Farmer Innovations Improving the System of Rice Intensification (SRI)

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Abstract

The System of Rice Intensification, assembled in Madagascar over a 20-year period and gaining application internationally since 2000, enables farmers to raise their irrigated rice production substantially just by making changes in the way they manage their plants, soil, water and nutrients, rather than by increasing inputs such as fertilizer, water and agrochemicals. Getting more output with less cost enhances profitability. This result is quite unprecedented, as discussed in a parallel paper for this workshop.

SRI is not considered as a 'technology,' and by not presenting it to farmers as a standard kind of technology, this opens SRI up to many adaptations and innovations by farmer-users, often but not always in collaboration with NGO or government staff who are working in a collaborative model. This paper reports on some of the innovations that have been and are being made in SRI practices, while another paper written for this workshop which considers SRI as a system for innovation, augments this presentation.

INTRODUCTION

SRI was not regarded at a technology either by its originator – Fr. Henri de Laulanié, S.J. (1993, 2003) – or by the NGO that he established with Malagasy friends in 1990 to disseminate its benefits, *Association Tefy Saina*. SRI was developed inductively, by observation and experiment, not shaped by scientific theory or any *a priori* reasoning. Accordingly, it has had difficulty gaining acceptance from 'mainstream' agricultural authorities, even though the evidence supporting it is very strong and continues to accumulate. That SRI methods produce more output with less input makes it suspect in a world where we are told that there is 'no free lunch,' and where financial interests reinforce a preoccupation with input-centered innovation.

SRI capitalizes on existing genetic potentials within the rice genome that have been inhibited or suppressed by sub-optimizing management practices. SRI methods yield more productive phenotypes as practically all genotypes of rice (*Oryza sativa*) respond well to SRI practices. Its methods achieve higher productivity of land, labor, capital and water, in part by mobilizing the services of soil biota that can benefit plant health and growth (Randriamiharisoa et al., 2006). To be effective, soil organisms, which range from microscopic to visible size, require supportive conditions that enhance their abundance, diversity and activity – appropriate soil structure, levels of soil organic matter, oxygen, temperature and moisture within certain ranges to maintain fertility of dynamic soil systems (Uphoff et al., 2006).

Such conditions depend more upon knowledge and management than upon capital expenditure. Indeed, many of the practices that have been introduced for 'modern' agriculture based on capital inputs have negative effects on soil systems. Use of heavy machinery compacts the soil; plowing reduces soil organic matter and nitrogen stores; large applications of inorganic fertilizer and agrochemical crop protection can alter the diversity and balance of species living within soil systems, making them ultimately less fertile and resilient and more vulnerable to losses caused by pests and diseases.

Many farmers have some intuitive sense of this even if they do not have scientific knowledge to explain their observations. Fr. Laulanié did not set out to develop an 'organic' system of agricultural production. Initially he used the other practices that he had assembled with chemical fertilizer because this was expected to increase crop yields most quickly and reliably. Only when government subsidies for fertilizer were removed in the late 1980s did he start using compost, discovering that it could give even better yields when used with the other SRI methods -- and at lower cost to the cash-constrained farmers with whom he worked. There are, however, times and places where some use of chemical fertilizer with SRI methods will be beneficial for farmers and compatible with soil-system health. So, SRI is a two-track system with 'organic SRI' being an important but not exclusive version of the original system. Most SRI is practiced with some reduction in chemical fertilizer and with increased organic fertilization. SRI is thus 'organic' pragmatically rather than theoretically, being concerned with 'whatever works for farmers.'

This is the central theme of SRI: whatever works for the farmer. Farmers vary, of course, in terms of the sizes of their landholdings, the extent of their household labor supply, the characteristics of their soils, the amount and reliability of water available to support their crops, accessibility of markets for both input acquisition and sale of products, etc. There is no single standard 'farmer.' Proponents of SRI have thus resisted standardizing and thereby homogenizing SRI. Instead, they take satisfaction and find benefit in the diversity of applications to which the core ideas of SRI (see below) have led.

This has been a cause of some frustration, and even of some hostility, from scientists who want to reduce SRI to a fixed, invariant set of practices. However, SRI is what it is: something unusual in the history of agricultural innovation, a methodology that can *produce more outputs from less inputs*. Possibly it will give impetus for new thinking and new paradigms for agricultural development in general. The proliferation of farmer contributions to improving SRI --and to adapting it to many different problems, different environments and even different crops – may be traced in large part to the novel nature of SRI. The discussion that follows documents some of the inventiveness of farmers for creating more and better opportunities to meet food security and livelihood needs, realizing that this may be done in cooperation with non-farmers or with intermediaries who share farmers' aspirations.

