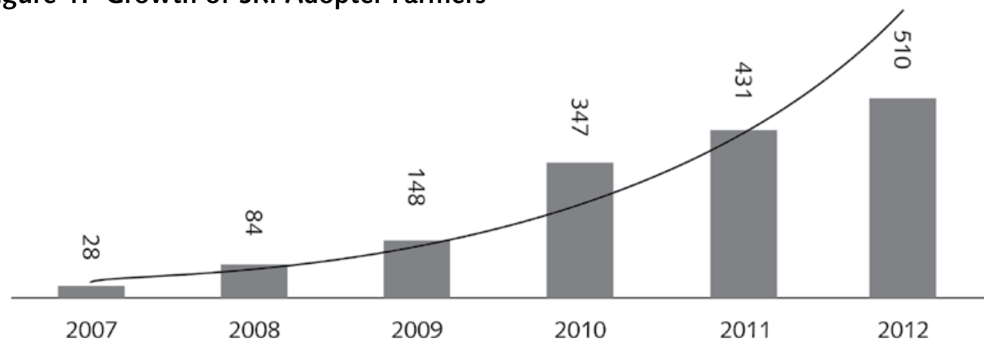
LABOUR COSTS FOR SRI AND CMP

SRI, it is said, is a labour-intensive method (Barrett, et al. 2004). However, some findings reveal that SRI helps save labour when the farmers gain expertise in the new technology. Usually, that stage comes after two to three years of experience.

According to the survey results, three out of the six districts, that is, Nalanda, Khunti and Raigarh, reported high labour usage for SRI compared to CMP whereas farmers in Gaya, Keonjhar and Sarguja reported labour saving for SRI. This could be attributed to the fact that the farmers, who had been practising SRI for two to three years or more, now needed less labour compared to those who were new adopters. However, in Nalanda, where more than 64 per cent of the farmers have been using SRI methods, had a high labour usage—108 labour days/acre compared to only 30 labour days/acre in Sarguja. One factor that could account for the higher labour usage in Nalanda is the availability of more irrigated area, requiring more labour days.

The average (aggregate) labour cost-saving across the six districts is negative, implying that there is no substantial saving in labour, but the average labour usage showed positive results (1.2 per cent). The picture changes when the inter-regional variation due to wage differences from place to place is considered.

Figure 1: Growth of SRI Adopter Farmers



When the district-wise cost of labour was analysed, it was found that Sarguja again accounted for the lowest cost relating to labour with Rs 2,398 and Rs 2,551 per acre for SRI and CMP, respectively. The highest cost for labour was observed in Nalanda and Raigarh, with a difference of Rs 3,900 per acre in SRI as compared to CMP. Farmers in Keonjhar reported the highest labour savings of 7.8 per cent, followed by Sarguja and Gaya. Thus, there is a mixed result of both the positive and the negative labour cost savings in Chhattisgarh and Bihar, which reflect regional characteristics. One of the reasons behind higher labour costs incurred in Nalanda and Raigarh can be attributed to the high wages (Rs 125 and Rs 120 per day, respectively) paid in the district.

It is important to keep in mind that the wages paid are the same in both the cultivation methods in all the districts, but because SRI is cultivated in smaller areas (for example, 10 decimals) as compared to CMP, the wages incurred in smaller plots are higher, due to the economies of scale. Furthermore, looking at the components of the labour costs in various inter-cultural operations, we find that harvesting and weeding incur the maximum costs in the SRI method and, therefore, improvements can be brought about in these inter-cultural operations.

INTENSITY OF SRI ADOPTION

The adoption of SRI techniques among the farmers in the selected districts over the last five years (2007–12) has increased from a mere 28 farmers in 2007 to more than 500 farmers at the end of 2012.

The growing interest in the SRI technique is a result of enhanced productivity. There is an average increase of 200 per cent in the yield using SRI methods in high and medium intensity villages and 170 per cent in low-intensity villages. Overall, this is ten quintals per acre more yield as compared to CMP.

Table 4: Outcomes from SRI (Yield and Labour Cost) in Different Intensity Classes

SRI Intensity	Average SRI Yield (Quintals/Acre)	Average CMP Yield (Quintals/Acre)	Difference in Yield (Quintals/Acre)
High	19.89	10.40	9.49
Medium	20.65	9.03	11.62
Low	17.85	10.50	7.35
Overall	19.77	10.18	9.59

Table 5: Factors Favouring SRI Adoption (Positive Experience as % of Respondent Farmers)

District	Respon-dent	More Yield (%)	Less Seed (%)	Less Water (%)	Less Labour (%)	Less Expense (%)	More Labour (%)	Easy Trans-planting (%)	Other (%)
Gaya	79	68	49	28	28	11	0	0	81
Keonjhar	161	89	46	5	60	57	0	12	16
Khunti	83	86	39	10	22	43	1	6	33
Nalanda	82	88	55	17	5	17	0	1	56
Raigarh	73	38	40	4	34	3	0	1	116
Sarguja	83	43	20	45	0	82	49	1	30

Table 6: Factors Determining Up-scaling to SRI

District	Respondent	More Yield (%)	Less Seed (%)	Less Expenses (%)	Less Labour (%)	Saves Time (%)	Saves Water (%)
Gaya	83	80	66	5	30	5	33
Keonjhar	158	96	58	68	74	1	7
Khunti	91	96	41	45	26	7	13
Nalanda	80	91	74	21	10	16	18
Raigarh	67	73	61	12	64	0	3
Sarguja	39	41	85	55	40	17	13

FARMER'S EXPERIENCES AND PERCEPTIONS ABOUT SRI ADOPTION AND UP-SCALING

Tables 4 and 5 show that the factors leading to farmers adopting SRI and up-scaling it are mainly the high yield and the lower requirement of seeds. Most farmers have a strong preference for SRI because they derive positive benefits from it. This is evident in Gaya, Keonjhar, Khunti and Nalanda, where a majority of the farmers considered the increase in yield as a major contributor for the adoption of and subsequent up-scaling to SRI. Interestingly, the economy of seed use was also a strong factor in the choice of SRI.

Farmers differed in their opinion of less labour usage and expenses incurred in SRI promotion—varying from 68 per cent farmers in Keonjhar thinking that SRI is labour-saving and, thus, a reason for up-scaling to only 10 per cent farmers in Nalanda holding the same view. Similarly, farmers had different views on the assumption that SRI is less expensive.

The principles of SRI emphasize the management of water through alternate wetting and drying (AWD) during (i) the vegetative growth period (VGP), and (ii) keeping a thin layer of water during reproductive growth periods (RGP) (Uphoff et al, 2008).

However, except in Sarguja and Gaya (45 per cent and 28 per cent of the farmers, respectively), the opinion about water saving in SRI as against CMP is mixed among the farmers. This could be attributed to the fact that most of the sample farmers cultivate paddy under rain-fed conditions, where they do not have the experience of water control and have not considered the cost of irrigating their fields.

MOTIVATIONAL DRIVERS FOR UP-SCALING SRI

When the farmers were asked about their opinion about their drivers for up-scaling, other than agronomic practices, the results were interesting. Answers to open-ended questions revealed that about 45 per cent of the farmers in Gaya and Nalanda believed that advertisement and publicity about SRI was a prominent factor in their adoption and up-scaling of SRI. The most effective method of promotion, according to them, was the establishment of awareness camps and regular meetings regarding SRI. This is the most common opinion all across the sample locations except in Nalanda, where the farmers said that visiting successful SRI villages and farmers' fields was more encouraging than advertisements.

However, in Khunti and Raigarh districts, the farmers reported that less investment and more production in SRI was one of the factors that influenced their decision to up-scale further. We can, therefore, infer that efficient extension services continue to play an important role in the adoption of SRI, not only in existing but also in new areas as well. Thus, this could be a useful recommendation for the state to keep in mind when creating policies for the promotion of SRI among farmers and other stakeholders.

FOOD AVAILABILITY AND FOOD SECURITY

Rice is an important staple; therefore, the increased production of grain under SRI will have a positive impact on food availability and a family's food security. Up to 43 per cent of the farmers reportedly produced food that was adequate for nine to twelve months. Approximately 21 per cent of the farmers

Table 7: Percentage of Farmers Achieving Additional Food Availability Due to SRI

Districts	1 to 4 Months	5 to 8 Months	9 to 12 Months
Gaya	22	23	53
Keonjhar	26	24	45
Khunti	12	21	31
Nalanda	11	16	51
Raigarh	33	40	22
Sarguja	0	2	58

reported an additional food availability of one to four months and another 21 per cent reported six to eight months of additional food availability after adopting SRI techniques. A similar picture emerged at the district-level disaggregate analysis (Table 6).

