SRI: Produce more rice with higher resource use efficiency and minimal environmental degradation.

Review of experiences and lessons on SRI in India

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1. Rice in the Country

India has the world's largest area devoted to rice cultivation, and it is the second largest producer of rice after China. Over half of its rice area is irrigated, contributing 75% of the total production, but also consuming 50-60% of the nation's finite freshwater resources. Of the country's 1.15 billion inhabitants, 70% rely on rice for at least a third of their energy requirements. India's population is projected to grow to 1.6 billion in 2050, putting tremendous strain on its land and water resources.

India shares around 21 % of global rice production from about 28 % of rice area. Rice area in India fluctuates around 43 million hectares and was at a maximum of 45.5 million hectares in 2008-09. Total rice production was also the maximum (99.2 million tonnes) during this year. Rice productivity which was at 668 kg/ha in 1950-51 had reached a maximum of 2202 kg/ha in 2007-08. The growth rates of rice area, production and productivity during 1994-95 to 2009-10 were (-) 0.04, 1.15 and 1.04 respectively. The estimate for 2009-10 and 2010-11 (Table 1) shows the alarming downward trend in rice area and production. The impact of the delayed and sub-normal monsoon was reflected in reduced area under rice cultivation during 2009-10 over 2008-09 by 14.3 per cent. (Annual Report 2009-10, NABARD).

The current productivity is much lower than many other rice producing countries and need to be enhanced under the circumstances of less hope for increase in area and irrigation potential. During the last decade the percent irrigated rice area has been fluctuating around 53 % showing no appreciable increase.

Table 1. Rice area, productivity and production (milled rice) in India

Year	Area (million hectare)	Productivity (kg/ha)	Production (million tonnes)
1950-51	30.8	668	20.6
2006-07	43.8	2131	93.3
2007-08	43.9	2202	96.7
2008-09	45.5	2178	99.2
2009-10*	41.9	2130	89.1
2010-11**	37.0	2177	80.4

* Fourth advanced estimates as released on 19.07.2010

** First advanced estimates as released on 23.09.2010

Source: Directorate of Economics and Statistics, 2008. Agricultural Statistics at a glance 2010. Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India, New Delhi.

Export of milled rice from India was a mere 0.5 million tonnes 1989 but reached a maximum of 6.7 million tonnes during 2001.

India's post-independence agricultural growth involved huge investments in irrigation projects that resulted in more than a tripling in the gross irrigated area from 22.6 million hectares (1950-51) to 76.3 million hectares (1999-00). This has contributed to a drastic reduction in per capita fresh water availability, from 5,410 cubic metres to 1900 cubic metres during that period. The greatest growth of irrigation has been through the installation of wells. In some regions, over- exploitation of ground water supplies through pump extraction is leading to serious declines in ground water levels. India is the largest user of groundwater in the world (over a quarter of the global total); 60% of irrigated agriculture and 85% of drinking water supplies are dependent on groundwater. According to the World Bank, if current trends continue, in 20 years about 60% of all aquifers in India will be in a critical condition. This will have serious implications for the sustainability of agriculture, long-term food security, livelihoods, and economic growth. It is estimated that over a quarter of the country's harvest will be at risk. There is an urgent need to change the status quo.

Rice cultivation is in crisis world over and India is no exception with shrinking area of rice cultivation, fluctuating annul productions, stagnant yields, water scarcity and escalating input costs. The cost of cultivation of paddy has consistently been increasing owing to escalating costs of labour and inputs. With increasing labour scarcity due to urbanization, sustaining the interest of the farmers in rice cultivation itself has become a challenge.

The future of country's rice production will depend heavily on developing and adopting strategies and practices that will use irrigation water efficiently at farm level. The country needs to increase its paddy production at the rate of 3.75 million tonnes per year until 2050 to meet its food security. The paddy productivity in many states requires to be enhanced from the current level.

2. Introduction of SRI in the Country

Introduction of SRI in India happened in 2000 in Tamil Nadu, Puduchery and Tripura. In Tamil Nadu, Tamil Nadu Agricultural University (TNAU) initiated experiments involving SRI principles and one farmer tried SRI under organic farming. The source of information on SRI was from Dr.Uphoff for TNAU and the farmer had learnt from LEISA. In Tripura some preliminary evaluation of SRI principles was initiated by the Department of Agriculture and demonstrations were organized from 2003. In Puduchery, SRI was tried from 2000 by Auroville Farm. When the Acharya N.G. Ranga Agricultural University (ANGRAU) introduced SRI in farmers' fields during *kharif* 2003, directly from the knowledge gained from Sri Lanka, the experience generated nationwide interest. Today SRI is known to all rice-growing states of the country and a major role has been played by CSOs especially in the northern and eastern states. The role of Donor agencies like WWF-ICRISAT project, SDTT, NABARD has been critical in promoting SRI through CSOs.