SRI CONCEPTS AND PRACTICES, PROBLEMS AND OPPORTUNITIES

The System of Rice Intensification changes a number of practices that farmers have used for centuries, even millennia, to grow irrigated rice. However, it should be understood that SRI is more than these practices. It is the concepts, ideas and principles preceding and justifying the practices that are the crux of SRI. The alternative methods are manifestations of a different way of thinking about and pursuing agricultural production. The techniques that Fr. Laulanié put together which represent operationally what has come to be known as SRI can be summarized as follows (Uphoff, 2005):

Conventional practice	SRI practice
Transplant **older seedlings**, 20-30 days old, or even 40-60 days old in traditional practice	Transplant **young seedlings**, 8-12 days old, and certainly less than 15 days old, to preserve subsequent growth potential
Transplant seedlings in **clumps of plants** and fairly **densely**, 50-150 plants m^2	Transplant seedlings **singly**, one per hill, and in a **square pattern**, 25x25cm, or wider if or when the soil is more fertile[1]
Maintain paddy soil **continuously flooded**, with standing water throughout the growth cycle	Keep paddy soil **moist, but not continuously saturated**, so that mostly aerobic soil conditions prevail
Use **water** to control weeds, supplemented by **hand weeding** or use of **herbicides**	Control weeds with **frequent weeding** by a **mechanical hand weeder** (rotating hoe or cono weeder) that also ***aerates the soil***
Use **chemical fertilizers** to enhance soil nutrient supply	Apply as much **organic matter** to the soil as possible; can use chemical fertilizer, but best results from compost, mulch, etc.

[1] Also, transplant seedlings ***quickly*** – getting them replanted within 15-30 minutes after removal from their nursery; ***shallow*** – only 1-2 cm deep; and ***gently*** – taking care to minimize any trauma to the roots, and not plunging the seedlings down ***vertically*** into the soil, which inverts the roots tips so that they point upwards and their resumption of growth is delayed while their tips reorient downward. For SRI, seedlings are slipped into the soil ***horizontally*** so their root tips are not inverted, speeding the restoration of growth.

Also, because SRI plants are more resistant to damage by pests and diseases, there is usually little or no need for agrochemical protection. SRI can thus be practiced without any chemical inputs, although these can be used as an option. Undertaking SRI should be done in a spirit of pragmatism, rather than one of dogmatism. SRI is a strategy for mobilizing plant growth potentials, so it is really a matter of ***degree*** rather than of ***kind***. One should ask: *how much and how well are these different practices utilized?* Instead of asking: *is this SRI or not?* To what extent, and how well, are SRI practices (operationalizing SRI concepts) being implemented?

Farmers adopt the SRI principles according to their specific conditions. For example, if their seedlings are old, farmers should reduce the wider spacing, or if there is too much water and it is difficult to drain, they can use older seedings and reduce their spacing, but still transplant one or two seedings. Farmers who understand SRI ideas will adapt its principles on age of seedling, width of spacing, and number of seedlings to meet their specific conditions.

Because SRI practices are novel, and are even counter-intuitive, they often require ***more labor time*** when first taken up. SRI transplanting takes more time when farmers are first getting accustomed to handling tiny seedlings. Once farmers become more skilled and confident, the process goes more quickly and can even become ***labor-saving*** because SRI reduces plant populations by 80-90%. Its seed rate is only 8-10 kg/ha, and possibly as low as 5 kg/ha, compared with ~50 kg or more with usual practice. If farmers who have not used the mechanical hand push-weeder (rotary hoe) before find that it takes some time to become proficient and quick with this.

SRI has been characterized as **labor-intensive** -- indeed so labor-intensive that this constitutes a barrier to adoption or a cause for disadoption (Moser and Barrett, 2003). However, evaluations in Cambodia (Anthofer, 2004), China (Li et al., 2005), India (Sinha and Talati, 2007), and Indonesia (Sato and Uphoff, 2007) have shown SRI methods to be labor-neutral or even labor-saving. Farmers who have gained experience and facility with the new methods find that they can reduce their labor inputs.

Even so, the main constraint that farmers have pointed to when questioned about SRI adoption has been **labor requirements**, and the fact that with SRI certain operations like transplanting and weeding are more 'time-bound.' To get the most enhancement of production, these key operations need to be performed in a timely way. Since transplanting is the most labor-intensive of the SRI operations, finding **alternative methods of crop establishment** has been attractive to many farmers. Also, given that there is growing evidence that tillage itself has negative consequences for soil systems, methods of establishing rice crops without tillage, i.e., zero-tillage or no-tillage, are of much interest to farmers.

One of the most attractive features of SRI is its **reduction of water requirements** for irrigated rice, by 25% or even 50% or more, when paddies are no longer kept continuously flooded (Satyanarayana et al., 2006). Farmers are quite eager to reduce they demand for water provided that labor requirements are not disproportionately increased relative to the benefits of using less water. There probably is scope for further reducing the water needs with SRI, since Laulanié's recommendations were entirely empirical without systematic evaluation of alternative regimes.[2] Thus far, there has not been much experimentation by farmers to test the limits of water reduction without curtailing yield. But in any case, being able to apply small amounts of water reliably on an as-needed basis is an objective need for SRI.

