DEVELOPMENT OF THE SYSTEM OF RICE INTENSIFICATION (SRI) IN MADAGASCAR

Norman Uphoff, Cornell University

The development of the System of Rice Intensification (SRI) 20 years ago in Madagascar by Fr. Henri de Laulanié, S.J. -- based on 20 years before that of working with farmers to improve their rice production without dependence on external inputs -- is a most unusual case. It is unusual partly because SRI is one of the most remarkable agricultural innovations of the last century, one only starting to be appreciated in this one. But it is also unusual because of the resistance, sometimes vehement, that it has encountered from the scientific community despite the evident benefits that it offered particularly for poor farmers and for the environment: doubling yields or even more without requiring the use of fertilizer or other chemical inputs, and using less water.

This case suggests a lesson for scientists as well as for extension personnel and farmers -- for all to be open to new ideas, no matter what their source. Not every proposed change in agricultural practices warrants much attention; but if a possible innovation would have many benefits, it should be subjected to empirical rather than just logical tests, because our scientific knowledge is not (and never will be) perfect or complete. In the SRI case, a paradigm shift was involved, one that is not yet fully understood and certainly not universally accepted. Typical positivist approaches for testing and validating new knowledge were not applicable because larger issues were at stake, one not amenable to either proof or disproof just by hypothesis testing.

The case is instructive also because it goes against the now popular view that farmer knowledge, being based on generations of trial-and-error and subsequent validation, is a superior source of information and insights about how to practice agriculture. SRI changes dramatically four practices that farmers growing irrigated rice have used for centuries, even millennia. Part of the resistance came from the innovation's being so counter-intuitive: where smaller would become bigger, and less could produce more. This sounds like nonsense; but it is possible and true.

The Challenge

When Henri de Laulanié was assigned by the Jesuit order to move from France to Madagascar in 1961, the first thing he saw around him was the great poverty and hunger of most of the people, one of the poorest populations in the world. He saw also their deteriorating natural resource base, with drastic soil erosion and accelerating deforestation, these two processes being connected.

Laulanié concluded, apparently, that raising the yields of rice, the staple food providing more than half of the daily calories of Malagsy households, was the greatest contribution he could make to the well-being of the people around him. It was also essential if continuing destruction of the precious tropical rain forest ecosystems was to be halted.

Laulanié had done a degree in agriculture at the best university in France (now known as Paris-Grignon) before entering the seminar in 1941, so he knew basic agricultural science if not much about tropical rice. There were few scientific resources to draw on in immediately post-colonial Madagascar, in libraries or in research institutes, so he started working directly with farmers, carefully observing their practices, asking questions, trying things out on his own paddy plot.

Assembling the Innovation

Laulanié found a few farmers not transplanting rice seedlings in clumps of three, four, five or more, as farmers all around the world choose to do, instead planting individual seedlings. These farmers in the miniority found that single seedlings produced as well or better than clumps of plants, and this way they could reduce their seed costs, a consideration for very poor farmers. So he tried this himself, and found it was a good practice.

Then, in another area he observed some farmers not keeping their paddy fields continuously flooded throughout the season, as is done around the world wherever farmers have access to enough water to do this. It is widely believed that rice plants fare best in saturated soil. But Laulanié found that they can grow even better if raised in soil that is kept moist but never continuously flooded. While rice plants can survive under flooded conditions, they do not thrive.

Having started to grow single seedlings in unflooded soil during their period of vegetative growth (i.e., up to flowering; after panicle initiation, he kept a thin layer of water, 1-2 cm, on the field), Laulanié next introduced a practice of his own. The government was promoting use of a simple mechanical hand weeder known as the 'rotating hoe' (*houe rotative*). This churned up the soil with small toothed wheels, burying weeds in the soil to decompose. It also aerated the soil in the process, though nobody considered this benefit at the time.