As far as research on SRI is concerned, experiments were undertaken in IARI in 2002 itself. The Directorate of Rice Research and Central Rice Research Institute initiated experiments on SRI from 2003 and 2005 respectively. Many other NARs had taken up experiments on SRI after 2005. SRI was introduced in the National Food Security Mission, as a method to improve rice production in the country in 2006.

Table 2. Introduction of SRI in different parts of India

S.No	Year	State	Introduced by
1	2000	Tamil Nadu	Tamil Nadu Agricultural University, Ramasamy Selvam (Organic farmer)
		Tripura	Dept.of Agriculture
		Puduchery	Auroville Farm
2	2001	Karnataka	Narayana Reddy, Organic farmer
3	2002	Bihar	Rajendra Agricultural University
4	2003	Andhra Pradesh	Acharya NG Ranga Agrl. University, Timbaktu Collective
		West Bengal	PRADAN
5	2004	Kerala	Mitraniketan KVK
		Andaman	Central Agricultural Research Institute
		Orissa	Central Rice Research Institute
		Punjab	Dept. of Agriculture
		Assam	Assam Agrl. University
		Gujarat	Anand Agricultural University
6	2005	Chattisgarh	Indira Gandhi Krishi Vishwavidyalaya
		Maharashtra	Dr Balasaheb Sawant Konkan Krishi Vidyapeeth
		Uttrakhand	Govind Ballabh Pant University of Agriculture & Technology
		Meghalaya	ICAR Research Complex for NE region
		Jharkhand	Birsa Agricultural University
7	2006	Himachal Pradesh	Peoples' Science Institute
		Jammu & Kashmir	Sher-E-Kashmir University of Agricultural Sciences & Technology
		Nagaland	'Prodigals Home'

After 2006 SRI has spread to almost all rice growing states.

3. Progress of SRI in the Country

The dissemination and adoption of SRI in India is in different scales in different parts of the country. Following successful results from on-farm evaluations, SRI was taken up for large-scale adoption in Tamil Nadu and Tripura by the state Governments. The World Bank supported IAMWARM project took up SRI as one of the important technologies for enhancing water productivity and rice yield in Tamil Nadu. In Tripura, research part was taken solely under State Plan and popularization/ adoption in the farmers' fields were taken through convergence of State Plan and Macro Management Scheme of GOI. The Panchayat Raj Institute is collaborating in the demonstrations across the state. In other parts of the country, CSOs played a major role in popularizing SRI. SRI is embraced by organic farmers also.

A national movement to promote SRI was taken up from 2006 by organizing national symposia, establishing Google groups and websites, publishing News Letters and developing policy frameworks by the initiatives and support of several agencies. Similar efforts were taken up in some states also. The Learning Alliance formed in Orissa is a typical example of convergence of agencies in promoting SRI, a new

happening in Indian agriculture. Funding support from WWF-ICRISAT project, SDTT, NABARD has helped several NGOs to take up SRI to the fields of remote and tribal areas.

Efforts have also been taken to develop a National Policy on SRI adoption and scaling up. A big initiative has now been taken up to establish a National SRI Consortium to streamline and guide the promotion and scaling up of SRI. A similar move is also taking shape in Andhra Pradesh to establish a state level consortium.

SRI has been adapted to rain fed conditions also by several CSOs. The principles of SRI have been applied to other crops like sugarcane, wheat, finger millet, red gram, etc, with success stories.

4. Experiences in on-farm evaluation, research and extension

On-farm Evaluation

All the agencies involved in promoting SRI started with on-farm evaluations and demonstrations combining with trainings. First evaluations commenced in 2003 in Tamil Nadu, Tripura and Andhra Pradesh and later by several CSOs in different parts of the country. Results of such evaluations showed yield advantages of 1.5 t/ha in Tamil Nadu, 1.67 t/ha in Andhra Pradesh. In Tripura, the Department of Agriculture started SRI demonstrations in 2002-03 and the number increased from 44 to 1,62,485 in 2007-08. The results with different land races, high yielding varieties and hybrids showed that irrespective of the varieties, yield increases under SRI were up to 100 %.

WWF-ICRISAT project supported systematic evaluation of SRI methods by ANGRAU and CROPS, a local NGO in Warangal, through on-farm field trials in 11 districts of Andhra Pradesh over several years, starting with the *Rabi* season of 2004-05.

