

# System of Rice Intensification as a Resource-Conserving Methodology : Contributing to Food Security in an Era of Climate Change

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## ABSTRACT

The system of rice intensification (SRI) developed in Madagascar is gaining acceptance in many parts of India and in three dozen other countries. SRI helps farmers achieve higher yields with reduced inputs: fewer seeds, less water, lower costs of production, and often less labor. This makes it more accessible to resource-limited farmers than Green Revolution technologies and thus it can assist in poverty reduction as well as enhanced food security. This paper reports data and experience from Himachal Pradesh, Uttarakhand, Orissa and West Bengal, sharing insights and evaluations from NGOs working particularly with poor households in vulnerable environments. The capacity of SRI methods to buffer adverse climate effects is particularly important in such settings. Data from northern India in the 2009 drought year show conventional paddy yields declining by 31% while SRI yields declined only by 13%. In absolute terms, SRI yields there were almost double conventional yields: 48 vs. 25 q ha<sup>-1</sup>.

**Key words :** Agroecology, Climate change, Food security, System of rice intensification.

## Introduction :

The success of green revolution strategies for raising agricultural productivity has depended on the development of crop varieties (genotypes) that are more responsive to increased applications of water, chemical fertilizer, and agrochemical means of protection against crop pests. For farmers to benefit from this process whereby investing in more inputs can lead to production of more outputs, they had to begin by purchasing and using new seeds. The green revolution was clearly seed-dependent.

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The system of rice intensification (SRI) and other agroecological approaches follow a different strategy, on the other hand. They work with whatever crop varieties the farmer already has or prefers to use (recognizing that it is always most productive to start with whatever genotype is best suited to the farmers' circumstances and goals). Agroecological methods are more likely to *reduce* the use of external input than to increase this as they mobilize and capitalize upon potentials that already within plants and upon the *interactions* between plants and their biotic and abiotic environments, i.e., mutual influences among plants, other organisms, climate, soil and other inanimate factors (Altieri, 1995; Gliessman, 1998; Uphoff, 2002). This is a very different envisioning of the agricultural domain.

Agroecological strategies change the ways in which plants, soil, water and nutrients are *managed*, promoting root growth and also the abundance, diversity and activity of the myriad soil organisms that make up the soil food web. These organisms range from microscopic bacteria and fungi to macrofauna such as earthworms, ants and termites, and everything in between (Coleman *et al.*, 2004; Wardle, 2002). The most direct beneficiaries of this soil food web are the plants that grow in the soil, but also collaterally, this soil food web provides benefit to the humans and the other creatures that subsist on them.

Agroecology addresses the multiple, complex and dynamic relationships that make the *inert mineral* portion of the soil, roughly half of its total volume, into a productive part of functioning soil systems (Uphoff *et al.*, 2006). The other half of soil systems is constituted by *air* and *water*, each 20-25%, and the *living organisms* and residual (inert) organic matter that make up about 5% of soil systems  $\pm$  3-4%. From an agroecological perspective, soil organic matter, living and dead, is like 'the tail that wags the dog.'

### **The System of Rice Intensification :**

Ever since the validity of SRI methods was first demonstrated outside of Madagascar, its country of origin, in China some 10 years ago, we have reiterated that SRI is ***not a technology***, and further, that it is ***a work in progress***, continuing to evolve, diversify and have greater impacts. SRI should be understood initially as a set of ***ideas and insights*** that derive from the life's work of Fr. Henri de Laulanié (1993).

These ideas and insights can in turn be justified and explained in terms of a number of principles that can be comprehended on the basis of knowledge that has been scientifically validated, to understand how more productive phenotypes can be elicited from existing crop genotypes (varieties). For example :

- When paddy soils are not continuously flooded, so the soil is not hypoxic (suffocated), plant root systems will be healthier and longer-lived, and soil organisms (the soil biota) will be more abundant and diverse, providing many symbiotic services and benefits to plants.
- When plant populations are much lower and individual plants are not crowded closely together, their lower leaves are more exposed to sunlight and they can

be fully functional photosynthetically. Leaves not receiving enough light to be photosynthetically active consume — rather than contribute to — the plant's stock of photosynthate (energy) and thus they become, in effect, parasitic.

- Also, with wider spacing, plants' roots will be better supplied with carbohydrates for metabolism because it is the lower leaves that are the roots' main source of energy supply.
- When rice seedlings are transplanted before they are 15 days old, i.e., before the start of their 4<sup>th</sup> phyllochron of growth, this minimizes transplant shock, and the plants' subsequent growth is better.

These are relationships that are easily seen and measured with empirical trials. So, at this level, SRI is a scientifically-based discourse on how to provide the most supportive growing environment for rice.

At an operational level, SRI is communicated to farmers — and its principles are implemented — through a set of **practices** that alter many age-old methods for irrigated rice cultivation: e.g., transplant very young seedlings, less than 15 days old, instead of 3-4 weeks or older;<sup>1</sup> transplant single seedlings instead of 4-6 in a clump; keep paddy soils moist and intermittently drained rather than continuously inundated, etc. These practices are the visible expression of SRI ideas and knowledge, making them concrete and practical. It is a common mistake to 'reduce' SRI to just these practices. These represent SRI, but it is much more than just certain recommendations.

The concepts, principles and practices of SRI, developed for irrigated paddy production, have been extended and extrapolated in India, Cambodia, Myanmar, Philippines and elsewhere to **rainfed** areas, for unirrigated rice production, even though the idea of 'upland SRI' seemed anomalous at first. Now we have seen SRI experience prompting farmers to extend the concepts, principles and practices of SRI to **other crops** such as wheat (Prasad, 2008), sugar cane (Anon., 2009a), and others as discussed below. We are thus dealing with something that does not fit previous prescriptions for how to achieve higher crop productivity and prevailing preconceptions of how technical progress should be pursued.

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<sup>1</sup> If the crop is established by transplanting, young seedlings should be used. Variations on the original SRI concepts have led to some alternative methods of crop establishment that are consistent that are consistent with the original ideas and insights of SRI. This is to say that the practices themselves can be modified without excluding a derivative cropping system from 'the SRI family'. There is now direct-seeded SRI, either by hand or by machine; also SRI with broadcasting of pregerminated seeds, thinning out the emergent young seedlings in a square pattern by doing the same soil-aerating mechanical weeding at 10-12 days as is recommended for 'traditional' SRI. Indeed, transplanting need no longer be done by hand as machines have been designed to transplanting young seedlings mechanically in a predetermined square system.