District-wise findings of the survey indicated that 11 to 33 per cent of the farmers reported that they had at least one to four months of additional food for their family because of SRI. In Nalanda, Gaya and Sarguja, more than 50 per cent of the farmers reported additional home-grown food for nine to twelve months for the family, which is evidence in support of SRI. Furthermore, another 16–40 per cent of the farmers in all the districts, except Sarguja, reported five to eight months of additional food, after adopting SRI.

GENDER PERSPECTIVE AND LABOUR-USE PATTERN IN INTER-CULTURAL OPERATIONS

In rural India, women who depend on agriculture for their livelihoods is as high as 84 per cent. Women make up about 33 per cent of the cultivators and about 47 per cent of the agricultural labour. These statistics do not account for work in livestock, fisheries and various other ancillary forms of food production in the country. According to the Food and Agriculture Organisation (FAO), in 2009, nearly 94 per cent of the female agricultural labour force in crop cultivation was involved in cereal production whereas 1.4 per cent worked in vegetable production, and 3.72 per cent were engaged in producing fruits, nuts, spices and beverages.

Considering the importance of the role of women in agriculture, the implications of SRI methods from a gender perspective were evaluated. Varying from a low of two per cent in Sarguja to as high as 100 per cent cases in Raigarh, more and more women are adopting the practice of SRI in their fields. Overall, more than 50 per cent of the women are practising SRI in sample districts except in Sarguja, where the percentage was significantly lower.

The labour-intensive operations in rice cultivation are transplanting, weeding and harvesting. The women's involvement in these three inter-cultural operations is generally higher than that of men. Women work in their own fields and as hired labour in other fields to earn wages.

As seen in Tables 8 and 9, the total labour use in all the three operations is less and saves a significant amount of labour for women when they adopt SRI.

Table 8: Average Family Labour Usage by Gender for SRI and the Conventional Method (in Labour Days)

Average Family Labour Use	Transplanting		Weeding		Harvesting	
	Male	Female	Male	Female	Male	Female
SRI family	10	15	7	10	8	10
CMP family	13	17	11	13	10	12

Table 9: Average Hired Labour Usage in SRI and the Conventional Method (in Labour Days)

Average Hired Labour Use	Transplanting		Weeding		Harvesting	
	Male	Female	Male	Female	Male	Female
SRI family	2	8	2	4	1	4
CMP family	3	10	1	8	1	7

Analysing the data on the average hired labour use in the SRI method and comparing it with the conventional methods in six districts, we find that the hired labour use in SRI is quite low (almost four times lower) for both male and female labour. The female labour used in transplanting, weeding and harvesting in SRI for each acre of land is seven, four, and four, respectively, compared to 14, 10, and 10 in the conventional method.

Looking at both the hired and family labour use in SRI, we find an interesting pattern of labour mobility for females. The female hired labour use is greater than the female family members involved in the fields, in both transplanting and harvesting, but lower in the case of weeding whereas the male hired labour use is lower than male family labour in most operations. This shows the female labour mobility within agricultural operations and illustrates a paradigm shift from conventional methods due to SRI. It can be inferred that the women, who worked as family labourers in their own fields, now work as hired labourers to apply SRI methods in others' fields and were transplanting and harvesting to receive an extra income. It, perhaps, indicates that women labourers acquired SRI skills faster and are being able to reap the advantages.

Furthermore, because there is an increased yield from SRI methods, it would require more hired labour to harvest the produce from the field and, therefore, more women are needed to do the job. However, female hired labour is less than family labour in the case of weeding, which can be attributed to the fact that weeding is done with the help of cono-weeders, mostly operated by men.

Overall, this shows a shift in the traditional work divisions wherein, earlier, women dominated the weeding practices but are now moving towards transplanting and harvesting by which they earn more income.

UNDERSTANDING THE DIS-ADOPTION OF SRI

According to Roger's theory on diffusion of innovations, an innovation will experience an increased rate of diffusion if the potential adopters perceive that the innovation:

- is being tried on a limited basis before its adoption
- offers observable or tangible results
- has an advantage, relative to other innovations (or the status quo)
- is not overly complex and
- is simple and compatible with the existing practices and values

SRI, as a technological innovation, can therefore, be considered a success because it fulfils all the five criteria listed above. Most of the farmers have tried the SRI techniques, albeit in a limited area, to begin with. This new method of rice cultivation does have observable results such as an increased yield advantage and input savings. It has various advantages and is not overly complex and is compatible with the existing cultivation practices.

The survey results show that farmers' acceptance and adoption of the SRI method has increased quite significantly over the last few years. For instance, in Keonjhar, the adoption spread from 14 farmers in 2007, to more than 120 farmers by 2011. In other districts also, the adoption increased from less than five farmers in 2007 to more than 50 farmers by the end of 2011. The reasons for adoption are analysed, based on the farmers' field information and the farmers' perceptions.

The survey results show that farmers' acceptance and adoption of the SRI method has increased quite significantly over the last few years.

However, there are farmers who have dis-adopted SRI and it becomes imperative to understand the pattern of dis-adoption of the SRI over the last five years and analyse the reasons for the abandonment of this new technology.

The percentage of dis-adoption varies across the districts. Figure 2 shows that Keonjhar (a highly vulnerable and disaster-prone district) and Khunti (a resource-poor district, adhering to the traditional production system) show high dis-adoption whereas the lowest dis-adoption was observed in Surguja.

Figure 2: Average Percentage of Dis-adoption in Districts during Various Years

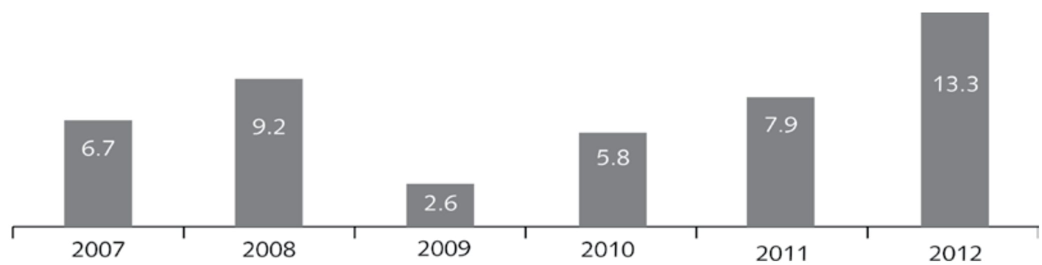


Figure 3: Average Percentage of Dis-adoption in Various Districts during 2007–12

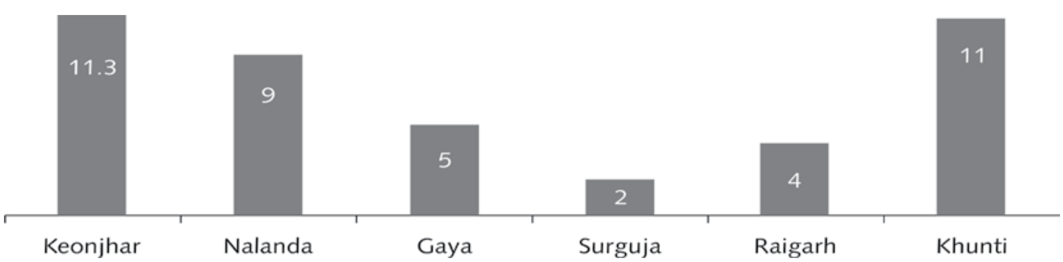


Table 10: Garrett Ranking of Most Prominent Factors of Dis-adoption of SRI

Average Family Labour Use	Failed Rain	Unavailability of Major Inputs	Issues of Labour Usage	Irrigation Problem	Credit Problem	Personal Health Problem	Lack Of Knowledge of Various Operations
Keonjhar	99	96	81	99	88	97	81
Nalanda	99	96	94	-	-	90	-
Gaya	99	99	96	92	85	92	-
Sarguja	-	99	-	95	-	88	97
Raigarh	99	90	94	83	-	-	97
Khunti	-	97	94	99	-	-	85

The Garrett ranking technique is a method to rank the constraints, based on the magnitude of the problems experienced by the respondents. This technique was used to find major problems farmers face, which compelled them to discontinue with SRI methods. Erratic and deficient rainfall (farmers termed it as failed rain); scarcity of skilled labour; lack of timely availability of inputs such as seeds, irrigation, and credit; lack of knowledge; and personal health problems were some of the reasons that compelled farmers to discontinue rice cultivation with SRI methods. Khunti and Keonjhar districts experienced the highest percentage (11 per cent) of dis-adoption, mainly because of the intermittent water supply and the failure of rains during the growing season in the region (with the highest Garrett Score—GS—of 99), which shows the criticality of water management in SRI.