The evaluations carried out by PSI (Peoples' Science Institute, Dehradun) in Himachal Pradesh and Uttarakhand (2007) showed an average increase in yield of 89 % over conventional cultivation.

Scaling up of SRI adoption

Large-scale initiatives in promoting SRI were taken in Tamil Nadu and Tripura by the respective state Governments. In Tamil Nadu, TNAU is promoting SRI in 63 river sub-basins from 2006 through the World Bank funded IAMWARM project. The state Agricultural Department has planned to cover 1/3rd of rice area under SRI.

WWF-ICRISAT project supported NGOs in Andhra Pradesh, Karnataka, Himachal Pradesh in promoting SRI and began working with other interested institutions and individuals so that the opportunities, which SRI was showing, could have more national impact. WWF thus took the initiative to develop a national platform to facilitate: 1) collaborative synergies among key stakeholders, namely national and state rice research institutes, agricultural universities, civil society organisations, municipal officials, and donors; 2) research and extension activities; 3) synthesis and sharing of information; and 4) dialogue among stakeholders from the farm level to national level. In addition to hosting a national SRI website [www.sri-india.net] and producing, together with government, academic and NGO partners, SRI-related

reports, newsletters, manuals, proceedings, fact sheets, and case history compendiums, the WWF-ICRISAT project has organized three national symposia on SRI. These symposia have served many purposes: facilitating cross-learning, supporting the development of networks of interested individuals and groups, strengthening the efforts of farmer- innovators, and refining the research agenda for persons engaged with elucidating the issues concerning SRI.

PRADAN started promoting SRI in 2003 with 4 families, which grew up to 6200 families in 2006. In 2008, 43.7 % of farmers in Purulia harvested 6-8 t/ha yield and 24 % harvested 8-10 t/ha yield. People discontinued SRI practices when crop failed (either nursery or transplanted field) due to drought.

The Peoples' Science Institute (PSI) started with 40 farmers in 2006 and could reach 12,009 farmers in 2008 in Uttarakhand and Himachal Pradesh.

SRI programme was adopted by the Sir Dorabji Tata Trust (SDTT) under its Natural Resources and Rural livelihoods initiative that had identified "Food Security for Small and Marginal Farmers" as a key focus area for its 2007-12 country programme and allocated Rs 10.94 crores for a dedicated program on SRI. Currently it is collaborating with 161 NGO partners in 104 districts of 10 states and 65,000 farmers. SDTT has also set up a SRI secretariat at Bhubaneshwar.

NABARD has taken a multipronged approach in popularizing SRI technology. Combination of awareness creation, capacity building method and result demonstration to the farmers has been adopted. The community based organizations such as Farmers' club, NGOs, Primary Agriculture Cooperative Societies (PACS)/ Samabai Krishi Unnayan Samity (SKUS) and banks have been involved in the process. Approach starts with identification of area where paddy cultivation is more concentrated and farmers are eager to adopt new technologies.

Research

Standard experiments on SRI were first initiated in TNAU from 2000 onwards and still SRI related research is going on in the University. The experiments conducted during 2000 – 2002 were aimed at understanding the influence of SRI principles on crop growth, crop physiology, rhizosphere soil dynamics and soil microbiology. Water saving was to the extent of 47 % without detrimental effect on yield. The most important result was the significant effect of weeder use on grain yield. Since then, several experiments are still being conducted. After 2003, some sporadic studies by scientists across the country were being conducted. The National Symposia on SRI organized during 2006, 2007 and 2008 provided opportunity to bring together information collected from such scientific studies. These studies were on comparing the performance of SRI vs. conventional cultivation, effect of changes in seedling age, spacing etc., effect of SRI on pest and diseases, water productivity, nutrient uptake and SRI adoption dynamics etc.

The Directorate of Rice Research (DRR) organized experiments at different irrigated rice sites in India and in clay loam soil at the Directorate of Rice Research farm during 2005-09 to assess the potential of SRI in comparison to transplanting (TP) under flooded condition. Contrary to the perception that SRI method is genotype neutral, significant differences were observed between the varieties under SRI. In general, it was observed that hybrids (4 - 42% yield advantage) performed better over the varieties (2 -17%) under SRI as against ST. The hybrids KRH2, HRI 126 and PHB-71 and DRRH2 performed better as compared to the varieties. Among the SRI