SRI is an unprecedented innovation in that it enables farmers to achieve '*more output with reduced inputs*.' This is possible by mobilizing and benefiting from the services and protection of soil biota, largely ignored by Green Revolution technologies, and even disrupted and diminished by its practices. The old wisdom – rather than feed the plant, it is better to feed the soil, and the soil will feed the plant – was eclipsed by a narrow focus on plants and their nutrient supplies, uptake and conversion into grain, regarding them as 'organic machines' converting (our) inputs into crop outputs (cf. Harvest Index).

Such a mechanistic perspective is at odds with an agroecological view that assesses and supports crops' performance within their immediate and larger **environments**. It is concerned particularly the multiple interactions and interdependencies that plants have with other organisms, flora and fauna at multiple scales. Some of these relationships are adverse, but these are usually outweighed by the symbiotic and synergistic connections that have sustained plants as components of ecosystems for over 400 million years. Accelerating and enhancing plants' net productivity to meet agricultural objectives presents some new challenges and faces some co-evolutionary constraints. But the latter cannot be wished away. We need to find ways of working with rather than against the processes and potentials of nature.

### ***Consideration of Indian Experience***

This introduction prefaces a consideration of SRI experience in India, in agroecosystems as diverse as those in western West Bengal, hilly central Orissa, and north-lying Uttarakhand and Himachal Pradesh. We underscore that SRI is ***not yet finished***, so this is a kind of progress report. We do not offer here any 'instruction' on SRI, as that is done elsewhere, e.g. on the SRI website at <http://ciifad.cornell.edu/sri/>. For Indian information, the websites <http://www.sri-india.net/> and <http://www.wassan.org/sri/> may be consulted; and for Orissa specifically, anyone can see: <http://groups.google.com/group/sriorissa>.

Neither will this article address the 'controversy' that has arisen from the rejection of SRI by some rice scientists, particularly at international level (e.g., Dobermann, 2004; Sheehy *et al.*, 2004; McDonald *et al.*, 2006; also Kassam and Stoop, 2005, and Uphoff *et al.*, 2008). It is time to move beyond the so-called controversy given that rice scientists in national research institutions in India, China, Indonesia and Vietnam have satisfied themselves that SRI concepts and practices have merit (e.g., Gani *et al.*, 2002; Zhao *et al.*, 2009; Thakur *et al.*, 2009). Our hope is that government agencies, NGOs, farmer associations, research institutions, universities, banks, companies, foundations, and other organizations will take an interest in learning more about SRI concepts and their application, and in extending them, with appropriate adaptations, to an ever-wider set of agroecologies for the benefit of rural producers and consumers, as well as of the environment.

## **Contributions to Food Security :**

SRI was developed specifically for households which are resource-constrained, with limited access to land and purchasing power, also for which maintaining soil and water resources in quantity and quality is of great importance. Some large farmers have used SRI methods on 20-30 ha, even more, and their higher output contributes to the meeting of national food security goals. However, our focus here is on direct benefits to small and marginal farmers.

### ***PRADAN Experience in West Bengal and Eastern India***

A case study was recently done by a Jawaharlal Nehru University, New Delhi research economist of the to assess the impact of SRI introduction for poor families.<sup>2</sup> The household headed by Nikodam Tuti is located 50 km away from Ranchi in Jharkhand state. The family previously could feed itself for only six months each year from its one acre of land; so Tuti had to work as a construction laborer in Mumbai for half the year, and the family is burdened by debts.

Since learning how to use SRI methods three years ago from staff of the NGO PRADAN, the household is able to raise the output from its half-acre of paddy land from 3 to 16q, boosting yield from 750 kg ha<sup>-1</sup> to 4 t ha<sup>-1</sup>. The household now feeds itself for the whole year, and Tuti no longer needs to migrate out of the community. Also, the household's debts have been repaid (Bera, 2009).

Such a transformation has not been achieved yet for all of the poor households with whom PRADAN staff work, but it is indicative of the kind of economic and social improvement that can be built upon the productivity gains from SRI practice. This reduces seed requirements by 90%, the seed saved going directly into household consumption. Water requirements are reduced because paddy fields are no longer kept flooded. Moreover, costs of production are reduced, and even labor requirements.

PRADAN began working with SRI in 2003, starting with just four farmers in Purulia district of West Bengal willing to try the 'counterintuitive' new methods. The results of the 150 farmers in that district who used SRI methods the next year were evaluated by a team from the India programme of the International Water Management Institute (IWMI), studying farmers in two villages (N=110). Most did not have reliable irrigation water supply, so this SRI production was mostly dependent on rainfall.

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<sup>2</sup> The documentation was supported by the Sir Dorabji Tata Trust (SDTT), Mumbai, which has been assisting NGOs working on poverty reduction in eastern and southern India, to ascertain what effect the SDTT assistance is having. A powerfupoint presentation on the SDTT program was made to the 3<sup>rd</sup> national SRI Symposium hosted by the Tamil Nadu Agricultural University in Coimbatore in December 2008: <http://www.slideshare.net/SRI.CORNELL/0869-promoting-system-of-rice-intensification-sri-in-india-experience-of-sir-dorabji-tata-trust>

Even with one of the two villages having been severely affected by drought, average yield was 32% higher, and because costs of production were reduced, net incomes  $\text{ha}^{-1}$  went up 67%. A detailed evaluation of labor inputs showed an 8% reduction with SRI management. The yield on one of the fields, personally measured by the IWMI team leader, reached  $15 \text{ t ha}^{-1}$ . The yield of grain per kg of seed was 61.35 kg with standard methods and 845.61 kg with SRI practice (Sinha and Talati, 2007).

SRI use in Purulia district has continued to expand, and PRADAN staff have extended its use to other states in eastern India, namely, Bihar, Chhatisgarh, Jharkhand, Madhya Pradesh and Orissa, with the number of families rising to 6,200 in 2006, 10,400 in 2007, and 20,000 in 2008. Average yields varied because of local soil and climatic conditions, although in general, yields were roughly doubled. SRI averages ranged from  $3.75 \text{ t ha}^{-1}$  in Keonjhar (Orissa) to  $7.5 \text{ t ha}^{-1}$  in Purulia (West Bengal).