Across all the districts, the failure of rainfall, in terms of the amount and its timeliness, was the major cause for dis-adoption. This was followed by lack of inputs and labour usage-related issues. The farmers also dis-adopted SRI because of personal health problems or sudden family problems. Farmers from four out of the six districts quoted this as a problem. Among other districts, the second highest percentage (ranked 80–96 per cent) of the farmers in Nalanda reported labour scarcity to be the most important problem because of which they were unable to continue SRI in their fields. The problem of irrigation and the lack of inputs also figured as important constraints and were the cause for dis-adoption of SRI in Nalanda. The lack of credit (with GS of 85 and 88) was another problem faced by farmers in Gaya and Keonjhar, which caused them to drop SRI methods in their fields. SRI involves the six steps in cultivation to be strictly followed, in order to get the desired results; lack of proper knowledge of these steps becomes a problem for the farmers leading to dis-adoption.

Clearly, proper training, hand-holding and capacity building are needed so that the farmers stay on course with SRI. Although farmers may know the importance of regular weeding in the SRI method, the unavailability of cono-weeders and the required extension services become major constraints in continuing with this new method in their fields.

Therefore, analysis of the data shows that whereas the adoption of SRI is overwhelming, there is also dis-adoption to some extent. Such dis-adoption may be termed involuntary dis-adoption, which implies that given the appropriate policy protection, SRI practice will be a boon for poor and small farmers.

The district-wise adoption pattern of SRI among farmers clearly outlines that there has been a steady increase in the adoption of SRI methods among the farmers

POLICY IMPLICATIONS AND CONCLUSION

The elaborate farm survey clearly provides the required empirical evidence on a few important policy parameters. The identification of factors such as yield advantage and labour usage strengthen the hypothesis that SRI methods, as an agro-ecological innovation, provide an opportunity of enabling farmers to produce more with less. Farmers with two or more years of experience of practice of SRI and who have acquired the skill were able to gain more input savings than novice SRI farmers in newer areas. An average yield advantage of 108 per cent in SRI over conventional methods portrays a precise picture of the huge potential of this new method of cultivation in rain-fed agriculture. The disaggregate analysis labour-use pattern provides evidence that the doubt on excessive labour use in SRI cannot be generalized. The negative perception of some new farmers on labour saving and reduced labour costs and other savings can be a question for further investigation. However, overall labour costs and savings under the different intensity levels give us enough evidence that the practice is amenable to small farmers. In fact, districts with high intensity of SRI adoption, representing intensity of promotion, show more promising results on their performance. District-wise wage differentials could be one of the reasons for higher cost of labour usage.

The district-wise adoption pattern of SRI among farmers clearly outlines that there has been a steady increase in the adoption of SRI methods among the farmers. The motivational and advocacy drivers behind up-scaling to SRI suggests that the sustainability of this new technology will depend not only on its productivity enhancing agronomic characteristics but also on extension services such as advertisements, awareness camps and field visits by farmers.

As mentioned earlier, SRI has the potential to contribute to family food security. It is satisfying that small farmers are able to capture the opportunity to improve their food security. Most respondents have unanimously expressed that the SRI method provides additional availability of food (rice) for the entire year, which has changed the household food security scenario. The results show additional food availability for more than eight months for at least 40 per cent of the sampled families.

The analysis also shows that SRI imparts positive implications on the nature of women's employment, as seen in the shifting of traditional woman-dominated operations such as transplanting, weeding and harvesting. This shift has reduced their workload in labour – intensive agricultural operations. Weeding and transplanting have been seen as a woman's job from time immemorial. These are not only labour-intensive but also involve long working hours. The survey results show that SRI has changed the nature of the work of women farm workers, reduced women's labour and can, in the future, result in women's mobility to hired jobs in the non-farm sector, thereby enhancing family income. A clear transition is observed from the traditional drudgery of weeding, transplanting and harvesting.

The dis-adoption pattern of SRI among farmers reveals a complex phenomenon. Several factors are responsible for the discontinuation of SRI, albeit in smaller quantum, among which the failure of rain, the unavailability of inputs and issues in the irrigation management are the most prominent. Whereas SRI has been acceptable to a large number of farmers, as depicted by the increasing adoption of the new method, the percentage of those who failed to continue due to various unavoidable reasons is a small proportion, ranging from an average dis-adoption of 6 per cent in 2007 to an increased level of 13 per cent in 2012.

The factors leading to dis-adoption of SRI include prominently failed rains during the critical crop season, irrigation and other input supply problems, etc. The failure of rains being an uncontrollable factor, the farmers can do very little, except to mitigate its impact by adopting methods such as SRI, which enable them to grow rice with less water. Farmers have realized that SRI is a climate-resilient practice; the process, however, requires that the soil be kept moist during the critical stages of growth. In extreme situations of consecutive drought, farmers intend to effectively manage water requirement in their fields. Because the soil cannot be kept moist, they are compelled to discontinue the crop. Therefore, farmers voted this as an overwhelming constraint and it reflected the highest Garret score of 99 per cent.

Farmers also identified other factors such as the unavailability of major inputs, issues of labour usage, irrigation problems, credit problems, personal health problems, lack of knowledge of various operations, etc., for dis-adoption. These factors may be termed desperate involuntary dis-adoption. The extension services using IT for a better understanding and implementation of SRI methods among farmers can solve these problems to some extent.

Soil Biology and Ecological Farming

OM RUPELA

Emerging as an effective alternative to the agro-chemical-based modern or conventional agriculture, the detrimental impact of which is evident both on human health and the environment, ecological farming, based on sound scientific principles, has yielded rich harvests while maintaining the micro-nutrients, microorganisms and macro-fauna of the soil—the Source of Infinite Life (SOIL)

India's growing population needs a proportional increase in food production. Much of the land is already under agriculture and, therefore, the required increase in production has to primarily come from increased productivity (yield per unit of land) and reduced pest damage. For at least five decades, India's agricultural research and education has focussed on agro-chemicals—Green Revolution (GR) technologies, and the development of genetically modified (GM), or transgenic crops. This has, in turn, influenced the agricultural research for development (AR4D) paradigm and the resultant policies.

In the initial years, GR-based agriculture led to a substantial increase in productivity and helped India overcome the low-yield phase. It led the country to being food secure. Over the past decade or so, however, the increase in productivity has essentially been stagnant. In addition, the use of GR technologies over 30 years has caused concern about the impact of agro-chemicals on human health and on the environment.

If in the 1970s, India was importing food grains, today it is importing much of the fertilizers (about 60 per cent of the nitrogenous, 80 per cent of the phosphatic and 100 per cent of the potassic fertilizers) needed for producing this food grain. Contrary to the impression being created, India is not yet a food secure nation.

In the past 20 years or so, organic or ecological farming has emerged as an effective alternative to the agro-chemical-based modern or conventional agriculture. Ecological farming is based on sound scientific principles. Several farmers, using good agricultural practices (without agro-chemicals), have claimed harvesting yields comparable to those of neighbouring farmers, who use agro-chemicals. Several review papers and publications including some from the UN-FAO, have reported results in favour of this type of farming.

This article discusses the plausible explanations on how such farms (without agro-chemicals) may have yields comparable to farms where agro-chemicals are used by enhancing soil fertility and plant nutrition.

