Photo: Edwin van der Maden

SRI initially requires more effort while farmers gain knowledge, skill and confidence. Here members of a self-help group exchange ideas.

The System of Rice Intensification and its implications for agriculture

Norman Uphoff

The System of Rice Intensification (SRI) reported on by several other contributors to this and previous issues of the *LEISA Magazine* is casting new light upon both "modern" agriculture and agroecological alternatives. Just because something is widely believed or practised does not necessarily make it true or optimal. Keeping our minds open to new evidence and new ideas is essential for faring well in the contemporary world.

Some old agricultural truths reconsidered

Twenty years ago, either of the following two statements would have elicited derision and dismay: "Farmers do not need to plough their fields to get the best results", "To get the best yield, farmers growing irrigated rice should not flood their paddies".

Because ploughing fields and flooding rice have been dominant practices for hundreds of years, both these statements would have appeared ludicrous to most farmers and most experts. "Everybody knew" that the statements were wrong. Conventional wisdom was supported by good logic, even though there were scientific reasons for casting some doubt upon it.

In the case of ploughing, agronomic requirements for crop establishment and weed control appeared to dictate it to be a necessary practice – even though agronomists had identified that ploughing had many harmful effects, especially deep ploughing. These included the loss of nitrogen and organic matter from the soil; loss of soil structure; increased wind and water erosion; and a decline in populations of earthworms and other beneficial soil organisms. The assumption of farmers and researchers that ploughing is essential for successful cropping has been revised in recent decades. No-till cultivation or zero-tillage –or their more robust version, Conservation Agriculture– have been proving beneficial for farmers' net incomes and for the environment. In the United States, the heartland of large scale mechanised tillage, more than 30 percent of the cropped area is now under some form of reduced-till or no-till, and globally, more than 70 million hectares are cultivated according to Conservation Agriculture.

Rice was considered in the literature, and by farmers, to be a water-loving plant. A leading text on rice states categorically: "A main reason for flooding a rice field is that most rice varieties maintain better growth and produce higher grain yields when grown in a flooded soil than when grown in a non-flooded soil". This belief has been sustained in the face of growing evidence to the contrary, and knowledge that soils with insufficient oxygen are detrimental to plant roots and most soil organisms. In this context, SRI has provided results that demonstrate that substantially increased yield can be obtained with 25 to 50 percent less water than is commonly used for irrigated production. This is because unflooded soil conditions offer many advantages for the growth of plants and soil fauna.

The lesson to be drawn from both these instances of revised agricultural wisdom is that some long recommended (one might even say, revered) practices can turn out to be constraints if they prevent practitioners and scientists from "thinking outside the box."

Revising the input-dependence of modern agriculture

By achieving higher yields and greater profitability with fewer purchased inputs, SRI is showing that the input-dependence of modern agricultural practices is not necessarily the most productive or the most economic approach. This alternative system manages plants, soil, water and nutrients differently – in ways that increase the abundance and diversity of the soil biota. Farmers are finding that they can get more output by reducing their external inputs, rather than by increasing them.

SRI initially requires more effort while farmers gain knowledge, skill and confidence. This initial cost (investment) is offset by reduced requirements for seed (by 80-90 percent), water (by 25-50 percent), and costs of production (by 10-30 percent). Results reported from eastern Indonesia, from 1849 on-farm comparison trials over three years on 1363 hectares, are representative of the productivity gains reported elsewhere: an 84 percent increase in yield achieved with a 40 percent reduction in water and a 25 percent reduction in production costs, which resulted in a five-fold increase in net income. Similar results have been documented in India, and in this issue, Uprety gives data on similar benefits achieved by farmers in Nepal.

Reducing water applications can require physical and organisational capabilities for water control, which are not always available. This can be a constraint to the adoption of SRI, but less than perfect control can still permit improvements from the other technological components of the system. The drastic reduction in plant populations under SRI is the main reason that labour requirements can be decreased over time. This has been documented in evaluations by the International Water Management Institute in India and GTZ in Cambodia, as well as by Cornell University researchers in Madagascar. One Chinese evaluation reported that farmers in Sichuan considered labour-saving to be the most important aspect of SRI.