When there were some reports that SRI yields were declining after several years, PRADAN analyzed the yields for farmers in Purulia, who had the longest experience with SRI methods, and found that farmers' yields, if anything, were increasing over time, without relying on soil amendments or chemical fertilizer (Fig. 1).

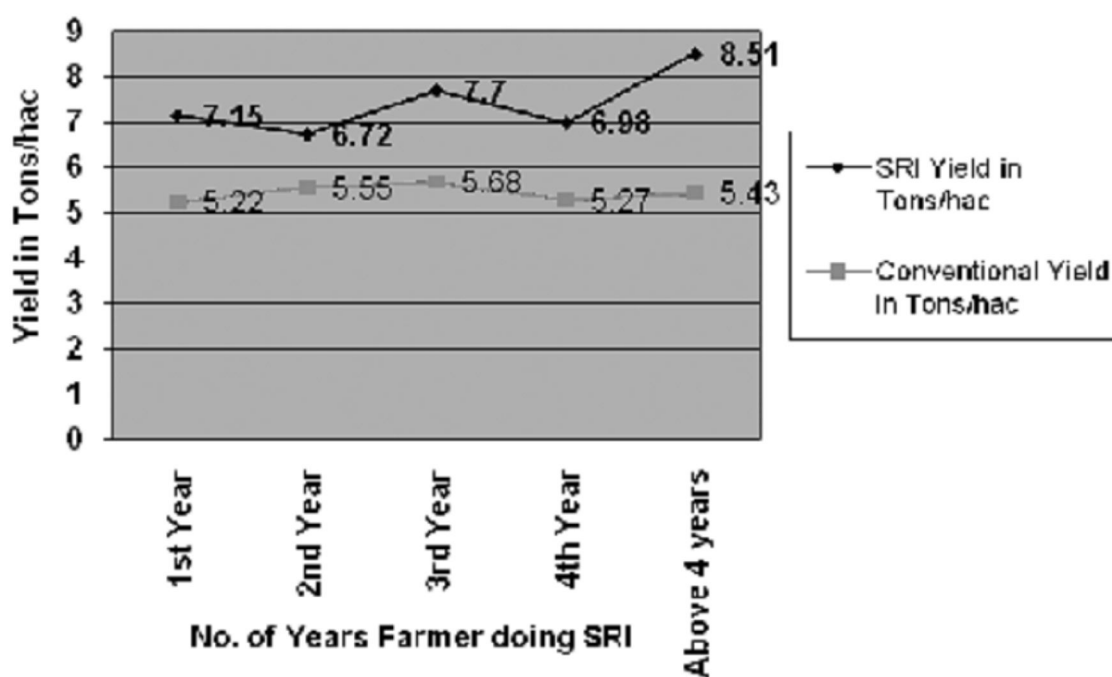
It may be noted that the farmers in Purulia who took up SRI had higher production than the average for the district as a whole,  $2.5 \text{ t ha}^{-1}$ . With conventional methods, the farmers using SRI averaged  $5.4 \text{ t ha}^{-1}$ , while with SRI practices they achieved  $7.1 \text{ t ha}^{-1}$  on average.

An analysis of the impact of SRI practices on household food security, even with adoption on small amounts of land showed a substantial improvement, especially in comparison with the levels of paddy production usually achieved in the district with conventional means. By expanding their area under SRI management, households can further increase the number of months for which they can have adequate rice availability (Table 1).

**Table 1. Impact of SRI practices on household food supply and sufficiency in Purulia, West Bengal during 2007**

| Farmers adopting SRI (N=3,793) Area extent = 528 ha               |          | Increase in grain supply |     |     |
|-------------------------------------------------------------------|----------|--------------------------|-----|-----|
| (tons of paddy)                                                   |          | Increase in              |     |     |
| (Rs. in lakhs)                                                    |          | cash received            |     |     |
| Increase in food grain availability (kg family <sup>-1</sup> )    |          | Incremental              |     |     |
| food sufficiency (in months)                                      |          |                          |     |     |
| Incremental yield compared to SRI farmers' conventional practices | 902.88   | 58.69                    | 143 | 1.2 |
| Incremental yield compared with average for Purulia district      | 2,449.92 | 159.24                   | 388 | 3.2 |

Source : Data from records of PRADAN team at Purulia, West Bengal



**Fig. 1. SRI and conventional paddy yields (t ha<sup>-1</sup>) in Purulia District, West Bengal, over time**



### ***PRAGATI Experience in Orissa***

In Orissa, the NGO PRAGATI based in Koraput district started working with SRI methods in *kharif* (2006), getting 11 farmers to try out the methods on 5.5 acres. Because they were able to increase their yields by 2-4 times, with other benefits as well, there was growing willingness to change production practices. Food security could be increased by 1-4 months depending on the amount of land put under SRI management. By *kharif* (2009), there were 948 farmers using the new methods on 637.2 acres, still with 2-4 times increase in yield. Discussions with the farmers, most of them tribal, have led to the following assessments and conclusions :

- Higher **grain yield** is accompanied by higher milling outturn bushel<sup>-1</sup> of paddy rice produced, by about 15%, which adds further to household food security.
- There is large reduction in the **seed rate**, as 2 kg is sufficient to plant 1 acre compared with 35-45 kg with conventional methods. This difference is directly added to household food supply.
- **Fodder production** has been improved by 40-50% compared to conventional methods, which contributes to better milk production.
- **Water use** was reduced on an average by 60-70% compared to conventional practice, as farmers learned that they had been wasting large amounts of water, which lowered rather than raised yields.
- SRI crops have **more resistance to crop loss** with less attacks by insect-pests and disease and fewer infested grains than with traditional practice.
- Crops are **more tolerant to climatic stresses**, with little or no crop lodging due to the plants' stronger root growth. Dry spells and erratic rainfall can be better coped with water management and timing as one or two crucial irrigation(s) at critical growth stages considerably enhance(s) crop yield.
- SRI crops also **mature sooner**, by about 15 days, than crops grown with conventional methods, and this reduces their exposure to various hazards.
- **Labor cost** for field preparation, nursery management, transplanting and weed control is reduced as less number of laborers need to be involved. This might be seen as a disadvantage for poor households, but as noted below, this has been a boon to landless women. Poor households which hire out their labor have more earning opportunities if they produce their basic food with less labor.
- **Cost reduction** is possible with organic agricultural practices and use of indigenous varieties permitting poor farmers to reduce their dependence on costly fertilizers, pesticides and new seeds.
- **Drudgery of women** is greatly reduced as they find it easier to perform the transplanting, weeding and other activities in SRI fields.