Laulanié decided to try planting seedlings in a square pattern, rather than in the rows being promoted by rice specialists. This way he could use the weeding in two directions, i.e., perpendicularly. He tried this with 25x25 cm spacing just to see what would happen. To his pleasant surprise, widely spaced rice plants, growing singly in moist but not flooded soil, did better than others grown with the common practices.

At this point, the priest established a small school in Antsirabe to teach young farmers these new methods and to give them a basic education that prepared them for life rather than for further studies and white-collar employment. In 1983-84, a fortuitous accident occurred. Two weeks after planting the rice nursery, Laulanié had second thoughts and decided that they might need more seedlings for the field, so more were planted for what was likely to be a water-short season.

A good rain fell when the first set of seedlings was 30 days old. Because they were not sure whether any more good rain would follow, the teacher and his students decided to transplant all of the seedlings into their rice field, the tiny ones only 15 days old as well. They had few hopes or expectations for the spindly younger seedlings. Yet after a month, these began to surpass the older ones, and by the end of the season, their yield was much higher (Laulanié 1993).

Rather than pass this off as a fluke, the next year younger seedlings were planted again, and then even younger seedlings. By the end of the decade, it was clear to everyone at the school and to the farmers who visited it that using younger seedlings gave much better results, provided that they were planted singly and far apart, in a square pattern (even up to 50x50 cm when the soil quality had been built up by these practices) in soil both well aerated and moist during the plants' growth period. They did not know that research had been published already showing that when rice plants are kept continuously flooded, up to 78% of their roots degenerate under the hypoxic conditions (Kar et al. 1974). The negative effect of continuous soil saturation on roots' growth and functioning was being overlooked by both scientists and farmers alike.

SRI was developed initially with the use of chemical fertilizers, because everyone believed that this was necessary to increase yields, especially on Madagascar soils that were mostly 'poor' as evaluated by standard chemical tests. When the government removed its subsidies for fertilizer in the late 1980s, and poor farmers could no longer afford to use it, Laulanié and his students began working with compost. In most instances, this gave even better rice yields when used with the other practices.

Proceeding with the Innovation

In 1990, Laulanié and several of his close Malagasy friends established an NGO, Association Tefy Saina, to promote SRI and rural development generally. The NGO name, in Malagasy, means 'to improve the mind,' because they saw SRI as not just a means to improve rice production and meet food and income needs. It was thought that SRI's spectacular results could open farmers' minds to further innovation beyond rice cultivation because they came from changing practices that had been used for generations by farmers' ancestors, greatly venerated in traditional culture and beliefs. For the priest and his friends, human development and spiritual growth were considered more important than agricultural improvement alone.

In part because SRI was not seen and treated in narrowly technical terms, it was scoffed at and rejected by Malagasy and international scientists who learned about it, though a few European NGOs gave Tefy Saina some small grants for training in the early 1990s. In 1994, CIIFAD, the Cornell International Institute for Food, Agriculture and Development, began working with Tefy Saina to introduce SRI to farmers in the peripheral zone around Ranomafana National Park. This was one of the last remaining large blocks of rain forest, under serious threat from the slash-and-burn cultivation of upland rice.

Farmers around Ranomafana were getting lowland rice yields of only 2 t/ha from their small areas having irrigation. To feed their families, they needed to practice upland cultivation. Raising lowland yields was thus seen as a requirement for saving the rain forest, as well as for reducing poverty. In 1994-95, only 38 farmers would try the new methods, which changed four things that had been done from time immemorial in Madagascar, and in most other rice-growing countries:

- Instead of planting seedlings 30-60 days old, tiny seedlings less than 15 days old were planted.
- Instead of planting 3-5 or more seedlings in clumps, single seedlings were planted.
- Instead of close, dense planting, with seed rates of 50-100 kg/ha, plants were set out carefully and gently in a square pattern, 25x25cm or wider if the soil was very good; the seed rate was reduced by 80-90%, netting farmers as much as 100 kg of rice per hectare.
- Instead of keeping rice paddies continuously flooded, only a minimum of water was applied daily to keep the soil moist, not always saturated; fields were allowed to dry out several times to the cracking point during the growing period, with much less total use of water.