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[2] The recommendation of alternate wetting and drying (AWD) up to the stage of panicle initiation (PI) -- but then keeping a thin layer of water (1-2 cm) on the field until 20-30 days before harvest -- was probably a compromise by Laulanié, assuming that it was would be to difficult to get farmers to stop flooding their paddy field for the entire season. An NGO partner in southern India (Timbuktoo Collective) says that it gets satisfactory results by extending AWD for the whole season, with much saving of water. If plants' root systems have been well developed during the vegetative growth period (because fields have not been kept flooded), intermittent applications of water after PI should be sufficient since there is usually water available in lower soil horizons that can be tapped by SRI plants' larger, deeper root systems.

With SRI, there is also a premium placed on providing the soil with amendments of **organic matter**. Sometimes there is simply not enough supply of biomass available within the environment, e.g., when the climate is arid or semi-arid. However, often it is the labor required to acquire, transport, process and apply vegetation or organic wastes in fields that is the constraint. Little research has been done on how to increase the supply of organic matter available for application in soils in an efficient manner, and there has been *even less improvement* over the past century in the tools and implements that can make labor much more efficient when handling organic matter (cutters, shredders, wheelbarrows, etc.). This is an area where farmer ingenuity has not yet become very much engaged with SRI improvement.

For many crops and innovations, farmers need to be concerned with **pests and diseases**, however, as a rule SRI plants are less susceptible to damage and losses from these, because plants are more resistant, probably for reasons proposed by Chaboussou (2004). Common measures for controlling rice pests and diseases include starting with healthy seedlings, using wider spacing and less water in the field, practices that are elements of SRI.

Some farmers using SRI methods, particularly in India, are passionate supporters of organic means of pest and disease control, often linked to application of organic sources of nutrients. But so far, this has not been a matter of innovation so much as adopting ancient Vedic prescriptions for crop fertilization and protection. These seem to be efficacious, but they remain controversial among scientists and many farmers. What will be reported here are innovations that have emerged in the course of SRI use and that have modified the potentials and applications of SRI well beyond where it was 10 years ago when the methods first started 'taking root' outside Madagascar.

FARMER INNOVATIONS

1. Nurseries

If farmers continue transplanting for SRI, there is quite a variety of ways in which seedlings can be raised. The conventional method is to grow seedlings densely planted in flooded portions of the main field. SRI, on the other hand, recommends having a 'garden-like' nursery with well-drained soil. Farmers have developed many different combinations of planting media for their nurseries. H.M. Premaratna in Sri Lanka uses equal proportions of **soil, compost, and chicken manure** as this mixture gives a non-sticky growth medium in which tiny, delicate seedling roots can be easily separated. Also, making nurseries as **raised beds** above the field level gives the soil more aeration (Figures 1 and 2). A farmer innovation reported by Jessie Magsayo in North Cotabato, Philippines, is growing SRI seedlings in **sand**, since seedlings get most of their initial nutrients from the seed rather than the soil. It is very easy to separate seedlings grown this way, he says, so it is gaining favor among SRI farmers in his area.

Figure 1: Raised-bed nursery of H.M. Premaratna, Mellawalana, Sri Lanka. (Dr. Gamini Batuwitage)

Rather than raise seedlings in or near the main field, because relatively few seedlings are needed with SRI, which reduces plant populations by 80-90% due to the radically wider spacing, they can be raised anywhere that is convenient, even in the homestead. (One farmer whom I have visited in Tamil Nadu was growing his seedlings on the roof of the family's house.) In Eastern Indonesia, where SRI is spreading rapidly with support from the irrigation department (PU) and Nippon Koei, raising seedlings is usually done on small **trays**, which are easily transported to fields (Figures 3 and 4). Seedlings can even be raised on banana leaves. Some Indian farmers are raising seedlings in indented **plastic trays** from which they can transplant the young seeding. With this technique, roots are stretched out naturally in the plug of soil, so there is no trauma to roots (Figure 5). A seedling-raising methodology using **mats** developed by IRRI can also be adapted appropriately to SRI (http://www.irri.org/irrc/streams/mat%20nursery.asp).