### **Enhancement of Women's Income**

PRAGATI reports on how women members of the Maa Mahima Self-Help Group of Hardoli village (Ghumar Panchayat, Kotpad block, Orissa) who after participating in a SRI training program persuaded their families to adopt SRI on half an acre each. They became skilled in nursery raising, use of the marker, SRI transplantation methods, and weeding, and proceeded to use their new skills to improve their incomes beyond their own paddy fields.

With traditional paddy cultivation, these women worked as a group of agricultural laborers, taking on the planting of 1 acre of paddy land for Rs. 2100/-, charging Rs. 30/- head<sup>-1</sup> for 70 laborers, as this was the number needed to transplant that much land in a day. With SRI methods, however, one acre can be planted by 15 laborers in one day. They are able to charge Rs. 70/- head<sup>-1</sup>, which amounts to Rs. 1050/-, a saving of 50% for the landowner who gets a higher yield as a result of their skillful work.

With the new methods which involve many fewer plants and require much less time, 15 women can sometimes plant even 2 acres in one day. By charging Rs. 1200/- for an acre well transplanted, they can now earn double this amount in one day. This works out to a daily income of Rs. 160/- each, a big improvement over their earlier Rs. 30/- day<sup>-1</sup>. Women thus are able to capture a good share of the SRI gains in productivity while, at the same time, landowners are greatly benefited as well.

### **Coping with Climate Change :**

Small and marginal farmers in India have had many constraints and risks to cope with since time immemorial, but they are now facing the hazards of more capricious climate as increasingly they must cultivate crops with large and uncertain variations in rainfall. They have always had to deal with water stress and drought interspersed with flooding and other problems like cold spells and unusually high temperatures. The extent and causes of climate change are still being debated by scientists and policy makers, but farmers are confronted with climate irregularities and extremes that make life literally more difficult and precarious for hundreds of millions of Indians. The effects of their crop failures are felt not only in rural areas but ramify and reverberate in the cities and even corridors of government when shortfalls drive up prices and uncertainty.

There are reasons to think that SRI and related agroecological practices – which enhance the growth of plant root systems, and the abundance, diversity and activity of the soil biota – can give a degree of protection or buffering for crops, and not just for rice (Uphoff, 2010; Uphoff and Mishra, 2009). There have been many reports on the ability of modified practices to give crops more protection against climate risks. The story related by Moti Lal Khanna, a first-time SRI farmer coping with the adverse weather effects in *kharif*, 2009 (drought and then flooding), is presented in a box given at earlier page.

### ***Experience in Western China***

In Sichuan province of China, SRI methods have been adapted and extended to a 'land-covered' strategy of rice cultivation that combines SRI practices (young, single seedlings widely spaced, with reduced water requirements and more use of organic matter) used on raised beds with black plastic sheets that suppress weed growth and reduce soil water loss through evaporation. This has had remarkable positive effects (Anon., 2009b).

An evaluation comparing the effects of using SRI methods with soil-cover mulch was found to enhance average yields in a normal season by 150-200 kg mu<sup>-1</sup> (2.25-3.00 t ha<sup>-1</sup>) while in a drought season, the increase was 3 t ha<sup>-1</sup> or more. The economic advantages of the new methods were even more dramatic, as farmers' net income ha<sup>-1</sup> was increased in a normal year from \$200 to >\$1,500, while in a drought year, farmers' returns would be a loss of \$550 ha<sup>-1</sup> with usual methods, and a net profit of \$880 ha<sup>-1</sup> with land-cover SRI (Lv *et al.*, 2009). This adaptation of SRI, using plastic mulch, has not been tried in India as far as we know, but it seems promising. And the mulch material need not to be very expensive and can be reused. With such profitability enhancement, the cost is certainly reasonable.

### ***People's Science Institute Experience in Northern India***

In the mountain villages of Uttarakhand and Himachal Pradesh (H.P.), rice is the major food grain sown and grown. However, households with small land holdings (average 1 acre in size) are unable to meet their annual grain requirements with grain yields as low as 2 t ha<sup>-1</sup>.

The People's Science Institute (PSI) based in Dehradun began introducing SRI in these two states over the past three years, starting with 40 farmers in 2006, and then almost 600 farmers in the next year. With extension activities in the two states respectively supported by the SDTT and World Wide Fund for Nature (WWF), the number of farmers using SRI methods was expanded to over 12,000 in 2008: 9,201 in Uttarakhand, and 2,013 in H.P.

In 2008, grain yields with usual paddy-growing methods stood close to 3.6 t ha<sup>-1</sup>, while SRI yields in the two states averaged around 5.5 t ha<sup>-1</sup>, an increase of 53%. The increase in straw yield averaged about 30%, giving farmers more fodder for their cattle and thus increasing milk yields.

In the past *kharif* (2009), 13,225 farmers utilized SRI methods on an area of about 545 ha in 12 districts of Uttarakhand and H.P., less than the target of 16,000 farmers and expected coverage of 897 ha. The shortfall has been mainly due to the drought conditions that prevailed in much of both states and that have affected much of the rest of India. The overall rainfall deficit in both the states was more than 40%, affecting adoption rate and coverage area.

To cope with this situation, PSI and its local NGO partners mobilized farmers to adapt system of crop intensification (SCI) practices for the less favorable climatic conditions, inspired by SRI concepts and experience. Farmers also tried out

adaptations of SRI methods with other crops such as maize, *mandwa* (finger millet), *til* (sesame), *urad* (black gram), *rajma* (kidney bean), soyabean, etc. More than 1,600 farmers have applied SCI practices on these other crops in an area of about 46 ha.

Due to the shortage of rainfall and lack of irrigation facilities, considerable modification of the previously recommended set of practices was observed in SRI fields. These included transplanting somewhat more seedlings hill<sup>-1</sup> (1-3 instead of just one), and somewhat older seedlings (10-25 days old instead of 8-12 days). Spacing between hills was somewhat closer than before, 15-25 cm. These practices compensated for the drier, more desiccating climate though plant populations were still considerably less than with conventional practice.