SOIL—A STOREHOUSE OF PLANT NUTRIENTS

A crop needs several organic elements such as vitamins and growth hormones and inorganic (or atomic) elements, and these constitute its cells (constitutive) or participate in its metabolism (non-constitutive). Four of the vital constitutive elements are carbon (C), oxygen (O), hydrogen (H) and nitrogen (N). Thirty elements may come from the soil and they form only two to eight per cent of the body dry mass of a plant. Most of these names can be found in books on soil science and plant nutrition. Claude Bourguignon has listed 12 of these as vital or essential elements for plant growth. If the concentration of these in the soil is below a threshold limit (as studied and reported by several research publications), their deficiency in the soil shows up readily through characteristic symptoms on different parts of the plant. Two of the 12 elements, potassium (K) and chlorine (Cl), are non-constitutive. The other 10 elements are constitutive—phosphorus (P), boron (B), calcium (Ca), magnesium (Mg), sulphur (S), iron (Fe), manganese (Mn), molybdenum (Mo), copper (Cu) and zinc (Zn). Eighteen other elements, also called the secondary micro-nutrients or trace elements, are required in very small quantities.

The function of some of these is not fully understood. Four of the 18—lithium (Li), sodium (Na), rubidium (Rb) and cesium (Cs) are non-constitutive. The other 14 are constitutive. These are fluorine, (F), silicon (Si), selenium (Se), cobalt (Co), iodine (I), strontium (Sr), barium (Ba), aluminium (Al), vanadium (V), tin (Sn), nickel (Ni), chromium (Cr), beryllium (Be) and bromine (Br). Significantly, only three of the over 30 elements—nitrogen (N), phosphorus (P), and potassium (K), widely known as major elements, are readily available in the market and are proactively promoted by the AR4D system globally.

An important fact that is overlooked, even by a large number of agricultural scientists, but which is essential to understand, is that the major part (92 to 98 per cent) of the body mass (dry and not wet mass) of a plant is made of carbon, nitrogen, oxygen and hydrogen. All the four are gases. One can confirm this from the fact that when the bio-mass of any plant is burnt, we get only two to eight per cent of the original weight of the burnt bio-mass as 'ash'. The rest goes into the air because they were gases. When we burn rice or wheat straw, we generally get about two per cent of the original mass as 'ash' whereas it is about eight per cent in the case of woody plant parts, for example, stems of pigeon pea plants. These four elements also occur in other forms in the soil. Carbon molecules can also reach the plant through the breakdown products of proteins and amino acids through the carbon skeleton. Nitrogen exists in several forms in the soil—ammonium ions, nitrates, amines, etc.—and can be taken up by plant roots. Hydrogen and oxygen are part of a water molecule. A plant assembles these elements during the photosynthetic process while growing under favourable conditions.

Micro-nutrients also include some plant growth factors such as vitamins and enzymes, which are organic compounds and are required in tiny amounts as nutrients. These are present in soils due to micro-organisms and macro-fauna (such as earthworms), resident in soils and are either excretory products of these living beings due to their normal life-cycle in soils, or are available after their death. Most of these growth factors are also available on the surfaces of roots, where populations of micro-organisms are abundant.

All the 30 mineral elements described above are available in most of the soils where crops are grown and in the plant bio-mass (leaves, branches, flowers, fruits) of every plant, but their composition/proportions differ between soil types, fields and from one plant part to another. Each of the 30 mineral elements exist in at least two forms—available, or water soluble, form and non-available, or bound, form. Much of the concentration of each of these nutrients in the soil and in the plant bio-mass is in the non-available form and only a small fraction (usually one to eight per cent of the total concentration) is present in the available form.

Micro-organisms and macro-fauna, resident in agricultural fields, keep converting the non-available form of nutrients to available forms, as part of their daily life, provided the conditions are favourable for their survival and functioning. This activity happens continuously throughout the day and night. Successful farmers (organic farmers producing yields comparable to chemical farms) practice a set of good agricultural practices (GAP) to create such conditions. These include on-farm production and the use of plant bio-mass as a source of crop nutrients, the maximum possible plant bio-diversity on the farm, integration of trees and animals on fields growing annual crops, recycling of crop residues, and soil and water conservation in a scientific manner.

SOIL: A SOURCE OF INFINITE LIFE

Soil is a source (S) of (O) infinite (I) life (L). It houses and supports several different forms of life, starting from photo-synthesizers (plants and their roots — 'First Trophic Level' — the primary food formers in the soil) to animals (predators and burrowers — 'Fifth and Higher Trophic Level'). In-between are the mutualistic de-composers and the root feeders (bacteria, fungi, nematodes — 'Second Trophic Level'), shredders and graders (protozoa, arthropods — 'Third Trophic Level'), and predatory nematodes and arthropods — 'Fourth Trophic Level'. All these different forms of life in the soil are intricately woven as a food-web and make it 'Living'. One cup of undisturbed native soil may contain up to 200 billion bacteria, 20 million protozoa, 100,000 m of fungi, 100,000 nematodes and 50,000 arthropods.

All these life forms need a lot of food and, as indicated above, plants are the basic food material for them. But soils of most agricultural farms today are heavily degraded biologically and lack life, and, therefore, lack the capacity to produce high yields without agro-chemicals.

To grow plants without fertilizers and harvest a high yield, one needs to recycle all crop residues or their converted form after their economic use, back to the soil. For example, if one has grown sorghum—the grains are usually for human consumption and the stalks for cattle. The changed form of stalks (that is, cattle dung) should be applied to farms. If cattle dung is needed for cooking food, however, its changed form, ash, should be evenly applied to the fields.

In addition, one needs to grow fast-growing trees as a source of bio-mass (food for the living beings in the soil) and fruit trees (as a source of both human and soil nutrition) on field boundaries and/or farm boundaries. All these form a local natural resource for a high yield without fertilizers. It is important to note that one does not need a large tonnage of cattle-dung (a myth among many farmers and even scientists) for a high yield without fertilizers. Cattle-dung is needed in small quantities as a source of agriculturally beneficial micro-organisms, in the same way as we need only one spoon of old but good quality curd to prepare curd out of 10 or even 100 litres of milk.

Cow-dung has been reported to contain five of the total six functional groups of agriculturally beneficial micro-organisms. These are nitrogen fixing micro-organisms, phosphate solubilizing micro-organisms, plant-growth promoting micro-organisms, cellulose degrading micro-organisms and antagonists of disease causing micro-organisms. The sixth functional group —entomo-pathogenic micro-organisms (those with the ability to kill insects)—may also be present in cow-dung, and are known to be present in soils of most agricultural fields (for example, the bacterium Bacillus thuringiensis). Because fresh cow-dung is an important ingredient in many liquid types of manure, all these agriculturally beneficial micro-organisms are present in these manure and in larger numbers than in cow-dung itself. Eventually, these become a part of the soil in large numbers and are not needed from market sources.

There are many recipes for liquid manures used by organic farmers in which fresh cow-dung is recommended to be used as inoculum for their preparation, for example, *Amrit Jal* or *Jeev Amrit* and *Gur-Jal Amrit*. The quantity of dung needed to prepare 100 litres of manure is only 10 kg and is enough for use in an area of one acre. The frequency of application may be three to four times in a crop cycle of about 120 days. One can thus manage to produce enough fertilizer for up to ten acres of land with just one cow. Like cow-dung, compost should also be viewed as a source of agriculturally beneficial micro-organisms and not as a source of N, P, K, and be evaluated accordingly.

Unfortunately, the agriculture education system has not internalized this knowledge of soil biology and the experience of ecological farming; therefore, it still calculates the nitrogen needs of a crop per hectare (if through compost) by measuring the N concentration in compost.

Chemical fertilizers, when applied to soils, negatively affect the population and the functions of the agriculturally beneficial micro-organisms. For example, the effectiveness of 'rhizobia'—known to convert inert nitrogen in the air to the plant utilizable form of nitrogen (called nitrogen fixation) is adversely affected by the use of nitrogenous fertilizers. The same is true with the use of synthetic pesticides and herbicides. Several publications report that fertilizers such as nitrogen and micro-nutrient mixtures can be applied by spraying these on plant surfaces to be absorbed by plants, perhaps through the stomata on the leaves. If applied through sprays, one would perhaps need one-fifth of the levels of fertilizers recommended for soil application. It is unfortunate that this mode of meeting plant nutrient needs is not researched sufficiently and wherever known, for example, as in the case of nitrogen, it is not promoted pro-actively, either by the industry or agricultural institutions or universities and extension agencies.

The plant root system may not differentiate whether a mineral element in the soil (for example, nitrogen) is from a bag of fertilizer or from the degradation of plant bio-mass. Cow-dung and compost are merely changed forms of plant bio-mass.

It is not only the soil of a farm but also all the plants (including weeds) growing on a farm that may have all the 30 mineral elements. Weeds are a menace but have some positive aspects as well. Some weeds are known to be rich in a particular mineral element. For example, Bathua, or Chenopodium album, has been reported to be rich in iron.