Figure 2: Close-up of Premaratna's nursery, removing seedlings carefully (Dr. Gamini Batuwitage)

Figure 3: SRI seedlings grown on small trays in racks for transplanting in Eastern Indonesia. (Shichi Sato, Nippon Koei DISIMP Office, Jakarta)

Figure 4: Transplanting young seedlings, carried to field on trays. (Shuichi Sato)

Figure 5: Farmers in Karnataka state of India showing tray method for raising SRI seedlings. (N. Uphoff)

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2. Marking fields for transplanting

The most visible difference with SRI is the planting of single plants in a square pattern. This ensures good and uniform exposure to sunlight and air; but also, if spacing is uniform in both directions, this makes mechanical weeding in perpendicular passes possible. Laulanié used **strings** tied to sticks/pegs spaced 25 cm apart along the edge of paddy fields to help farmers transplant in a precise grid pattern (Figure 6). An adaptation of this in Tripura state of India has been to use a **bamboo rod** instead (Figure 7). In Iraq, a cheap tool has been developed for guiding transplant spacing using a **board with nails** driven into it (http://ciifad.cornell.edu/sri/countries/iraq/iraqhameedrpt1207.pdf).

Some farmers in Madagascar and India have, on their own, constructed wooden **rake-markers**, in French called a *rayonneur*, with 'teeth' spaced 25 cm apart. These can be pulled along the surface of a leveled and muddy field to score lines onto the surface which then guide transplanters (Figures 8 and 9). If the soil is too saturated, the lines made by the rake-marker do not remain visible. So while this method greatly speeds up transplanting, it also gives farmers a simple way to assess the viscosity of the soil, to know when it is suitable for SRI transplanting.

Figure 6: Transplanting with guidance of a string in Madagascar. The string is moved after each row is planted. (Association Tefy Saina, Antananarivo)

Figure 7: Farmer adaptation in Tripura state of India, using a bamboo stick instead of a string to maintain uniform 25x25 cm spacing. (Baharul Majumder, Dept. of Agriculture, Agartala)

Figure 8. Farmer in Lombok, Indonesia using rake-marker to mark parallel lines on a muddied field. The next step is to draw the rake across the field in a perpendicular direction to make a grid. (Shuichi Sato, Nippon Koei DISIMP team, Jakarta)

Figure 9: Farmers in Nepal transplanting according to a grid imprinted on field with a rake-marker. (Rajendra Uprety, DADO, Morang District, Biratnagar).

Farmers in India have developed a **roller-marker**, inspired by the simple roller that households use to mark rice-flour patterns around the windows and doorways of their houses at Diwali festival time. This lays down a perfectly square pattern on the surface of their fields very quickly (Figure 10). This saves even more labor time and cost than a rake-marker. Research at the KVK extension center in Madurai, Tamil Nadu state, India has evaluated trapezoidal and triangular patterns marked onto fields with a roller (http://ciifad.cornell.edu/sri/conferences/2irc1006/inZigzagPstr.jpeg). Data indicate 14-25% more tillering from these alternative spatial relationships among plants compared to a perfectly square pattern.

Figure 10: Roller-marker developed by Lakshmana Reddy, Ramavaram, Godavari Delta, Andhra Pradesh, India. Reddy is one of the best SRI farmers in the area, having achieved an average paddy yield of 16.25 t/ha on 9 acres of rice land in 2004. (Dr. Alapati Satyanarayana)

Another method that I learned about on a recent visit to India is to stretch an **elastic rope** across the full length or breadth of a field that has been puddled to make its soil muddy. While two persons hold down both ends of the rope at the edges of the field, a third person lifts the tightly-stretched rope at its middle, to chest height, and snaps it back into the soil. This makes a straight line across the length (or width) of the field. The rope is then moved 25 cm to make another line parallel to the first. By stretching the rope across the field, and then snapping it, and they doing the same perpendicularly, lines can be imprinted on the muddy soil to form a grid pattern, very quickly according to farmers. All of these adaptations improve upon the original strings-and-sticks technique by speeding up the SRI transplanting process.

3. Crop establishment

Transplanting is the norm for paddy rice in most countries, and there is good evidence that transplanting very young seedlings (8-12 days old) carefully and precisely gives the best crop growth. However, **direct-seeding** can avoid having to spend so much time and resources establishing a nursery and then transplanting seedlings, both labor-intensive activities.

One farmer in System 'H' of the Mahaweli System in Sri Lanka (Ariyaratna Subasinghe) has devised an alternative system that involves **broadcasting germinated seed** on a puddled (muddy) paddy field. He does this at a rate of 25 kg/ha, five times that recommended with 'normal' SRI for transplanted seedlings. When the tiny plants coming up in the field are 10 days old, he 'weeds' his field with a rotary weeder *as if he had transplanted single seedlings into the field at 25x25 cm spacing*. This drastically thins out of the crop, eliminating about 80% of the plants and leaving usually only 1 plant at the intersections of his weeder transects. Sometimes there is no plant, and sometimes 2 seedlings or even 3, so the plant distribution is less precise than with transplanting. But it can give a yield of 7 t/ha, and it reduces labor requirements greatly by sacrificing 20 kg of seed. According to a study by Tamil Nadu Agricultural University (http://ciifad.cornell.edu/sri/countries/india/intnramasapster06.pdf), this method reduces labor by 40%, while giving comparable yield. This system could over time become the most common method for SRI crop establishment because of its great labor-saving possibilities.