Why hadn't farmers tried these new practices before? All looked very risky, and even a little crazy. Why should tiny young plants perform better than larger ones? Why should fewer plants give more yield than more plants? Why should plants not be kept flooded if water was available? Water was thought to be like fertilizer, and rice was regarded as a water-loving plant. The chance that a farmer would ever try *all four of these practices together*, and risk the scorn of his neighbors as well as the wrath of his ancestors, was infinitesimal.

The farmers around Ranomafana who used SRI in 1994-95 averaged over 8 t/ha, more than four times their previous yield, and some farmers reached 12 t/ha and one even got 14 t/ha. The next year and the following year, the average remained over 8 t/ha, and a few farmers even reached 16 t/ha, beyond what scientists considered to be 'the biological maximum' for rice. But these calculations were based on rice plants that had degenerated and truncated root systems.

Understanding the Innovation

How could such remarkable results be obtained? There is demonstrable *synergy* among these practices, when used together, especially when the rotating hoe is used to control weeds -- and aerate the soil frequently during the growth period. This has been documented by replicated multi-factorial trials (N=288 and N=240) in contrasting agroecological situations: tropical climate, poor sandy soils at sea level vs. temperate climate, better clay and loam soils at high elevation. These trials showed that when compost is added to the soil, increasing soil organic matter and nourishing soil microorganisms beyond what the plants' own (greater) exudation can support, large increases, even a tripling in yield, can result. On poorer loam soil, SRI practices gave 6.39 t/ha compared to 2.04 t/ha with standard practice (mature seedlings, close spacing, continuous flooding, NPK fertilizer). On better clay soils, yields went from 3.0 with standard methods to 10.35 t/ha with SRI (Randriamiharisoa and Uphoff 2002).

With SRI methods, one could see, after the first month a much greater number of tillers, 30-50 per plant, with some plants producing even 80-100 tillers. If one pulled up SRI plants, one could see that they had much larger and deeper root systems. A pull test to measure the resistance that plant root systems give to uprooting found that it took 5-6 times more force (kg/plant) to do this for SRI plants. Having more roots can support more tiller growth and more grain filling, while plants having a larger canopy with more photosynthesis can support more root growth.

Scientifically, the most interesting phenotypic change was in the relationship between number of tillers/plant and number of grains/tiller (panicle). For SRI plants, this correlation was *positive* rather than *negative*, as is widely reported in the literature. With a larger root system, SRI plants can access both more soil nutrients, right through the ripening stage with less plant senescence, and a wider variety of nutrients, including micronutrients not provided by NPK fertilizer. SRI methods contribute to more grain production and also to a lower percentage of unfilled grains and to higher grain weight.

SRI achieves higher yields, sometime over 20 t/ha when soil conditions approach are optimal. It does not follow the two strategies that produced the gains of the Green Revolution: (a) **changed and increased genetic potential**, and (b) **use of external inputs** -- more fertilizer, more water, more agrochemicals. SRI was hard at first to understand because it took such a different path.

Instead, SRI changes common practices for plant, soil, water and nutrient management so as to: (a) **increase plant root growth and functioning**, and (b) **enhance the abundance and diversity of soil biota**, from microorganisms (bacteria and fungi) through micro and meso-fauna (nematodes and protozoa) to macro fauna (particularly earthworms).

Spread of the Innovation

This case study cannot go more into the mechanisms and processes, which are still only partially documented and understood, but they are increasingly validated by SRI use in a growing number of countries around the world (see Stoop et al. 2002, and Uphoff 2003). Good SRI results have now been reported from countries ranging from China, through Indonesia, Philippines, Cambodia, Laos, Thailand and Myanmar, to Bangladesh, Sri Lanka, Nepal and India, to Madagascar, Benin, Gambia, Guinea and Sierra Leone, and now to Cuba and Peru.