management practices, seedling age ranging (from 8 to 32 days) indicated superiority of young seedling age (8 days) for higher productivity. Among nutrient management practices, application of organic + inorganic (50:50) found promising (5.72 t/ha) over 100% inorganic or 100% organic alone. Dehydrogenase activity, a measure of microbial activity in the soil increased by 23% in the rhizospheric and bulk soil during vegetative stage as compared to TP. Even though SRI resulted in higher productivity, the nutrient uptake was similar with marginally higher nutrient use efficiency (8, 8 and 12 % of N, P and K) without depleting the available nutrients compared to TP during the initial two seasons. SRI method saved the water application to the tune of 25-38% depending on the season (wet and dry) without affecting the grain yield. Comparison of SRI vs. TP at research farms across the locations (25 Nos.) representing different soil and climatic conditions resulted in higher grain yield ranging from 6 to 65 % at majority of locations wherein SRI performed consistently (Mahendrakumar *et al*., 2010)

In a systematically conducted experiment supported by WWF-ICRISAT project at Hyderabad in the rabi season of 2009-10, SRI crops under organic and inorganic nutrient management resulted in 8.1 and 8.2 t ha^{-1} grain yield with 12.6 and 13.7% yield increase over control, respectively. Careful measurement of water use showed that water productivity is higher under SRI and the water savings reached 37.5% and 34.2% under SRI-Organic and SRI, respectively.

Detailed studies conducted by Thakur *et al*. (2009) presented scientific explanations of the effect of SRI and showed that alterations in management practices can induce multiple, significant, and positive changes in phenotype from a given rice genotype. The increase in yield with SRI when compared with those used with recommended management practices reached 42% and it was associated with various phenotypical alterations such as longer panicles, more grains panicles, higher percent of grain-filling, increased productivity per plant, deeper and better distributed root systems, higher xylem exudation rates, more open plant architecture with more erect and larger leaves, more light interception, higher leaf chlorophyll content at ripening stage, delayed senescence and greater fluorescence efficiency, higher photosynthesis rate, and lower transpiration.

Research on SRI is also being carried out by CSOs to some extent in nutrient management, spacing etc., The study conducted by Ravindra and Bagyalakshmi (2010) in Andhra Pradesh showed that the SRI farmers in the 2009–2010 season had an 18% yield advantage, with a much higher increase in their net returns per hectare (52%) due to reductions in the cost of production. There was 90% reduction in seed costs, 36% lower labor costs, and 52% reduction in water use at field level, resulting in substantial electricity savings.

Constraints in adoption, scaling up and research

Constraints in adoption of SRI are location specific but lay on the mindset of the farmer (willingness to change, need for more attention), mindset of labourers (lack of experience in handing young and single seedling and planting in squares, more concentration, etc.). Other constraints are inadequate education on SRI, local soil conditions, water availability, availability and quality of weeders.

Lack of adequate policy and financial support from Governments is one of the major constraints in scaling up SRI adoption.

Research in SRI was limited to TNAU and ANGRAU in the beginning but slowly ICAR institutes (DRR, CRRI and Regional Centres) and other Agricultural Universities have started working on SRI. There is more to be done on research as many questions on the effect of SRI principles on soil and plant system remain unanswered. Also there is no study on the long term effect of doing SRI on the soil fertility.

SRI is a case of 'land to lab'. New crop production techniques come from research establishments after careful experimentation and evaluation. SRI has not come through that channel but is being followed by several thousand farmers. Still, SRI requires research support not only to explain how it makes the difference from conventional and existing recommended practices but also to understand the effect of the modified agronomic practices on the soil-plant-water system. Though considerable research efforts are there, there is no systematic and organized research to address the issues concerning SRI and more importantly there are no national policies and institutional mechanisms for investment in SRI research.

5. Future of SRI in the Country

- Educating the farmer to change his views on rice cultivation by multipronged approaches involving demonstrations, trainings, exposure visits, acquiring skills is crucial in SRI adoption.
- improved irrigation service delivery in major irrigation schemes
- Providing the most suitable weeder in adequate numbers to a particular location
- Eliminating the constraints related to disadoption by local analysis is important towards sustainability of SRI adoption
- There needs to be policies and institutional mechanisms for designing and delivering a common strategy for the investment on scaling up and research.
- A definite policy framework to achieve an increase in rice production by 10-20 % through SRI has to be made at national level.

6. Any other remarks

Currently about Rs. 48 crores of funds (NFSM: 8 crores; NABARD: 16 crores; SDTT 24 crores) have been allocated by major donor agencies. This is a welcome and appreciable sign towards scaling up of SRI in the country. But this will not be sufficient to carry out the task in a larger scale. Involvement of the apex research agency like ICAR in a much strong way is important.