Most farmers could not practice alternate wetting and drying of their fields in 2009 as recommended since in many places irrigation water was unavailable. This in turn limited the use of mechanical weeder. However, despite the incomplete utilization of the recommended SRI practices, most farmers expressed satisfaction with their SRI crop's performance. Already by August (2009), a difference could be seen as SRI paddy crops compared to those in previous years. SRI plants produced an increased numbers of tillers, 10-18 as compared to 2-4 tillers plant<sup>-1</sup> under conventional crop management (Table 2).

**Table 2. Crop performance in H.P. and Uttarakhand in a drought year of 2009**

| Crop parameters                    | Normal year (at harvest) |       | Drought year (at 75 days) |       |
|------------------------------------|--------------------------|-------|---------------------------|-------|
|                                    | Conventional             | SRI   | Conventional              | SRI   |
| Plant height (cm)                  | 99                       | 122   | 30-45                     | 60-75 |
| No. of tillers plant <sup>-1</sup> | 5-8                      | 10-21 | 2-4                       | 10-18 |

Source: Data from records of PSI, Dehradun

PSI staff have made on crop cuttings from the fields of farmers who used SRI methods during 2009 to assess yields under both irrigated and rainfed conditions in the two states. The results from HP are shown in Table 3. Data from crop cuttings on 95 farmers' fields are summarized in Table 4. These show average grain yields from irrigated and rainfed rice production in the range of 70-100%. The performances of other crops, i.e., kidney bean, finger millet, maize and soyabean, have also been encouraging to observe in the field, although harvested results are not yet known.

**Table 3. Results of irrigated and rainfed SRI crop cuttings in Himachal Pradesh during 2009**

| Condition                            | Irrigated    |     |               |     |       |     | Rainfed        |     |                |     |              |     |       |     |
|--------------------------------------|--------------|-----|---------------|-----|-------|-----|----------------|-----|----------------|-----|--------------|-----|-------|-----|
|                                      | Kangra (GSA) |     | Chamba (RTDC) |     | Total |     | Bilaspur (MVS) |     | Kangra (SWERA) |     | Kangra (ERA) |     | Total |     |
|                                      | Conv.        | SRI | Conv.         | SRI | Conv. | SRI | Conv.          | SRI | Conv.          | SRI | Conv.        | SRI | Conv. | SRI |
| Effective tillers plant <sup>1</sup> | 5            | 24  | 4             | 18  | 5     | 21  | 3              | 15  | 4              | 14  | 5            | 24  | 4     | 18  |
| Plant height (cm)                    | 91           | 113 | 86            | 104 | 89    | 109 | 89             | 97  | 84             | 119 | 86           | 77  | 86    | 98  |
| Paricle length (cm)                  | 19           | 25  | 19            | 30  | 19    | 28  | 19             | 26  | 18             | 28  | 18           | 24  | 18    | 26  |
| Grains paricle <sup>1</sup>          | 115          | 202 | 61            | 192 | 88    | 197 | 86             | 235 | 55             | 205 | 95           | 250 | 79    | 230 |
| Grain yield (q ha <sup>-1</sup> )    | 35           | 60  | 22            | 50  | 29    | 55  | 44             | 70  | 28             | 63  | 30           | 56  | 31    | 63  |
| Straw yield (q ha <sup>-1</sup> )    | 60           | 66  | 72            | 132 | 66    | 99  | 77             | 98  | 40             | 116 | 56           | 90  | 58    | 103 |
| Grain yield increment (%)            | -            | 70  | -             | 127 | -     | 90  | -              | 59  | -              | 125 | -            | 87  | -     | 103 |
| Straw yield increment (%)            | -            | 11  | -             | 83  | -     | 50  | -              | 27  | -              | 190 | -            | 61  | -     | 78  |

Note : Conv. = Conventional

**Table 4. Results of crop cuttings for SRI and conventional paddy production (qha<sup>-1</sup>) during 2009**

| State       | Irrigated Production |     |            | Rainfed Production |     |            |
|-------------|----------------------|-----|------------|--------------------|-----|------------|
|             | Conv.                | SRI | % Increase | Conv.              | SRI | % Increase |
| Uttarakhand | 26                   | 46  | 77         | 11                 | 19  | 73         |
| H.P.        | 29                   | 55  | 90         | 31                 | 63  | 103        |

Interestingly, the yield advantage for SRI methods in H.P. was higher under unirrigated conditions, and about the same in Uttarakhand. The best performance with SRI methods, absolutely and relatively, was under rainfed conditions in H.P. where there was a little more rainfall than in Uttarakhand, enough to nurse the crop through if minimal requirements for soil moisture could be satisfied.

PSI staff have summarized data on yield and components yield both the states during 2009, for both SRI and non-SRI small holder rice production, to compare the results with those obtained in previous, more normal years (2006-08). These comparative data, presented in Table 5, show that while grain yields with conventional cropping methods decreased by 31%, the SRI yields declined on an average by only 13%. Moreover, while non-SRI yields in a drought year stood close to 25 q ha<sup>-1</sup>, the SRI yields averaged almost twice as much, 48 q ha<sup>-1</sup>.

**Table 5. Crop cutting results of 2009, compared to more normal years (2006-08)**

|                                                      | Normal year (Average2 of 006-08)<br>Drought year (2009) |     |              |     |
|------------------------------------------------------|---------------------------------------------------------|-----|--------------|-----|
|                                                      | Convventional                                           | SRI | Conventional | SRI |
| Average no. of effective tillers plant <sup>-1</sup> | 7                                                       | 21  | 5            | 18  |
| Average plant height (cm)                            | 99                                                      | 122 | 88           | 102 |
| Average panicle length (cm)                          | 18                                                      | 24  | 19           | 25  |
| Average no. of grains panicle <sup>-1</sup>          | 93                                                      | 177 | 90           | 174 |
| Grain yield (q ha <sup>-1</sup> )                    | 36                                                      | 55  | 25           | 48  |
| Straw yield (q ha <sup>-1</sup> )                    | 111                                                     | 145 | 51           | 85  |

Source : Data from records of PSI, Dehradun.