Some weeds may be rich in some other mineral elements. Up to 1.8 tonnes of dry weed bio-mass per ha has been measured in rain-fed areas in a long-term study by the International Crops Research Institute of the Semi-Arid Tropics (ICRISAT). Weeds are thus a potential source of several mineral elements needed for plant growth. Other noted uses of weeds are (a) enriching plant bio-diversity on a farm, and (b) serving as habitat for agriculturally beneficial insects and, thus, helping manage insect-pests on a farm. However, we need to manage weeds appropriately because they compete with crop plants for sunlight and soil moisture. They are best removed manually or mechanically and not by the use of herbicides. Herbicides, like other agro-chemicals (fungicides, insecticides), are poisons and adversely affect the various forms of soil life listed above, and should not be used.

Innovative farmers in Punjab are experimenting with soft options of managing weeds—spraying with undiluted cow-urine and soap powder (two per cent) solution (with two eggs as sticker for every 15-litre spray tank). Spraying can be done on weeds growing between two plant rows (at least one foot apart), using nozzles with hoods.

All these are the basic facts of agricultural science and also form the core of the science and the practice of organic or ecological farming.

The regular addition of plant bio-mass, as surface mulch, and microbial agents results in high organic matter in the soil, leading to better soil health, making plants tolerant to drought and pests, and eventually resulting in a high yield.

As stated, only a small fraction (about 1 to 4 per cent in case of nitrogen) of all the 30 mineral elements in the soil may occur in the available form, and the rest in bound form. Interestingly, all the soil testing laboratories that are stated to help farmers (but are designed to help industry) measure only the available form of elements. Most, or all such laboratories in India, lack a facility to measure the total or bound form of any mineral element. All these laboratories are designed to promote the use of fertilizers and the soil-test results are used for generating advisories on the quantity of a given fertilizer that a farmer should apply to the soil.

The typical soil of a farm may contain 0.1 per cent of soil mass as total or bound form of nitrogen. The roots of a plant can access nutrients from up to 30 cm of soil depth, and this upper 30 cm layer of soil weighs about four million tonnes (for every hectare) and thus translates to 4,000 kg of bound N in every hectare. And 1.0 per cent of the 4,000 kg (that is, 400 kg) is in available form. The root system of a plant is, therefore, exposed to a large quantity of nitrogen. Typically, less than one per cent of dry mass of a cereal grain is nitrogen. If a yield, say of sorghum, is 3,000 kg per ha, it would remove a maximum of 30 kg of N per ha; but if the yield is 5,000 kg, it will remove about 50 kg N per hectare, and this quantity is much smaller than the high quantity of nitrogen in the soil (400 kg available and 4,000 kg bound form).

The same is true for the other mineral elements. We, however, need to facilitate a plant's access to this small quantity of N (30 to 50 kg) through the use of liquid manures rich in agriculturally beneficial micro-organisms or through making soil—a living soil of the kind indicated above.

A plant accesses nutrients largely through its root system. The micro-organisms and the soil macro-fauna play an important role in this function. Published literature indicates that the roots of a plant play a large role in selecting the microbial life around it. For example, only the rhizobium of chickpea can enter the roots of a chickpea plant and no other type of rhizobium species enters its roots. Some species of rhizobia have been reported to enter the root system of rice, travel to the leaves through its stem and enhance plant growth. The population of micro-organisms in the soil, in the close proximity to the roots (called the root rhizosphere), is about 10 to 100 times bigger than that in the neighbouring soil mass. There is a whole world of endophytic micro-organisms (those living and functioning inside a plant system, rhizobium is only one type) that are expected to help a plant in various ways and are yet to be explored substantially. The GAP promoted under ecological farming helps the plants access adequate nutrients needed for good plant growth and yield.

There is no doubt that conventional agriculture is based on science, but its focus is on developing research outputs that make farmers depend on the purchased inputs. Moreover, these research outputs are tuned mostly to serve the interests of the input-providers and corporate organizations. On the contrary, if we are serious about addressing the distress widely observed in the farm-sector, we need agro-technologies that empower the farmers to produce inputs on-farm, which will help them reduce the cost of crop production. The challenge for us is to make the AR4D cater to this need, and also to ensure that science is articulated to the agri-practices of the organic farmers. This should help in scaling-up with confidence.

The Soil-Health Card programme of the Government of India and of the states working on this programme is at present targeted at analysing pH, electrical conductivity (EC), the organic carbon, the available form of nitrogen, phosphorus and potassium. As stated earlier, this programme too is targeted at promoting the use of fertilizers and only pays lip service to 'soil health'; in practice, it will still harm soil health but at a slower pace than when the fertilizers are used indiscriminately.

CONCLUSION

In the present scenario, wherein the AR4D works more in favour of external input providers and less in the interest of the farmers, every farmer should become an experimenter and grow crops using GAP (all or most of the methods stated earlier), to meet the need for crop nutrients on a small area (say one acre), and compare the results with the neighbouring area where fertilizers have been applied. If the yield in the experimental area without the agro-chemicals is lower, he/she must visit some successful farmer of their area to find out what additional practices the successful farmer of the area is employing to get high yields. The knowledge and confidence that high yields are possible without agro-chemicals lie with successful organic or ecological farmers and not with the agricultural scientists, and agricultural institutions and universities mandated with the AR4D.

Interactions with a large number of successful organic farmers of India that shaped my understanding of organic farming/ecological farming, and assistance from Ms Lydia Flynn, former Senior Manager, Scientific Editing and Publishing, ICRISAT, are gratefully acknowledged.

The references for this article are available on request from newsreach@pradan.net

Partnering with Civil Societies: Enhancing Food Security of Farmers in Chhattisgarh

KUNTAL MUKHERJEE

Introducing the SRI method of crop cultivation in some regions of Chhattisgarh, PRADAN, in partnership with other NGOs and the support of Sir Dorabji Tata Trust, has been successful in extending the technology to thousands of families, to ensure year-round food sufficiency and increase soil health and fertility

BACKGROUND

Small-holder farmers are crucial for India's rural economy. They constitute about 78 per cent of the country's farmers (according to the Agricultural Census 1990–91). About three-fifth of the holdings was marginal or sub-marginal, and about one-fifth were small. However, the sub-marginal holdings—comprising 40 per cent of all holdings—commanded only 9.8 per cent of the total agricultural land area. Between 1971 and 1991, the percentage of holdings, smaller than 1 ha, increased from 51 to 62 per cent.

These households do not follow a systematic approach and do not have an appropriate land-use plan to make each piece of land productive. The pressure of food insecurity forces the farmers to grow paddy on all kinds of lands, including the upper reaches, in spite of the very limited water holding capacity of such lands. These lands can provide more sustainable returns through horticulture and other activities. The challenge, thus, is to produce more paddy from the low and mid low-lands, ensuring year-round food security and to help farmers gain confidence about diversifying into horticulture in the upper reaches. Diversification in farming is necessary to be able to cope with the adversities of climate change.

The System of Rice Intensification (SRI) has emerged as a potential tool to address this challenge. SRI is not a standardized, fixed, technological method. It is a set of principles by which to approach cultivation.

Small-holder rice farmers, who apply SRI techniques, benefit from a more stable rice production system with reduced inputs; they earn higher incomes because of improved market opportunities thereby reducing the risk of households falling back into poverty, and, at the same time, increase food security and resilience to the impact of climate change.

With the SRI methodology, setting a target of producing an average of 4,000–6,000 kg of rice from a hectare of land is realistic whereas the national average paddy yield is less than 2,500 kg per ha

With the SRI methodology, setting a target of producing an average of 4,000–6,000 kg of rice from a hectare of land is realistic whereas the national average paddy yield is less than 2,500 kg per ha. A family, therefore, that has four months' worth of food security from their own farm can reach year-round food security using SRI methods. Families that are at a higher level of food security can comfortably move to high value crops to earn more.

In Chhattisgarh, where the Hunger Index in 2008 was 26.63, (it was 14th of 17 states), rice is the principal food crop (62 per cent gross cropped area). Augmenting the status of paddy production can go a long way in ensuring food security for families.