Agroecological practices usually involve some trade-off between more labour input to achieve reductions in other inputs. The net result is an improvement for farmers and the environment. However, SRI can reduce all the inputs and increase their productivity because it mobilises productive inputs from soil biota, which are inhibited, suppressed or

Advantages and benefits of SRI

Field experiences from all over the world have shown many wider benefits resulting from SRI management:

- SRI practices provide immediate benefits. There is no "transition" period, as necessary with many conversions to a more organic agriculture. After prolonged exposure to synthetic chemicals soil ecosystems often require some time to become fully restored. SRI yields generally improve over time, but there is no initial period of loss: first-season yields are usually higher than before.
- Accessibility for the poor. The lower capital costs of using SRI mean that its economic and other benefits are not limited by access to capital, nor does it require loans and indebtedness. It can thus contribute rapidly to greater food security for the poor. Some initial evidence suggested that labour requirements made SRI less accessible to the poor; but a larger study in Sri Lanka found poorer farmers to be as likely to adopt SRI as richer ones, and less likely to abandon it.
- Human resource development. The recommended strategy for dissemination of SRI emphasises farmer experimentation and encourages farmer innovation in ways that conventional agricultural technology development and extension strategies do not. Father de Laulanié, who first promoted SRI, intended that it should enhance the human condition, not just meet people's material needs.

While most attention has been focused on increases in yield, this is only one consideration among many when assessing production systems:

- No need for mineral fertilizers, which are a major cost in modern agriculture and have adverse environmental impacts. Compost gives better yields.
- Little or no need for other agrochemicals, since SRI plants are more resistant to damage by pests and diseases.
- While more labour is initially required, current documentation shows that SRI can even become labour-saving once farmers have mastered its methods.
- Yield increases of 50 -100 percent are seen, without changing rice varieties. There is no need to buy new seed, since all varieties respond to these methods, although some varieties respond better than others.
- Greater profitability. The costs of production with SRI averaged about 20 percent less per hectare, according to seven evaluations from five countries (Bangladesh, Cambodia, China, India and Sri Lanka). This, along with higher yields, means farmers' incomes from rice production increase by more than just their yield increase.
- Environmental benefits. Reduction in water requirements and reduced reliance on agrochemicals for high yield takes pressure off water-stressed ecosystems and enhances soil and water quality.

In specific agronomic terms, SRI farmers report the following advantages along with their higher yield and profitability:

- Drought resistance. Because SRI rice plants develop larger and healthier root systems, and establish these at an early age, the plants are more resistant to drought and periods of water stress.
- Resistance to lodging. With stronger root systems and tillers, in part due to the greater uptake of silicon when soil is not permanently saturated, SRI plants show remarkable resistance to wind, rain and storm damage.
- Reduced time to maturity. When SRI methods are used properly the time for maturation can be shortened by as much as 15 days, even while yield is being doubled. This reduces farmers' risk of agronomic or economic losses due to extreme weather events, pests or disease and/or frees up the land for other production.
- Resistance to pests and diseases. This has been frequently commented on by farmers and is now being documented by researchers. The China National Rice Research Institute, for example, reported a 70 percent reduction in sheath blight in Zhejiang province.
- Conservation of rice biodiversity. While high-yielding varieties and hybrids have given the highest yields with SRI methods (all SRI yields over 15 t/ha have been achieved with improved cultivars), very respectable yields can be obtained with traditional varieties as SRI plants resist lodging despite their larger panicles. In Sri Lanka, farmers using SRI methods have obtained yields of between 6 and 12 t/ha with "old" varieties. These are more profitable to grow because consumers are willing to pay a higher price for them, preferring their taste, texture and aroma.

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unbalanced by agrochemical applications or are limited to anaerobic organisms by flooding.

Changing production systems that have heavily utilised chemical inputs to systems that rely primarily on organic fertilisation usually involves a period of adjustment after the inorganic inputs are halted. However, SRI farmers usually achieve year-on-year improvements as soil fertility improves, with no initial penalty for converting to the new practices. However, for long-term sustainability of productivity, continued provision of organic matter to the soil will be necessary. SRI is not unique among more biologically-based production systems in offering substantial productivity gains resulting from a reduction in dependence on external inputs. The SRI experience has prompted more systematic consideration of scientific knowledge about agricultural production systems that are less dependent on chemicals.