Direct seeding is being introduced and evaluated by a number of farmers making their own adaptations of SRI in places as diverse as Cuba (Figure 11), India (Figure 12) and Thailand (Figure 13). Over time, direct-seeding is likely to supersede transplanting as the main method of crop establishment.

Figure 13: SRI direct-seeder built by Luis Romero, San Antonio de los Baños, Cuba, for three rows with spacing 40x40 cm; this proved to be too wide because it permitted too much weed growth. His neighbor built a 12-row weeder to be pulled by oxen, but we have no report on results. (Dr. Rena Perez)

Figure 12: Direct-seeder developed for SRI by KVK extension center in Chittoor, Andhra Pradesh, India (Dr. Bala Husein Reddy, Chittoor KVK)

Figure 13: Section of SRI seeder being built by farmers from plastic materials in Roi-et Province, Thailand (Dr. Prabhat Kumar, Asian Institute of Technology)

Along with direct-seeding, I expect that **raised beds** will also become a prominent alternative method of soil management for SRI over time, together with **zero-tillage**. One of the most innovative SRI farmers in China has adapted SRI to raised-bed/zero-tillage cultivation in Sichuan province, getting a yield calculated by the Provincial Department of Agriculture to be 13.4 t/ha (Figure 14).[3]

Figure 14: Liu Zhibin, Meishan, Sichuan province, China, standing in section of an SRI field recently harvested, in which he had transplanted seedlings onto raised beds with zero-tillage (N. Uphoff)

Another innovative Chinese SRI farmer in Bu Tou village (Nie Fu-qui), Tian Tai country, Zhejiang province has combined mechanized direct-seeding with zero-tillage, getting a yield over 11 t/ha with

[3] Liu Zhibin developed a 'triangular' method of transplanting SRI seedlings, where there are three plants per hill but in half as many hills (more widely spaced), and with 8-10 cm between the three plants in a triangular shape. This way the benefits of wide spacing are maintained while plant population is increased by 50% over conventional square-planted SRI (http://ciifad.cornell.edu/sri/countries/china/cntriang.pdf).

reduced labor costs (http://ciifad.cornell.edu/sri/countries/china/index.html -- second item under 2005 Updates). The implement that Nie designed and built for direct-seeding uses 23.3x30.5 cm spacing for this alternative method of SRI crop establishment.

Another method for SRI crop establishment still under development in Tamil Nadu state of India forms the soil mechanically to create **ridges and furrows** (Figure 15). Two rows of direct-seeded rice are planted on each ridge, maintaining wide spacing between plants in both directions. Irrigation is then done through the furrows that lie between the ridges, with a saving in water as well as labor. I have talked with Khmer farmers who work with CEDAC in Cambodia and who have experimented with their own raised-bed/zero-tillage SRI methods. They were pleased with the results, but were still undecided between direct seeding vs. transplanting. Further experimentation and evaluation on these alternatives, with various adaptations, will surely continue for some years.

Figure 15: Ridge-and-furrow SRI field in Kadiramangalam, Cauvery Delta, Tamil Nadu, India (G. Swaminathan)

4. Means of weed control

Some years ago, a mechanical hand weeder was developed in Japan that was taken up by some farmers in many countries to facilitate weed removal between rows. It has various names and modifications, but is widely known as a **rotating hoe** (or *houe rotative* in French) (Figure 16). IRRI engineers subsequently developed what is called a **cono-weeder**, which works better (more easily, more quickly) in various soils, especially heavy clay soils (Figure 17). Laulanié introduced the planting of rice plants in a square pattern into SRI so that a mechanical weeder could be used in perpendicular directions, aerating the soil all around each plant, rather than just between rows.

Farmers in many countries have come up with various versions of the rotating hoe or cono-weeder. In Figure 18, we see examples of the range of innovation -- from a simple home-made weeder constructed from local materials (heavy nails, wooden axle, iron rods) for less than $3 in Cambodia, to a more expensive motorized weeder in Sri Lanka that enables the farmer to weed and at the same time aerate the soil on his 2-hectare farm without needing to hire any labor.

Figure 16: "Japanese weeder" demonstrated in Sri Lanka, on left; weeder developed in China, called 'wolf-fang,' shown on right (N. Uphoff)

Figure 17: On left, improved cono weeder designed by H.M. Premaratna, Mellawalana, Sri Lanka, and on right, a model made by local engineer in Madagascar to inter-cultivate two rows at a time, with the option of adjusting the cones for wider or narrower inter-row spacings (N. Uphoff)

Figure 18: On left, a weeder designed and built by Nong Sovann, Kandol village, Kampoth Speu, Cambodia, from local materials (wooden axle, heavy nails, iron rods) (N. Uphoff); on right, more expensive, motor-powered weeder designed and built by Ariyaratna Subasinghe, System H, Mahaweli project, Sri Lanka (A. Subasinghe)