Households can get benefit from changing their crop management toward more agroecological methods. Among other advantages, these improve the capacity of soils to absorb and retain water, a critically important function when water supplies are diminished. Also, SRI practices have been seen repeatedly to mitigate the pressures from crop pests, usually greater under drought conditions. Agroecological management that can help farmers cope with both biotic and abiotic stresses will become more salient as these pressures increase in response to climate changes in the future.

### ***PRADAN Experience in West Bengal and Eastern India***

In Purulia district of West Bengal, farmers working with PRADAN encountered very serious dislocations of the cropping calendar due to the delayed monsoon in 2009. Many farmers (1,344) who had planned to use SRI methods, but almost half gave up their plans because their seedlings became too old in the nursery without enough water to prepare their fields and they reverted to traditional methods with older seedlings and higher plant density.

However, 715 farmers who had become firmly convinced of SRI's merits because of prior experience or observation persisted. Most had to abandon the first two nurseries established because the seedlings became too old. But they were able to transplant their third nursery. Fig.2 shows one SRI field at 30 days after transplanting in Purulia during the drought year of 2009. Harvesting was not done then in Purulia, but tiller counts in SRI plots indicated that tillering was good (25-30 plant<sup>-1</sup>). This was 60-70% of what was previously achieved with SRI methods and a normal rainfall pattern.





**Fig. 2. SRI rice field in Purulia, West Bengal during drought season of 2009 at 30 days after transplanting (Courtesy: PRADAN team in Purulia)**

In Gaya district of Bihar during 2008, PRADAN staff found that 25% of the households using SRI methods experienced crop failure due to drought. However, they reported that the crop losses of non-SRI users were even more disastrous in that *Kharif* season.

### **Coping with Other Climatic Stresses**

It appears that the climate benefits of SRI practice can extend in the opposite direction of drought, also being able to buffer rice plants, at least to some extent, against the effects of **cold temperatures**. In *rabi*. (2006), researchers at the Acharya N.G. Ranga Agricultural University (ANGRAU) who were studying the impact of SRI management on pest incidence, happened to document how SRI methods could also confer a surprising degree of protection against the effects of cold temperatures during a critical growth period. Table 6 shows how even five days of ambient temperatures below 10°C did not impair a *kharif* rice crop using SRI methods, while rice plants of same variety in an adjacent plot were rendered unproductive by this stress (Sudhakar and Reddy, 2007).

**Table 6. Effect of cold temperatures on grain yields with SRI and normal management during 2005-06**

| Period                                                                                                          | Mean temperature (°C) |         | No. of sunshine hours |
|-----------------------------------------------------------------------------------------------------------------|-----------------------|---------|-----------------------|
|                                                                                                                 | Maximum               | Minimum |                       |
| Nov. 1 - 14                                                                                                     | 27.7                  | 19.2    | 4.9                   |
| Nov. 16 - 30                                                                                                    | 29.6                  | 17.9    | 7.5                   |
| Dec. 1 - 15                                                                                                     | 29.1                  | 14.6    | 8.6                   |
| Dec. 16 - 31                                                                                                    | 28.1                  | 12.2*   | 8.6                   |
| <b>Season Yield (t ha<sup>-1</sup>) under conventional method    Yield (t ha<sup>-1</sup>) under SRI method</b> |                       |         |                       |
| <i>Rabi</i> , 2005-06                                                                                           | 2.25                  |         | 3.47                  |
| <i>Kharif</i> , 2006                                                                                            | 0.21**                |         | 4.16                  |

\* Sudden drop in minimum temperatures, staying between 9.2-9.8°C, for five days during December, 16-21.

\*\*Low yield due to cold injury

Source : Sudhakar and Reddy (2007)

There will always be some temperatures above or below which no rice or other crop plants, can cope with and yield a product, and some extremes of rainfall or drought that will destroy a crop. So no measures can completely 'climate-proof' local or regional agriculture. But Indian agriculturalists must begin factoring adverse climatic conditions into their production strategies.

More evaluations are needed to draw firmer conclusions about SRI methods in this regard, especially as used for other crops in addition to rice. Evidence is accumulating that agroecological methods can make crops more resilient and more resistant to climate stresses, and also to biotic stresses (insect pests and diseases) which are exacerbated by the heat and water stresses likely to be associated with climate change. An example of SRI crop resistance to **storm damage** is seen in Fig. 3. That SRI method can give higher results in spite of the **flooding** that followed the long drought in 2009 is reported by a farmer in Maharashtra in the accompanying box.





**TNAU trials – after storm passed over the rice fields;  
conventional methods in foreground; SRI methods in center**

**Fig. 3. Trial plots at the Tamil Nadu Agricultural University after a storm has passed over the rice fields (Courtesy : Dr. T. M. Thiyagarajan, TNAU)**

[Note : Conventional methods in foreground; SRI methods in centre]

### **Dealing with Flooding as Well as Drought in Maharashtra**

Moti Lal Khanna, an engineer who took up farming post-retirement, reports the following SRI experience during *kharif*, 2009 on his two acres of land in Maharashtra state:

“My farm is in a very heavy rainfall area. Growing rice in the two fields that I have available to me made sense. Virtually ‘out of the blue’ and as a God-send, I discovered SRI on-line when I needed help in rice cultivation. I read whatever I could find out about it from the Internet and decided to follow its practices, at least in one field. The local residents recommended that I get 8 kilos of rice seed for planting, but I got just two.

When I removed all the blocks in channels created to collect water in the field, to keep it water-logged, my employed workers were dumbfounded. When I wanted the rice seedlings to be transplanted after just 6 or 7 days, I was considered a ‘mad old coot’. I had to innovate a method for spacing the plants evenly, so I used two curtain rods with twine tied at 12” distances. Keeping the poles spread apart, I could lay out 8 planting lines covering a distance of about 12 ‘. A similar pair of curtain rods was used to mark out the cross distances. Both these sets were moved after planting approximately 48 rice saplings.

The other problem was to get the women transplanters to lay the seedlings into the soil carefully and shallow. I ended up planting the first set of seedlings myself. The nine women then, under my constant vigilance, finished half a field in one day, and they finished the second half by mid-day on the second day. We had used less than 25% of the nursery for the SRI plot.

To satisfy the egos of my workers, I asked them to plant the second field in whatever manner they wanted. That stopped all the guffawing, and with a whoop and a holler they finished planting the 2nd field before the day’s end with an hour to spare.