The methods raise, concurrently, the productivity of land, labor, capital and water, without tradeoffs, something never seen before. SRI practices achieve different and more productive *phenotypes* from any genotype of rice by providing a better growing environment in which the plant can express its genetic potential. SRI is best understood as part of a growing movement in the agricultural sector toward what can be characterized as *agroecological innovation*. This strategy seeks to capitalize on *synergies* among species and organisms when these are provided with optimum growing conditions. Conventional agricultural practices, favoring monoculture, seek to maximize production of single species, one at a time, taking them out of the context of their natural environments, changing that environment by ploughing, fertilization, irrigation, etc.

What can be learned from this experience about participatory research and development?

1. One should not assume that current farmer practices are always ideal or the best. They have been developed under certain conditions, constrained by knowledge and imagination as well as biophysical factors. Farmer knowledge is a good place to start, and should always be respected. But it should not be idealized. It was just a few 'deviant' farmers who contributed some of the novel ideas that made SRI possible.
2. One should work closely with farmers in the development of any agricultural innovation. Fr. de Laulanié had a great and self-evident love for rural people, demonstrated throughout his 34 years living among them in Madagascar. He was devoted to helping them improve their productivity and welfare. He avidly learned from them. But he also formed his own opinions, always subjecting practices and ideas to empirical tests.
3. Scientists should avoid becoming prisoners of their present knowledge, captives of prevailing paradigms. Paradigms are needed to make sense of the world and to be able to act upon it. But they are constructs made by human beings, not true in themselves. Anyone who seriously follows scientific principles knows that while theory is necessary to organize knowledge and to test it, the ultimate tests are always empirical, not logical. While quantum physics is the most powerful body of scientific theory in the world today, its strength lies not in its logic -- it is quite illogical in many ways -- but in its repeated verification by empirical results.
4. There has been a lot of effort going into systematizing the processes of participatory research and development, e.g., through participatory action research and participatory rural appraisal (PRA). As recent reflections on PRA show, it is important not to let techniques and processes become rigidified and routinized because then means become ends in themselves (Cornwall and Pratt 2003). Fr. de Laulanié worked with great originality and dedication. He had respect for science, having been trained in it, but particularly for farmers and for empirical truth. He improvised the whole process by which SRI was developed.

If Father de Laulanié had been guided (and constrained) by a lot of preconceptions, it is unlikely that he could have discovered anything as unique and powerful as SRI, breaking with ages-old practices to 'liberate' genetic potentials that have existed in rice plants for millennia. We must never let form triumph over substance and over vision and imagination.

For more information on SRI, see the SRI home page: www.ciifad.cornell.edu/sri/ -- or communicate with Tefy Saina (tefysaina.tnr@simicro.mg) or the author (ntu1@cornell.edu).

REFERENCES

Cornwall, A. and G. Pratt. 2003. *Pathways to Participatiohn: Reflections on Participatory Rural Appraisal*. London: Intermediate Technology Development Group Publishing.

Kar, S., S., Varade, T. Subramanyam, and B. P. Ghildyal. 1974. Nature and growth pattern of rice root system under submerged and unsaturated conditions. *Il Riso* (Italy) 23, 173-179.

Laulanié, H. de. 1983. Le système de riziculture intensive malgache. *Tropicultura* (Brussels) 11, 110-114.

Randriamiharisoa, R. and N. Uphoff. 2002. Factorial trials evaluating the separate and combined effects of SRI practices. In: *The System of Rice Intensification: Proceedings of an international conference, Sanya, China, April 1-4, 2002*. Ithaca, NY: Cornell International Institute for Food, Agriculture and Development.

Stoop, W., N. Uphoff, and A. Kassam. 2002. A review of agricultural research issues raised by the System of Rice Intensification (SRI) from Madagascar: Opportunities for improving farming systems for resource-poor farmers. *Agricultural Systems* 71, 249-274.

Uphoff, N. 2003. Higher yields with fewer external inputs? The System of Rice Intensification and potential contributions to agricultural sustainability. *International Journal of Agricultural Sustainability*, 1, 38-50.