System of rice intensification responds to 21st century needs

BY NORMAN UPHOFF

The system of rice intensification (SRI) was developed in Madagascar 20 years ago by Fr. Henri de Laulanié of the Society of Jesus after 2 decades of working with farmers to raise their rice production without depending on external inputs. Today, SRI is gaining acceptance around the world. Practiced only in Madagascar until 1999, it has since demonstrated its environmentally friendly benefits from China to Cuba and from the Philippines to Peru.

SRI is still controversial in some circles, despite our ability — given more space than is available here — to explain in scientific terms why younger and fewer seedlings transplanted with wider spacing and no continuous flooding, and nourished by compost rather than chemical fertilizer, give much higher yield than conventionally grown rice (see http://ciifad.cornell.edu/sri). By changing how plants, soil, water and nutrients are managed, SRI can achieve average yields about double the present world average of 3.8 t/ha. When the methods are applied well and so improve the soil, yields can reach 15-20 t/ha. SRI practices improve the growing environment of the plant so that any rice genotype can result in different, more-productive phenotypes having much larger root systems. The growth and health of the plants are supported by the greater abundance and diversity of soil biota.

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With SRI, farmers do not need new rice varieties, because all cultivars respond positively. The best SRI yields have been achieved with high-yielding varieties or hybrids, but even traditional varieties can produce 6-8 t/ha — and as much as 10-12 t/ha. Since SRI reduces seed requirements by 80-90%, it slashes otherwise significant hybrid seed costs. Farmers do not need to use chemical fertilizer or other agrochemicals, as the highest yields come with compost made from any available biomass, and SRI-grown plants naturally resist pests and diseases.

The possibility of achieving higher yields with a 25-50% reduction in water requirements addresses a growing need to conserve water in this century. As SRI rice paddies are not continuously flooded, they may also reduce greenhouse gas emissions, though this cannot be assessed until SRI is used on a larger scale. Stronger root systems help the plants stand up to drought, wind damage and cold spells, and also make more feasible ratoon crops harvested from stubble regrowth.

Farmers who adopt SRI need information and training but no new capital expenditures. Once initial skepticism is overcome, SRI is easy to learn and disseminate. Anyone who knows how to grow rice and is motivated can easily learn the system. As farmers are encouraged to experiment with variations to the methods and thus to improve them, developing human resources is an intrinsic part of SRI extension.

SRI requires more investment in water management to allow farmers to apply smaller amounts only as needed. And it is initially more labor-intensive by 25-50%. However, once farmers have mastered the methods, SRI can even become labor-saving and applicable on a large scale. One commercial farmer in the Godavari Delta of the Indian state of Andhra Pradesh planted nearly 45 ha to SRI rice in the last *rabi* (dry) season.

Some suggest that SRI is a niche innovation, relevant only for certain conditions regarding soil or other factors. However, practically all of the recent 300 *kharif* (wet) season on-farm trials of SRI in Andhra Pradesh, distributed across the diverse soils of its 22 districts, were successful (excepting those on saline soils). In China, SRI yield increases have been documented from Zhejiang in the east to Sichuan in the west, and from Hainan in the tropical south to Heilongjiang in the far north.

SRI is spreading because it is versatile and can more than double farmers' net income (see an International Water Management Institute evaluation of SRI in Sri Lanka at www.iwmi.cgiar.org/pubs/rrindex.htm, Research Report No. 75). With respect to the agricultural and food-security needs of the new century, SRI is a "designer" innovation that efficiently uses scarce land, labor, capital and water resources, protects soil and groundwater from chemical pollution, and is more accessible to poor farmers than input-dependent technologies that require capital and logistical support.

We hope that many institutions and individuals will join in helping to improve the understanding and spread of this innovation, which can go far toward meeting this century's economic, social and environmental needs.

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Agronomic UFOs waste valuable scientific resources

BY THOMAS R. SINCLAIR

Discussion of the system of rice intensification (SRI) is unfortunate because it implies SRI merits serious consideration. SRI does not deserve such attention. A multinational team has shown from both theoretical evaluations and a number of experimental tests that SRI offers no yield advantage. Significantly, these results by Sheehy et al. were published in *Field Crops Research* (2004), an international journal that requires anonymous reviews. Their research used the classical scientific approach of assessing a concept's consistency with existing facts and knowledge, and conducting critical experimental investigations with appropriate controls and statistical tests.

Three components of the SRI strategy run directly counter to well-established principles for high crop growth. These principles were developed over many years of careful testing and scrutiny by scientists worldwide, and they have stood the test of time.

First, SRI uses very low plant densities. Energy for crop growth results from intercepted sunlight, and the amount of light intercepted translates directly into plant growth. High plant density enhances light interception, growth and yield. SRI suffers from poor light interception because of low plant densities.

> *One lesson to be learned from the SRI experience of unconfirmed field observations (UFOs) is that there are no shortcuts to increasing crop yields*

Second, SRI replaces paddy flooding by simply maintaining "moist" soil conditions. The physiology and physics of plant water use have been researched for more than 300 years, and the relationship between growth and plant water use is unambiguous. Ample water maximizes rice yields, and flooded paddy fields assure that no water limitations develop.

Third, SRI emphasizes organic nutrient to the exclusion of mineral fertilizer. SRI faces a serious challenge in obtaining sufficient mineral nutrients from organic sources to achieve high yields. Rice grains contain about 0.013 grams of nitrogen per gram of seed (1.3% N). A claimed yield of 15 t/ha requires nitrogen from over 50 t/ha of organic matter. Such a monumental demand for organic matter creates huge challenges in sourcing, handling and managing these materials.

Further, the basis for SRI is explained with misinterpreted or fragmentary literature, which is used without a full understanding of the overall processes regulating and influencing plant growth and yield. Crop growth is fundamentally the accumulation of carbon and nitrogen and their partitioning to growing seeds. For example, one erroneous assumption is that shortening the phyllochron (leaf emergence rate) in itself accelerates growth; no such direct link to growth exists.

Another example of misunderstanding is the claim that not flooding the soil overcomes the supposedly negative consequences of aerenchyma (air channels) in rice roots. Aerenchyma are naturally present in rice roots and form both when the roots are flooded and in SRI. Further, aerenchyma form in the root cortex and neither infringe on the vascular tissue nor negatively impact water or nutrient transport.

Regrettably, SRI appears to be only the latest in a family of unconfirmed field observations (UFOs) that have several features in common with their space UFO cousins. While there is an abundance of "sightings," they are anecdotal and reported by people who have minimum understanding of the basic scientific principles being challenged by such reports. In many cases, mysterious circumstances are invoked to explain the miraculous — for SRI, there are unexplained "synergies" and processes in the rhizosphere (the zone in which plant roots interact with soil microbial populations).

Egregiously, some people who have little or no research experience are able to influence the agricultural research agenda and cause UFO reports to be taken seriously. Such decisions require widely published scientists to produce documented responses, causing losses in time and resources that could otherwise be committed to investigating well-founded hypotheses for true understanding in maintaining and increasing crop productivity.

One lesson to be learned from the SRI experience is that there are no shortcuts to increasing crop yields. The history of crop yield increase tells of decades of hard-won scientific advances in understanding the biology, biochemistry and physics of plant growth and yield. Research requires intensive investigations by those trained to understand the theoretical context of their research and to undertake the critical experiments. Most importantly, results are not accepted until the research is described in an unbiased manner in a scientific journal that relies on anonymous reviews.

It is hoped that the SRI experience will infuse those making funding decisions for agricultural research with renewed skepticism and caution upon the next "sighting" of an agronomic UFO.

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