Other weeder designs have been developed for other situations and needs e.g., a weeder that can cover four rows at the same time, thereby greatly reducing the time and cost required for soil-aerating weeding (Figure 19). Some poor farmers find even this kind of implement too expensive. Working with farmers in Madagascar, Association Tefy Saina has developed a super-simple weeder that has no moving parts, so it is quite durable, and costs only about $2 to make. It requires two persons to operate – one to pull and the other to guide it between the rows of plants -- but farmers say that it can be pulled up and down the rows quickly enough (and labor costs in Madagascar are relatively low), so that this model is a good alternative to metal weeders, being quite inexpensive. The weeder on the left in Figure 17 is very popular with farmers and costs less than $10 in Sri Lanka.

Figure 19: On left, four-row cono weeder developed by Gopal Swaminathan, Kadiramangalam, Cauvery Delta, Tamil Nadu, India (G. Swaminathan); on right, underside of the simplest weeder devised to date, developed by Tefy Saina in Madagascar (Association Tefy Saina)

Still more weeder models could be shown. The purpose of showing above the variety of models is to make very evident the diversity and ingenuity of farmers' solutions to an important constraint for SRI (weed growth) when flooding of fields is not used as a method of weed control. The point here is that farmers can and will innovate if the production system and options are presented to them not as a final, finished product for adoption (or turning down), but rather as an opportunity, for which further thought and innovation on their part are expected.

RAINFED SRI

The System of Rice Intensification was developed for irrigated rice production in Madagascar. But many of the world's poorest households do not have access to irrigated land, needing to support themselves from upland (unirrigated) fields. The extrapolation of SRI concepts and methods to such circumstances has been initiated usually by NGOs working closely with farmers. The methods are worked out with extensive farmer involvement, instead of being devised by 'experts' and then 'extended' to farmers.

In the 1998-99 season, a government rice specialist and university student working with Tefy Saina and CIIFAD around Ranomafana National Park in Madagascar tried to adapt SRI concepts to rainfed production. They worked directly with farmers on their fields, seeking an alternative to slash-and-burn cultivation (*tavy*). After clearing a farmer's upland plot without using fire, hills were planted with 3-4 seeds each instead of with whole panicles of rice, as was local practice -- and with wide spacing, 30x30 cm. Ten days later, each hill was thinned to leave just the most vigorous single plant, and the space between hills was mulched with shredded branches of leguminous plants (*tephrosia* and *crotalaria*). Some chemical fertilizer was used to supplement the compost applied at planting time. With wide spacing and very few plants, a yield of 4.02 t/ha was achieved from replicated trials, which was 2.5 to 5 times more than the 0.8-1.5 t/ha usually produced with shifting cultivation methods

(Barison, 1999). While more labor was required, the time invested was better remunerated per day of work than traditional shifting cultivation.

This idea was taken by Robert Gasparillo of the Philippine NGO, Broader Initiatives for Negros Development (BIND), who learned about it at the first international SRI conference held in China in 2002. The next year, he set out 20 trials with 5 spacings and 4 replications (4,000 m^2 total area) on farmers' fields in Negros Occidental province. The average for the whole area, without any irrigation, was 7.2 t/ha -- instead of more typical yield of 3 t/ha. The best spacing (20x40 cm) gave a yield of 7.7 t/ha, without irrigation, just with rainfall (Gasparillo et al., 2003).

Metta Development Foundation, an indigenous NGO working in northern Myanmar, began adapting SRI concepts to rainfed rice cultivation starting in 2001, using Farmer Field School training methods where farmers are actively engaged in the evaluation and adaptation of new methods. Within three years, over 5,000 farmers had been trained in SRI methods, and over 20,000 farmers were using the new methods by 2004, thanks to farmer-to-farmer dissemination at village level. (Within three years of training one-third of the farmers in an FFS cohort, almost 100% of the farmers in a village were using the improved practices.) On FFS demonstration and learning plots, where SRI methods were used mostly as recommended, yields were 6 to 7 t/ha, instead of the usual 2 t/ha in the region. On farmers' fields, with incomplete use of SRI methods, average yield for a large number of farmers (N=612) was over 4 t/ha (Kabir and Uphoff, 2007).

In neighboring Cambodia, where SRI use has expanded from 28 farmers in 2000 to over 100,000 now, 90% of the SRI users are rainfed; only 10% have irrigated rice paddies. National average yields are below 2 t/ha (1.5-1.8 t/ha usually), whereas SRI yields have been 2.5-3.5 t/ha, and up to 6 t/ha or more. One recent report from one of the poorer areas in Cambodia, where 146 farmers tried the new methods with NGO support. Their previous paddy yield was only 1.04 t/ha, but with SRI the average was 4.02 t/ha (http://ciifad.cornell.edu/sri/countries/cambodia/camldsrpt07.pdf). Such improvements for rainfed rice farmers is really significant.