SRI in a broader perspective

Two factors underlie the concurrent increases that SRI achieves in the productivity of land, labour, water and capital employed in irrigated rice production. These are quite different from the changes that sparked the Green Revolution. The increases in cereal production accomplished under the Green Revolution depended on a) genetic changes in crop potentials to make them more responsive to external inputs, and b) increases in inputs of water, fertilizer and other agrochemicals.

SRI involves neither of these strategies. Instead, it a) enhances the growth and health of plant roots, which are generally given little attention in crop science, and b) mobilises the services of vast numbers of soil organisms, ranging from the microscopic bacteria and fungi up to earthworms and other macro-fauna. SRI is reminding everyone of the importance of symbiotic relationships between plants and soil organisms – relationships that go back more than 400 million years. Studying these relationships is difficult and demanding, but they represent the next major "frontier" for agricultural scientists.

We know that SRI is still a work in progress, with knowledge and understanding accumulating from season to season, and we expect that SRI performance will attract more interest from researchers, extensionists, policy-makers and, of course, farmers. Farmers in a number of countries are already extrapolating SRI concepts and techniques to other crops such as millet, sugar cane, wheat, cotton, even chickens!

Practitioners of agriculture who have paid close attention to the ways in which their crops grow under different conditions often have a good sense of the linkage between soil fertility and the living status of the soil. The very term "soil" does not reflect adequately the extent to which its fertility is a consequence of the life within it – the abundance, diversity and activity of soil organisms. It would be better to talk and think in terms of "soil systems", as implied by the motto of organic farmers: "Don't feed the plant – feed the soil, and the soil will feed the plant".

This may not sound very scientific to some readers, but the scientific basis of such an agroecological conception of farming is growing every year. The foundations of this knowledge are reviewed in Uphoff *et al.* (2006), and the penultimate chapter suggests that this body of knowledge provides a basis for a "post-modern agriculture". This is more appropriate to the conditions and realities of the 21st century than many of the technologies currently in use. The emerging paradigm for post-modern agriculture differs from its namesake in the arts and humanities in that it embraces modern science, rather than being hostile to it. Indeed, post-modern agriculture is the most modern agriculture because it builds upon cutting-edge research in microbiology and ecology:

- It is not hostile toward genetic improvement, but it does not regard advances in agriculture as being primarily led by the manipulation or modification of genes. Genetic differences are very important for capitalising on all available inputs, but these differences should be considered in an interactive rather than deterministic fashion.
- There can be a role for soil nutrient amendments to correct deficiencies or imbalances, so it is not "organic" in a doctrinaire way. It does, however, reject efforts to accelerate plant growth by "force feeding" plants, with large amounts of nutrients. This supply-side approach is generally less effective and less efficient than one which nurtures and supports plants' demand for nutrients.

A general principle of post-modern agriculture is that plant-soil-water-nutrient management practices should foster synergistic relationships between plants and soil organisms. With SRI, when paddies are not kept flooded, weed control becomes a challenge. But the use of a rotary hoe aerates the soil at the same time as it churns weeds back into the soil, where they decompose and their nutrients are retained within the cropping system. Formal studies remain to be done on the effects of this kind of weeding, but substantial data sets from both Madagascar and Nepal show that additional weedings, beyond what is needed just to control weeds, can add between one and two tonnes per hectare to yield, without the application of inorganic nutrients.

The building blocks for this extra growth have to come from somewhere, and they are obviously being mobilised from within soil and plant systems, both of which contain tens of billions of micro-organisms. For example, recent research reported from China has documented how soil rhizobial bacteria migrate into the roots and up through the stem, their presence in leaves adding to the production of chlorophyll and photosynthate and consequently to grain yield.

There is still much more to learn about these relationships and their present and potential contributions to agriculture. My conclusion from a decade of working with SRI and being drawn into the larger realm of agroecology is that, as agricultural scientists, we should expand our thinking beyond the primarily chemical and physical understanding of soil, to encompass and make central the myriad of biological factors, that are at play both in the soil and above it. To achieve this we need to add also a cognitive dimension, as thinking and knowledge are critical for comprehending and making use of these factors in more productive and more sustainable ways.

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