In this context, PRADAN is collaborating with other NGO partners (the state consortium called the SRI-Manch) to introduce the SRI method of paddy cultivation in some regions of Chhattisgarh, with support from Sir Dorabji Tata Trust (SDTT). The purpose of the collaboration was to demonstrate SRI techniques in the poor pockets of the region and prepare the villagers for large-scale replication, following the pilot.

In the Consortium, initially, PRADAN's role was that of an R-NGO (Resource NGO), to promote SRI on a large scale with small and marginal farmers throughout the state. At present, PRADAN is not the only resource agency; there are other partners facilitating as resource organizations in various fields such as sustainable organic farming and MGNREGA. Mutual learning among partners has been envisaged. Over the last one or two years, the State Consortium has been involved with all the partners for organizational development. Earlier, the stance of the partnership was very activity-specific; now it is gradually developing into a mutual trust-based relationship that has grown over the years. The following shows how this was built up.

- **2008–09:** First state-level workshop; 800 families in SRI paddy;
- **2009–10:** Second state-level workshop; 4,000 families in SRI-paddy; training on SRI paddy, millets and vegetables in Ganiyari, Bilaspur; initiation of the Chhattisgarh SRI Manch
- **2010–11:** Initiation of the second phase of the project; 5,455 families in SRI paddy and other crops; *gram panchayat*-level *kisan mela* started; third state-level workshop
- **2011–12:** Initiation of district workshops; training in finance, MIS and accounts; 11,570 families in SRI paddy and other crops
- **2012–13:** Convergence with MGNREGA started; 18,975 families in SRI paddy and other crops; training on livelihoods and village-level planning conducted; involvement with partners to help build or rework financial and management system.
- **2013–14:** Initiation of the third phase of the project; 21,402 families were

covered under SRI crops on a year-round basis; focus on family based, year-round planning; initiation of the formation and working with collectives and organizing trainings on group development and dynamics; involvement with partners to seek help from others to update all legalities and build robust financial and management systems; events on organizational systems and process development; formation of a Selection Committee for the new NGO selection from Northern Chhattisgarh.

- **2014 onwards:** Increasingly decentralized relationship with the project team and partners based nearby has been visualized; a mutually dependent relationship for activities and organization has taken place in the southern parts of the state; expected to cover 23,000 families in 12 districts.

The SRI *Manch* is now in its third phase (from 2013–16), focussing on the extension of SRI to 30,000 small and marginal farmers in about 600 villages in 12 districts of Chhattisgarh through partnerships with NGOs. It also aims at broadening the engagement through a farmer-centric approach (especially with women) in select districts of Chhattisgarh.

The third phase started in October 2013. The objectives of the project in this phase are:

- Ensuring year-round food sufficiency for participant families
- Increasing soil health and fertility to sustain agriculture-based livelihoods
- Creating a knowledge platform to raise awareness
- Sharing the lessons learnt from the project by networking among stakeholders

Figure 1: Partner NGOs and their Areas of Operations

Partner NGO	Districts Covered
AASHA	Surguja, Surajpur
APSSS	Surguja, Surajpur, Balarampur
SGVSS	Surguja, Raigarh, Jashpur
CGVSS	Surguja, Surajpur
KARMA	Surguja
GVK	Jashpur
CARMDAKSH	Bilaspur, Korba
ASORD	Gariabandh, Bilaspur
SSSS	Kanker, Kondagaon
DHS	Kondagaon,Bastar
BSM	Bastar, Kondagaon, Kanker
PRADAN	Raigarh, Kanker, Dhamtari, Bastar

The intervention area comprises two main Clusters: the northern hills of Chhattisgarh and the southern Bastar plateau. Both are among the poorest pockets of Central India. The tribal population is more than 50 per cent and those below the poverty line (BPL) are 70 per cent. The agro-climatic conditions and the topography are extremely challenging because the lands are scattered and fragmented, with high to medium slopes, and receive more than 1,000 mm of rainfall within 35–50 days. Approximately, 28 per cent of the rural families are dependent on forests and almost 50 per cent of the food grains are available from their own land-holdings. In both the Clusters, institutional linkages are extremely weak. The districts covered under the collaboration were Surguja, Surajpur, Balarampur, Jashpur, Raigarh, Bilaspur, Korba, Gariabandh, Dhamtari, Kanker, Kondagaon and Bastar.

PRADAN's Intervention

- Building capacities of all participating families, especially women, in adopting skills related to locally suitable PoPs
- Promoting soil health improvement practices, including green manuring, vermi-composting and other composting techniques
- Promoting the adoption of small mechanization for weeding and post-harvest technologies to reduce drudgery
- Building a pool of NGO staff and skilled extension workers, who can work with an overall perspective on resources
- Facilitating networks of organizations to share learning, and influence other stakeholders
- Focussing on the saturation of whole villages, inclusion of left-out families

APPROACH

The approach adopted for implementation of the programme is an amalgamation of the practices of various partner organizations. PRADAN, with the other stakeholders, works towards effective capacity building of the community. The following steps have been taken.

Women-centric farming system

Development of regionally suitable, women-centric, socio-technical-institutional models for agricultural evolution and farm-allied activities has been a major step. The emphasis is on helping women gain knowledge and skills related to a locally suitable Package of Practices (PoP), to improve productivity of staple food crops, that is, paddy, maize, millets and pulses, and to diversify into commercial crops such as vegetables and oilseeds.

Training for partners

Focussed training events are conducted by PRADAN for the field staff of the NGOs involved. The staff members have been provided with hands-on training to carry out each critical step. NGO personnel, trained by PRADAN, are responsible for instructing trainers and farmers. PRADAN and other NGOs provide the necessary on-field support during the implementation.

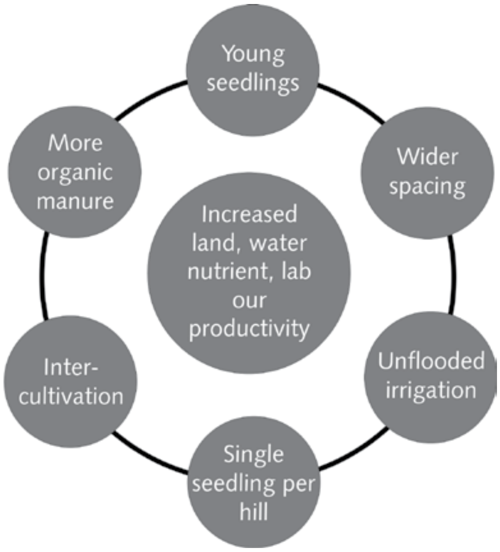
A group of Community Resource Persons—CRPs—(one for 50 families), identified by the people, were trained and engaged to guide the community and ensure proper practices in every farmer's field.

Regular refresher training courses have also been conducted for resource persons involved in the earlier phases. Also, new approaches and themes such as risk mitigation strategies in agriculture and group facilitation processes have been discussed.

Village-level farming support

Training on SRI, exposure visits to areas where SRI has been successfully implemented and resource management have been conducted at the community level. Initially, this was done by PRADAN for partner organizations which, in turn, trained their own staff. Sometimes, PRADAN helped them in the field as well. However, at present, some resource persons from partner organizations support other

Figure 1: SRI Hexagon



partners and even the PRADAN team. The focus has not only been on strengthening the practices for SRI paddy but also on introducing better practices for vegetables, millets, oil seeds, etc., with at least 25 per cent of the families of the selected area.

Adoption of Safe Practices

Agronomic practices proposed in the SRI technology require the farmers to shift from their traditional practices. Very often, the fear of downside risks is a deterrent to the adoption of the technology, particularly with subsistence farmers. Figure 1 shows the SRI hexagon in relation to agronomic, environmental and social contexts.

To moderate the risk, financial assistance under the project has been provided to the families involved in SRI cultivation in 50 decimals per family. A sum of Rs 800 per family is provided as a one-time assistance to SRI paddy-participant families and Rs 150 each to SRI other crop-participant families.

SUSTAINABILITY AND CAPACITY BUILDING

To ensure the sustainability of the action, the focus has been on the following operations.

Social and cultural sensitivity and inclusiveness: Participation of women of disadvantaged, poor and diverse ethnic groups have been taken into account. Stakeholders have been linked and associated within the project, to promote inclusive partnerships that ensure that small-holder producers benefit.