The Indian NGO PRADAN started introducing SRI in rainfed areas of the Eastern Gangetic Plains, where poverty is greater than many other parts of the country, in 2003. The first year its staff could get just 4 farmers to try out the methods. Next year, 150 farmers were willing to take up the methods, with a 67% increase in net income per hectare, as calculated by an IWMI-India Programme research team (even with half of the farmers studied having experienced severe drought; Sinha and Talati, 2007). By 2006, the number of SRI users reached 6,500, with average yields of 7.2 t/ha where yields had been 2-3 t/ha previously (PRADAN, 2007). In Cambodia, the NGO working with rice farmers in rainfed areas uses SRI ideas to improve upland rice production simply by reducing the number of seeds put into each planting hole, from more than 10 to just 3-5, also arranging the holes in rows and using compost each. These changes are giving good results, with yield increases more than 50%. These results are cited from diverse countries to show how farmers working with NGOs or researchers under difficult agroecological conditions can make productive modifications and even some transformations of their farming systems under the influence of new ideas, with positive results.

OTHER CROPS

Sugar Cane: A number of farmers in southern India, some working with NGO or university collaborators, have begun adapting SRI concepts and practices to the production of sugar cane (also a *gramineae* or grass-family plant species like rice). Farmers have reported doubling and even tripling their cane yields with adaptations of SRI (http://ciifad.cornell.edu/sri/countries/india/indiabangtrep205.pdf -- pages 5-6). The *Financial Express* (Bombay) reported November 27, 2006, that 3,000 acres in the state of Andhra Pradesh had been devoted to trials and demonstrations of Sugarcane Renewed Intensification system (SRI) (http://www.financialexpress.com/news/story/185049/). A comparison of phenotypes is shown in Figure 20, with an SRI plant on the left. A write-up of this alternative SRI for sugar cane is available on the web, written by a farmer: http://ciifad.cornell.edu/sri/countries/india/othercrops/inSRIsugarcane07.pdf

Finger Millet: The Green Foundation, an NGO based in Bangalore, India, has learned about and documented farmer-devised system, *Guli Ragi*, which is helping promote for cultivating finger millet. This crop, known in India as ragi, is one of the most important cereals crops for the poor, not very high-yielding but very drought-resistant. This system which farmers have developed resembles SRI in many ways. In Haveri district of Karnataka state, it gives yields 2-3 times higher than with conventional methods (see http://www.greenconserve.com/Guli%20Ragi%20Method.htm; and also pages 26-29 of field report http://ciifad.cornell.edu/SRI/countries/india/inntutrep1006.pdf). Staff of the Indian NGO PRADAN working with farmers in Jharkhand and other eastern Indian states have developed what they call the System of Finger Millet Intensification (SFMI), producing large differences in phenotype (Figures 21 and 22).

Figure 20: Comparison of sugar cane plants grown with 'SRI' (Sugarcane Renewed Intensification) and standard agricultural methods (A. Satyanarayana)

Figure 21: Millet plant on right is a local variety managed with traditional methods; in center, an improved-variety plant (A404) grown with same methods; on left, an improved-variety plant grown with adapted SRI methods: single seedlings, wide spacing, organic matter, soil aeration, etc. (PRADAN)

Figure 22: 'SFMI' roots on left, and roots of same variety of millet grown with usual methods on right (PRADAN)

Wheat: The first application of SRI concepts to wheat that we know of was by a Polish farmer, Tadeusz Niesiobedzki, who discovered the benefits of growing single plants with wide spacing by accident (when his seed drill got stuck). He happened to find the SRI website on the internet (http://ciifad.cornell.edu/sri/) and contacted me at Cornell. A picture of his winter wheat field before going into winter dormancy is shown in Figure 23. This spacing was probably too wide as there was not as much yield improvement as expected, but that wheat plants respond positively to SRI practices could be seen. In 2007, an Indian NGO based in Dehradun, People's Science Institute (PSI), did its own 'SWI' trials, with a 28-40% increase in grain yield and 18% more straw yield (Sen et al., 2007).

Figure 23: Winter wheat field with SRI spacing and mulching in Poland (T. Niesiobedzki)

Cotton: Since SRI is not a technology, but rather a set of insights, concepts and practices that focus on inducing larger root growth and promoting the abundance and diversity of soil biota, it should have some relevance to crops that are not in the grass (*gramineae*) family. Gopal Swaminathan in Tamil Nadu state of India has used his knowledge from SRI to improve his cotton production, starting by planting single seeds in paper cups (1 cup of hybrid seeds is enough for 1 acre). After 10 days, he removes the bottoms of the cups and plants them into the field with very wide (2 ft by 4 ft) spacing, and he mulches between the plants. His increase in yield is only 20%, not as much as with SRI methods for rice, but cost savings increase his profitability by more than 20%. Because cotton production is not very profitable even with these improvements, Gopal is now adapting SRI methods to pulse production (pers. comm.). There is also a farmer's report of the 'system of mustard intensification' that he has developed now available on the SRI website (http://ciifad.cornell.edu/sri/countries/india/othercrops/inSMImustard1207.pdf).