The rains failed in this area this year. Both fields had to be watered manually until the days when the rain would come. The rice crop did reasonably well, however, and was due for harvesting on the 90th day. That was when all hell broke loose. Untimely rains came, and it rained incessantly for 4 days. There was a deluge, and most of the rice lodged. Only about 25% of the plants in the SRI field, and 15% in the other field, remained standing.

On or about the 98th day, after two days of sunshine, the rice crop was cut and threshed in the old-fashioned method of beating bundles of rice stalks on a drum. I recovered 240 kgs of paddy rice from the SRI field, and 110 kgs from the other, both fields being the same size. The rice has still to be polished. The yields were about 3 t ha<sup>-1</sup> and 1.375 t ha<sup>-1</sup>, from the two fields, respectively. The laborers now understand why I asked them to try out the SRI methods for a demonstration.”

## Constraints and Challenges :

SRI represents a paradigm shift within the agricultural sector, and its replication on a larger scale needs a lot of effort for motivating farmers. They are reluctant to add to their already many risks because they have only small landholdings, and they are dependent on the results from a single crop grown during an uncertain monsoon season. Their survival depends on that single crop; so, they need to be firmly convinced of the merits and safety of anything new.

At the outset, without ever having used SRI methods themselves, farmers were of opinion that it is cumbersome and labor-intensive. There was also a lack of training and extension facilities which farmers need to gain both knowledge and confidence. As many government agencies have been reluctant themselves to get involved with this innovation, it is mostly civil society organizations that have been involved in the grassroots for promotion of SRI. However, governments in Tamil Nadu, Tripura, Orissa and some other states are now making efforts to popularize this method through demonstrations and training like farmer field schools (FFS). These efforts are undertaken in cooperation with a number of central government initiatives – the National Food Security Mission (NFSM), the Agriculture Technology Management Agency (ATMA), the National Agricultural Development Program (*Rashtriya Krishi Vikas Yojana*, RKVY), and other channels. There is need for more intensive government initiatives to achieve large-scale replication and up-scaling.

From discussions with farmers in Koraput district of Orissa concerning reasons for non-adoption of SRI or for disadoption, PRAGATI staff have identified the following factors as slowing wider spread :

- Erratic rainfall or unreliable supply of irrigation water is the most certain deterrent, having adverse effects on yield when water stress occurs during critical growth stages, and it affects the feasibility of weed control with mechanical weeder.
- SRI needs regular crop monitoring and timely performance of field operations to get most benefit from the methods. Part-time or unmotivated farmers find this to be problem.
- Lack of certain inputs is a constraint, interfering with performance of certain operations. There is need for availability of labors who are reasonably skilled and motivated for SRI cultivation, and certain implements such as weeder and markers, and organic inputs for making compost;
- Sometimes field conditions may prevent weeding in a timely way, which will affect crop yield, particularly in rainfed upland areas.

The need for **water** presents a limitation for agricultural production generally, not just for SRI, and SRI's lower requirements than conventionally flooded paddy offer some relief for this constraint. But all living things require water, and there will be some absolute limits on when and where SRI can be used. The use of water to

control weeds by inundation is going to have to stop because water is too scarce and too valuable for such use. Where facilities are inadequate for applying smaller but reliable amounts of water to paddy fields, investments in infrastructure will become economically more justifiable, given the higher value of water. Further, SRI gains in productivity can create incentives for farmer cooperation in water management; so, creating the human 'software' for managing water becomes more attractive.

A common constraint in SRI, mentioned in different references, is the need for **weed control**, which is a greater challenge when paddies are not kept continuously flooded. We recommend the use of simple mechanical push weeders, which control weeds by churning them into the soil to decompose, thereby adding nutrition for the crop. Even more important, this makes the soil better aerated, for the benefit of plant roots and diverse soil organisms. In many places, there are serious limitations on the availability of weeders, however, and often their design is not optimal, or they are not well-made.

Few things could give more impetus to wider SRI utilization resulting higher output and water saving, enhanced income for farmers, eventually lower food prices for consumers, and environmental benefits than ensuring the availability of well-designed, well-built weeders appropriate to local conditions throughout the country. Engineers, farmers, blacksmiths and manufacturers should be able, working together, to design and manufacture motorized versions of the SRI weeder that are effective and not too expensive. This would reduce the time needed for weeding and could achieve even better soil aeration-cum-weed removal.

For government to give out weeders to farmers does not appear advisable because free weeders may not be of best design or durability. Weeders are not expensive implements, and can be shared; so, private-sector manufacturers and suppliers should be encouraged to compete and innovate in meeting what we think will be a growing demand for quality weeders.

In some places, the supply of **biomass** may not be sufficient to meet soil needs for supplementary nutrients and, as important, enough organic matter to improve soil structure and functioning. Compost should not be assessed or used simply as an alternative form of fertilizer to raise stocks of nutrients. It is more beneficial than the amounts of N, P and K that compost contains. Where there is not enough biomass for fully organic fertilization of SRI soils, chemical fertilizer can be used with beneficial effect. But factorial trials have showed compost to be superior to fertilizer when used with the other SRI practices (Randriamiharisoa and Uphoff, 2002). Given the benefits of organic fertilization, it makes sense for researchers and farmers to experiment with ways to increase that supply, e.g., with vermicompost.

The extension of SRI concepts and methods to **other crops** like wheat and sugarcane (Anon., 2009a) also warrants more experimentation and evaluation, to contribute to an agricultural sector that is more agroecologically-oriented and

enabled to cope with the adverse effects of climate change. All of these innovations will aim at conserving resources, producing more output with less expenditure on inputs.

While there will be limits on the extent to which more can be produced with less, our previous privileging of engineering and chemical solutions over biological ones has biased our agricultural development in directions that are economically and environmentally costly. For the 21<sup>st</sup> century, especially with the pressures and hazards of climate change, it will be important to learn to capitalize on some of the opportunities that are embedded in the co-evolution of flora and fauna with their microbial progenitors (Margulis, 1998).

**Acknowledgement :** We would like to express appreciation to Dinabandhu Karmakar and Avijit Choudhury with the PRADAN team in Purulia district, West Bengal, for their inputs of experience and data from PRADAN's work with communities on SRI in that area.