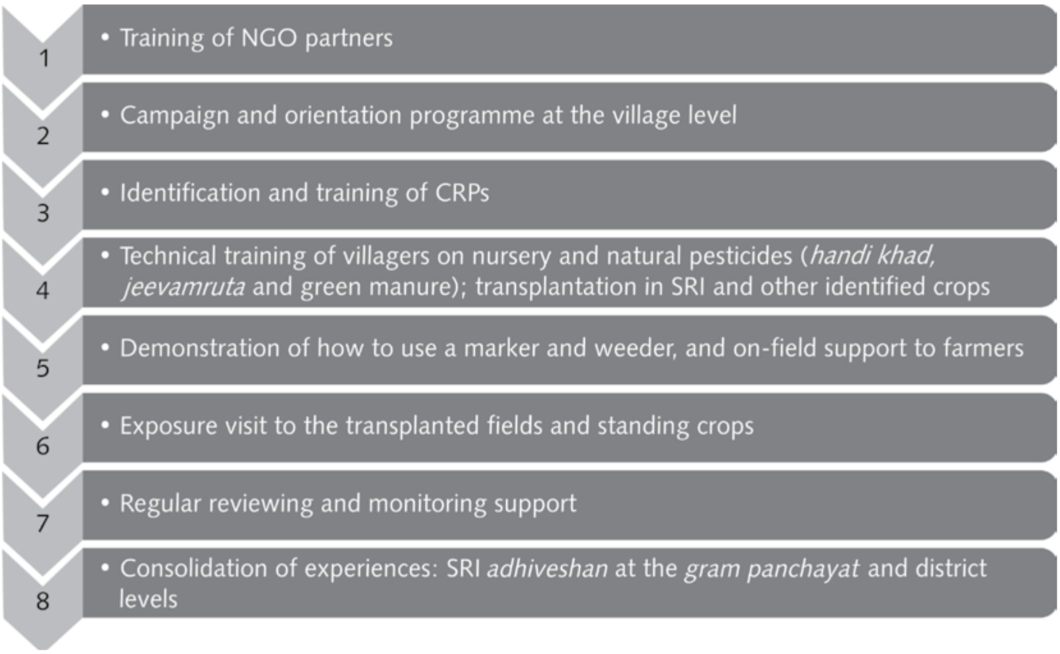
Economic viability: The SRI system has economic benefits. It can reduce input costs and increase yields, which, in turn, increase the income of the farmers. The cost-benefit analyses of SRI paddy and millet depict significant income increase and input cost deduction during the last phases of the project.

Exchange programme: To encourage cross-learning and exchange of ideas in various areas of the project, several cross-visits were organized. Numerous events were held on the dissemination of knowledge in *gram panchayat adhivesans* (meetings), district workshops, etc., which have been organized regularly. Most of these events have been co-partnered with the Department of Agriculture, Government of Chhattisgarh.

Linkage with institutional settings: The thrust has been on channellizing existing institutional structures so that the new technologies required for SRI production system can be leveraged from the agriculture support services. Also, capacity building of the institutional structures was carried out in order to ensure that the support remains, even after the project's intervention is complete.

Governance: The project and partners have been practising inclusiveness, participation,

Figure 2: Process Followed for the Extension of SRI



accountability and transparency to ensure ownership of the community and equitability, in general.

EXPERIENCE SO FAR

During 2013–14, the SRI *Manch* reached 21,402 families, spread over 488 villages in 12 districts, with a coverage area of 7,510 ha. It was also found that 85 per cent of the families were continuing with SRI for the second crop.

Mainly, SRI *Manch* has worked with paddy, mustard, millets, wheat, sugarcane and vegetables on a year-round basis. Across the year, productivity has increased to 6.37 MT/ha (yield analysis of 13 per cent of the total number of families), with a significant increase of 109 per cent, per family coverage. This is much higher than the average state yield of 2.2 MT/ha and 1 MT/ha when traditional practices are used for paddy and millet, respectively. The average yield of the SRI millet is 3.06MT/ha (yield analysis of 10 per cent of the total number of families).

Along with this, the Consortium has devoted time to influence the government in adopting SRI through field visits, yield certification, workshops, etc. In the *rabi* season, the crop coverage was 1,363 families in paddy and 1,737 families in other vegetables, pulses and millets.

From Tables 1 and 2, it can be interpreted that 91 per cent of the families achieved a yield of more than 4 MT/ha (the state productivity average of traditional paddy is 2.3 MT/ha). The average productivity for the SRI paddy is 6.37 MT/ha.

With SRI millet, 79 per cent of the families of the sample study achieved more than 2 MT/ha (the state average of millets in traditional practice is 1 MT/ha). The average productivity of SRI millet is 3.06 MT/ha. The highest productivity reported is 11.20 MT/ha for SRI paddy and 3.9 MT/ha for SRI millet.

Figure 3: Year-wise Comparison of Coverage (Families and Area)

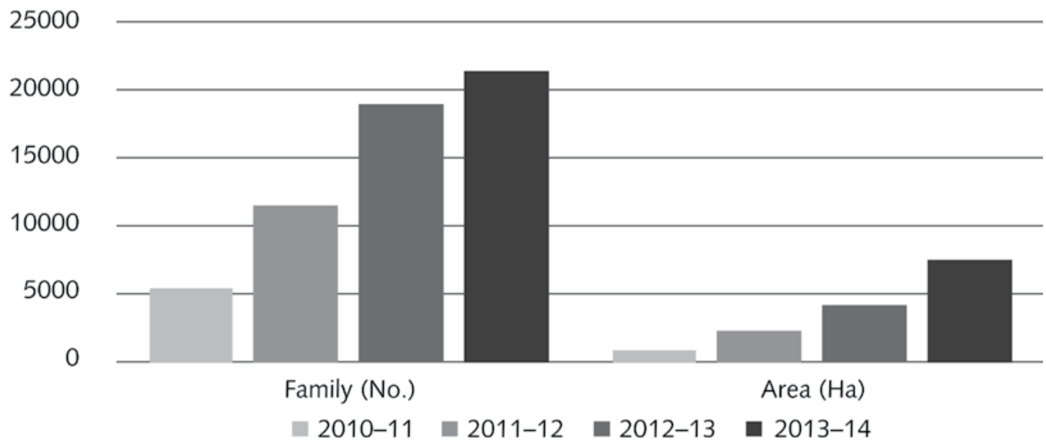


Table 1: Analysis of Production Data of SRI Paddy in the *Kharif* Season 2013–14*

Productivity Range (MT/ ha)	Number of Families	Total Per cent of the Sample Families
10–12	25	1.0
08–10	322	12.5
06–08	1,001	38.9
04–06	998	38.8
02–04	219	8.5
00–02	6	0.3
Total	2,571	100.0

*Based on a sample of 2,571 families; which is 13 per cent of the total number of families.

Table 2: Analysis of Production Data of SRI Millet in the *Kharif* Season (2013–14)*

Productivity Range (MT/ ha)	Number of Families	Total Per cent of the Sample Families
5–6	4	1.3
4–5	54	17.4
3–4	112	36.1
2–3	74	23.9
0–2	66	21.3
Total	310	100.0

*Based on a sample of 310 families, which is 33 per cent of the total number of families.

Farmer demonstrates weeding in SRI millet plot using wheel hoe in Mundagaon village, Bastar

OTHER INITIATIVES OF SRI *MANCH*

- **Initiation of Organic Practices in Farming**

  One key variable for success in the SRI technique is the humus content of the soil, which allows for beneficial microbial action in the root zone. Using organic manure, as part of the project design, led to at least 53 per cent of the families adopting the technique completely. Sesbaniaaculiata *(dhaincha)* or other leguminous green manure crops, which are available locally, are used in some areas to reduce the cost of cultivation and improve land husbandry, including its nitrogen content and moisture-holding capacity. Vermi-composting, liquid fertilizer application (*jeevamruta,* etc.), leaf-composting and organic repellent application have also been used to revive soil health and increase the organic carbon content across the project area.

- **Convergence with MGNREGA**

  For year-round, agricultural, farm-based development, irrigation during the critical phases of crop development is crucial. Convergence with MGNREGA for land and water development was tried on a pilot basis. For this, PRADAN extended help to partner NGOs to facilitate a comprehensive planning process in the villages, in the presence of the *panchayati raj* institution (PRI) staff and government officials. As much as Rs 2.79 crores was sanctioned for 518 families in 33 villages of eight districts from Land and water development. The plans were implemented through the respective *gram panchayats;* the convergence of various developmental interventions at the *gram panchayat* level is the major focus. The NGOs facilitate this initiative on a voluntary basis. Each NGO has selected a small Cluster within the SRI project area to work on, in an integrated manner.