Seeing how SRI concepts have been extrapolated to other crops as well as to upland rice adds to our appreciation for farmer innovations within the System of Rice Intensification, developed for irrigated rice. How far this creativity will extend, to how many other crops, cannot be foretold, but what has been seen so far bodes well for the future of smallholder agriculture.

DIVERSIFICATION OF FARMING SYSTEMS

To conclude this paper, I will give two examples of how farmers are using the productivity gains from SRI methods for irrigated rice production to transform their farming systems. When visiting Sichuan province of China in 2004, I learned about an **SRI-mushroom farming system** that was spreading rapidly. Mushrooms have become a profitable export crop in the province, with rice straw used as the substrate for growing mushrooms. Farmers had discovered that with SRI methods, they can produce much more straw. Five mu of rice with SRI produce enough straw for one mu of mushroom beds (1 mu = 1/6 ha), whereas with conventional methods, 10 mu of rice are needed to support one mu of mushrooms. Moreover, with SRI, agrochemicals are not applied, so the soil is more suitable for mushroom growth, and the improved soil fertility with mushroom growing permits much wider spacing of SRI seedlings, 40x45 cm. An average paddy yield of 9 t/ha from an SRI crop contributes to very attractive total income from this farming system which raises SRI, April-September, and mushrooms, October-March (Figure 24).

Figure 24: Mushrooms being grown in rotation with SRI rice in Sichuan province, China (Zheng J., SAAS)

The most comprehensive use of SRI so far is being made in Cambodia, where farmers working with CEDAC have begun to diversify their smallholder farming systems by capitalizing on the productivity increases that SRI is making possible. Even farmers with as little as 0.3 ha have taken 40-50% of their paddy land out of rice production, because with SRI methods they can get 3-4 times their previous rice yields and thus meet their families' basic food needs with less land. The land as well as labor and water that are freed up from staple food production are redeployed to other, more remunerative (and more nutritious) production, starting with a fish pond. This is complemented by vegetable, fruit and small livestock production.

CEDAC has published a manual with details on the farming systems devised by five of the most innovative Cambodian farmers who have diversified their farming systems after adopting SRI methods (http://ciifad.cornell.edu/sri/countries/cambodia/cambSidMPREng.pdf). An average investment of about $300 permits them to raise their annual household incomes from less than $200 to almost

$600. Details on two of these farmers are at:
http://ciifad.cornell.edu/sri/countries/cambodia/camntutrpt0707.pdf (see pp. 7-8 and 12-14)

This reporting on farmer innovation reflects that fact that SRI is still '*a work in progress*.' Although developed for irrigated rice production, it is having an influence on upland rice and other crops. Although SRI was developed for small, resource-limited farmers in Madagascar, in China SRI is being adopted most rapidly by larger farmers, such that one-third of the rice area in Zhejiang Province was under SRI cultivation methods by summer season 2007. SRI has previously been considered as *labor-intensive*, indeed, too labor-intensive for widespread uptake. But with farmer adaptations, SRI has become attractive to bigger farmers because they are able to use its principles to *reduce their labor requirements* for rice production. There will be many more ways devised to make SRI less labor-demanding once the principles of SRI well understood and the benefits of their application are more fully realized.

SRI was a 'farmer-first' innovation from the outset, truly farmer-centered in the experimentation and evaluation undertaken by Fr. Laulanié, and it has been farmer-participatory in its further development. In country after country, we have seen farmers excited, even inspired, by their SRI observations and experience, undertaking to make further innovations in the methods, and to spread knowledge about SRI to fellow farmers, as discussed in the parallel paper for this Farmer First Revisited workshop.

The story of SRI is not a 'farmers-only' story, because it started with significant corrections proposed to the standard rice-growing practices that farmers have engaged in for centuries, even millennia. The innovation emanated from the dedicated work of a Jesuit priest who worked closely and collaboratively with farmers for over three decades. 'Chapters' of this story have been written in over two dozen countries already, through the efforts of NGO workers, researchers, teachers, administrators, and other motivated individuals who continue to work closely with farmers much as Fr. Laulanié did.

In a growing number of situations now, leadership in the improvement and dissemination of SRI has passed to farmers, as Fr. Laulanié and those who think like him always wanted to happen. SRI was created through actions and expressions of human solidarity. It will continue to advance and evolve that way, through persons – both farmers and non-farmers – who work not so much ***for*** others as ***with*** others. Not only **bureaucratic** or **technocratic** management of SRI but also ***paternalism*** of any sort will be a barrier to realizing the full extent of the opportunities that an understanding of SRI presents.

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