#### **References :**

Altieri, M. (1995). *Agroecology: The Science of Sustainable Agriculture*. Westview Press, Boulder, CO.

Anonymous. 2009a. *Sustainable Sugarcane Initiative: Improving Sugarcane Cultivation in India – Training Manual*. Dialogue Project on Food, Water and Environment. International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) and World Wide Fund (WWF) for Nature, Patancheru, Andhra Pradesh.

Anonymous. 2009b. Available at : <http://ciifad.cornll.edu/sri/countries/china/ChinalSichuanDroughtResist09.pdf> (Accessed on Oct. 30, 2009).

Bera, S. 2009. A magic wand for hungry stomachs. *Tehelka Magazine* 6 : 18, May 9. Available at : [http://www.tehelka.com\\_story\\_main41.asp?filename=cr090509a\\_magic.asp](http://www.tehelka.com_story_main41.asp?filename=cr090509a_magic.asp) (Accessed on Oct. 30, 2009).

Coleman, D.C., Crossley, D. A. and Hendrix, P.F. 2004. *Fundamentals of Soil Ecology*, 2<sup>nd</sup> edition. Elsevier, Amsterdam.

Doberman, A. 2004. A critical assessment of the system of rice intensification (SRI). *Agricultural Systems* 79 : 261-281.

Gani, A., Kadir, T.S., Jatiharti, A. , Wardhana, L.P. and Las, I. 2002. The System of Rice Intensification in Indonesia. (in) *Assessments of the System of Rice Intensification: Proceedings of an International Conference*, April 1-4, Sanya, China, (Uphoff, N., Fernandes, E.C.M., Yuan, L.P., Peng J.M., Rafaralahy, S. and Rabenandrasana, J., eds.). CIIFAD, Ithaca, NY : 58-63.

Gliessman, S. 1998. *Agroecology: Ecological Processes in Sustainable Agriculture*. Ann Arbor Press, Chelsea, MI.



Kassam, A. and Stoop, W.A. 2005. The System of Rice Intensification controversy: A response. *Field Crops Research* **91** : 357-360.

Laulanié, H. de. 1993. Le système de riziculture intensive malgache. *Tropicultura* **11** : 110-114.

Lv, S.H., Zeng, X.Z. , Ren, G.J. and Zhang, F.S. 2009. Introduction of the land-cover integrated technologies with water saving and high yield. *Journal of Sichuan Agricultural Science and Technology* **2** : 23.

Margulis, L. 1998. *Symbiotic Planet: A New Look at Evolution*. Basic Books, New York.

McDonald, A.J., Hobbs, P.R. and Riha, S.J. 2006. Does the System of Rice Intensification outperform conventional best management? A synopsis of the empirical record. *Field Crops Research*, 96 : 31-36.

Prasad, A. 2008. Going against the grain: The system of rice intensification is now being adapted to wheat – with similar good results. *Outlook Business*, New Delhi, Oct. 18.

Randriamiharisoa, R. and Uphoff, N. 2002. Factorial trials evaluating the separate and combined effects of SRI practices. (in) *Assessments of the System of Rice Intensification*, (Uphoff, N., Fernandes, E., yuan, Y.P., Peng, J.M., rafaralahy, S. and Rabenandrasana, J., eds.). CIIFAD, Ithaca, NY : 41-47. Available at : [http://ciifad.cornell.edu/sri/proc1/sri\\_10.pdf](http://ciifad.cornell.edu/sri/proc1/sri_10.pdf) (Accessed on Oct. 30, 2009).

Sheehy, J.E., Peng, S.B. , Dobermann, A., Mitchell, P.L., Ferrer, A., Yang, J.C. , Zou, Y.B. , Zhong, X.H. and Huang, J.L. 2004. Fantastic yields in the system of rice intensification: Fact or fallacy? *Field Crops Research* **88** : 1-8.

Sinha, S.K. and Talati, J. 2007. Productivity impacts of the system of rice intensification (SRI): A case study in West Bengal, India. *Agricultural Water Management* **87** : 55-60.

Sudhakar, T.R. and Reddy, P.N. 2007. Influence of System of Rice Intensification (SRI) on the Incidence of Insect Pests. Powerpoint presentation to 2<sup>nd</sup> National SRI Symposium, Agartala, Tripura, India. Available at : [http://ciifad.cornell.edu/sri/Countries/India/TripuraPPTs07/Agartala23\\_PestswithSRI\\_ANGRAU.ppt](http://ciifad.cornell.edu/sri/Countries/India/TripuraPPTs07/Agartala23_PestswithSRI_ANGRAU.ppt) (Accessed on Oct. 30, 2009).

Thakur, A.K., Uphoff, N. and Antony, E. 2009. An assessment of physiological effects of system of rice intensification (SRI) practices compared to recommended rice cultivated practices in India. *Experimental Agriculture* (in press).

Uphoff, N., ed. 2002. *Agroecological Innovations: Increasing Food Production with Participatory Development*. Earthscan, London.



Uphoff, N. 2010. Agroecological approaches to 'climate-proof' the agricultural sector while also raising its productivity in the 21<sup>st</sup> century. Conference paper being published in proceedings by John Wiley & Sons.

Uphoff, N., Ball, A. , Fernandes, E.C.M. , Herren, H., Husson, O., Laing, M., Palm, C.A., Pretty, J.N., Sanchez, P.A., Sanginga, N. and Thies, J., eds. 2006. *Biological Approaches to Sustainable Soil Systems*. CRC Press, Boca Raton, FL.

Uphoff, N., Stoop, W. A. and Kassam, A. 2008. A critical assessment of a desk study comparing crop production systems : The example of the 'system of rice intensification' vs. 'best management practices.' *Field Crops Research* **108** : 109-114.

Uphoff, N. and Mishra, A. 2009. 'Climate-proofing' : Opportunities with the system of rice intensification. *The Hindu Survey of Indian Agriculture* : 12-13.

Wardle, D.A. 2002. *Communities and Ecosystems: Linking the Aboveground and Belowground Components*. Princeton University Press, Princeton, NJ.

Zhao L.M., Wu, L.H. , Li, Y.S., Lu, X.H., Zhu, D.F. and Uphoff, N. 2009. Influence of the system of rice intensification on rice yields and nitrogen and water use efficiency with different application rates. *Experimental Agriculture* **45** : 275-286.