- **Community Mobilization**

  In the current phase, another component of involvement is helping the partners in community mobilization. In the quarterly meetings, all the partners said that they needed to focus more on this aspect. An integrated training for all the staff was, therefore, conducted and the partners have now started promoting women's Self Help Groups (SHGs) in their project areas.

- **Organizational Development**

  PRADAN and other partner organizations are engaged in organizational development also. Mainly, there is cross-learning from and influencing of other NGOs, to build a robust system of accounts, finance and administration. For this, training in accounts and finance was conducted in three phases. At present, partners are being influenced to prepare a financial manual in their own organizations and to take help from other partners, who have financial manuals (CGVSS, CARMDAKSH, PRADAN, etc). PRADAN and other NGO partners have engaged with each other to move towards more decentralized decision-making in the NGO administration.

WAY AHEAD

PRADAN and partner NGOs use the SRI *Manch* to share the lessons learned, facilitate other initiatives (community mobilization, convergence through MGNREGA, Community Forest Right etc.), and to influence the government to spread a community-based developmental cluster model throughout the state. This forum also facilitates the emergence of leadership. It usually meets once every three months to review the engagement of the last quarter and draw up the plan for the next three months. The focus of the facilitator from PRADAN, in these meetings, is to promote group functioning norms and values, and to ensure that PRADAN does not occupy the dominant space.

Although partnership in Chhattisgarh started with a specific goal of SRI promotion. Gradually with the development of network among the partners, common agendas have emerged keeping in view the need of the area and demand of the community. The future engagement of the state-level forum is to develop a mutual learning-based network and an enabling environment in the state for the growth and betterment of the human condition of the poor and the marginalized people of Chhattisgarh.

Open Letter to the 4th International Rice Congress

Drawing the attention of the global community, the letter urges the IRC to support such agro-ecological production methods as SRI, which provide multiple benefits to farmers, the communities and the environment in increasing output, reducing water usage and enhancing resilience to climate changes.

The International Rice Congress (IRC) is a quadrennial event with the largest gathering of rice scientists and experts from across the world for exchanging ideas, experiences and best practices, and learning about the latest developments in rice science as well as key issues in the rice industry. The 4th International Rice Congress (IRC2014), with the theme "Rice for the World", will focus on the increasing the food security of half the world's population. IRC 2014, is organized by the International Rice Research Institute (IRRI) and Kenes MP Asia Pte. Ltd. and held on 27 October – 1 November in Bangkok, Thailand.

Addressing on the theme of IRC 2014, "Rice for the World", a group of eminent researchers, experts and practioners have written an open letter to the IRC 2014 drawing attention of the global rice community on the pressing issues faced by rice farmers and collaborating with the farmer's organisation for research relevant to the food and resource insecure farmers.

Here is the published copy of the open letter to the IRC 2014.

The 4th International Rice Congress (IRC 2014) is taking place from 27 October to 1 November 2014 in Bangkok, Thailand. The IRC 2014 theme is "Rice for the World". The IRC is a quadrennial event that brings together researchers, government representatives, business interests, civil society participants, and rice producers.

This meeting of the IRC comes at an opportune time, when climate change, food insecurity and poverty are challenges to people's prosperity and our planet's sustainability. Rice is an important crop for food security, national economies and ecological systems.

Given these challenges, we who work with the System of Rice Intensification (SRI) as scientists, practitioners, and private sector and government actors, are pleased to attend the Congress and to share the results of our research and field experience. We have abundant evidence that the use of SRI concepts and methods can contribute immediately and effectively to raising crop productivity, reducing rice crop water requirements, making crops more resistant to the hazards of climate change, and reducing greenhouse gas emissions.

2014 is the International Year of Family Farming — a reminder to the international community of its obligations to work with smallholder family farms to improve the quality of their lives and their farming systems. This year has galvanized concrete initiatives and policies aimed at mobilizing resources and improving access to land, water, and other inputs and natural resources. Smallholder farmers and their organizations have been working together to bring greater attention and resources to the promotion of agro-ecology and farmers' control over their production; especially their ownership of seeds, which should be strengthened, ensuring respect to their rights and traditions.

It is important that IRC support agro-ecological production methods such as SRI, as these can utilize more productively the resources that are available to farmers with positive effects on soil and environmental quality. SRI is a principle-based management system that has gained wide popularity among resource-poor farmers, conscious consumers, social entrepreneurs, and sustainable supply chains. SRI management practices have been shown to give more productive plants (phenotypes) from practically all varieties (genotypes). Knowledge and use of SRI has spread largely through the efforts of international and national NGOs, farmers' organizations, and research organizations in over 50 countries.

The IRC has provided opportunities to share this knowledge and experience, and we hope that the 5th Congress will give greater attention to agro-ecological practices and opportunities such as SRI given the productivity and sustainability challenges that agriculture faces. SRI can provide multiple benefits to farmers, their communities, and the environment: reducing water usage, increasing yield and input efficiency, and improving resilience in a changing climate. These modifications in practice are changing the lives of farmers and their communities. As a part of a larger agro-ecological movement, SRI is also helping to address the vitally important issues of justice in food and agriculture—that is, who gets access to what resources and how these decisions get made. There are over 600 publications, including the large body of scientific research from China, which provide scientific validation and explanation for these ideas and methods.

We would like to work with the International Rice Research Institute and the rest of the rice science community to address the pressing issues facing rice farmers. Farmers are not only producers; they are innovators, particularly when the right conditions exist to build on their knowledge of the specific techniques that work in their respective situations, taking into account their natural resource constraints, soil conditions and weather patterns, as well as social and cultural considerations.

We would like to draw the attention of the global rice community to:

- Collaborate with farmers' organizations on research that is particularly relevant to improving the situation of resource-limited and food-insecure rice farmers, developing more beneficial sustainable value chains, more adequate technologies and investment, and improving market access.
- Give more attention to issues of concern to farmers and their organizations, such as risk management at the plot and landscape levels, models for accessing financing credit that work for farmers, and land tenure issues. Also, attention needs to be given to producing small farm machinery that can help farmers overcome constraints such as labor.
- Involve farmers and their organizations in the design of research: farmers' organizations should be endowed with more capacity for independent analysis, critical assessment and monitoring.
- Work with the SRI community, which includes a wide range of disciplines and occupations. Our experience and research is showing that by providing more conducive growing environments to rice plants, their genetic potentials can be more fully expressed for the benefit of both farmers and consumers.

The letter is written by Le Nguyet Minh (Global Agriculture Advisor, Oxfam), Erika Styger (Director of SRI-Rice, Cornell University), Norman Uphoff (Professor of Government and International Agriculture, Cornell University), BC Barah (Indian Agriculture Research Institute Representative, National Consortium of SRI in India), A. Ravindra (Watershed Support Services and Activities Network, Secunderabad, India), Debashish Sen (People's Science Institute, Dehradun, India), Amod Kumar Thakur, (Senior Scientist, Directorate of Water Management, Orissa, India) Edward W. Baxter, (Executive Director, SRI Global Inc., Ithaca, New York, USA) and other experts, researchers and practitioners.

Rani Sing Mura from village Poradih, district Purulia, West Bengal identifying the difference between the paddy cultivated through the traditional method and the SRI method (right).

Farmers in many states of India, over the past decade, have already begun producing more crop per drop of water, more crop per acre of land and more crop per unit of work, by changing their agricultural practices. By modifying their methods of plant establishment and water management, farmers can create more favourable growing conditions for their crops, both above and below the ground. This is especially true for rice and is applicable to many other Indian crops also.

PRADAN is a voluntary organization registered in Delhi under the Societies Registration Act. PRADAN works through small teams of professionals in selected villages across eight states. The focus of PRADAN's work is to promote and strengthen livelihoods for the rural poor. It involves organizing the poor, enhancing their capabilities, introducing ways to improve their income and linking them to banks, markets and other economic services. The professionals work directly with the poor, using their knowledge and skills to help remove poverty. *NewsReach,* PRADAN's bimonthly journal, is a forum for sharing the thoughts and experiences of these professionals working in remote and far-flung areas in the field. *NewsReach* helps them to reach out and connect with each other, the development fraternity and the outside world.

NewsReach is published by the National Resource Centre for Rural Livelihoods, housed in the PRADAN Research and Resource Centre.

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