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Development of the System of Rice Intensification (SRI) in Madagascar

by 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, ones 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 Malagasy 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 seminary 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.

SRI was developed in Madagascar through half-a-lifetime of effort of a French priest, Henri de Laulanié, who spent the last 34 years of his life with poor farmers in that country. He sought to help them reduce their poverty and hunger by improving their production of rice, the source of more than half of the calories that are consumed daily by typical Malagasy. His approach was to rely on simple methods that would not require farmers to purchase external inputs. Few Malagasy farmers could afford these, and they were anyway unavailable in much of the country even if farmers had the money to buy them.

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 minority 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 (continued on page B-2)
So What’s all this About Crop Intensification?

by Jack Kittredge

We are excited about this issue of The Natural Farmer. The principles which have been developed around rice production on small African and Asian farms in the last generation are true revolution. Called SRI (for ‘System of Rice Intensification’), these methods are often counterintuitive and fly in the face of conventional farming practices and agricultural theory. Yet they are delivering stunning results — very significant yield increases, higher plant health and quality, all with lower input costs.

“So,” you muse, “that’s great. It is wonderful that you are excited about a new system for rice production in the Third World! But I’m a farmer in the northeast US with limited time. Why should I read about this?”

Why? Because these principles can be, and have been, applied successfully to other crops. In many cases these crops are the very ones we grow: potatoes, carrots, beans, eggplants. And once you wrap your mind around these principles, and think about why they work for raising plants, you will never farm the same way again.

That is strong language. But give this issue a chance to prove it to you. We devote several articles to the development and spread of SRI. The story is fascinating in and of itself. But we also look at other crops than rice that Third World farmers are raising this way — wheat, millet, teff, lentils, mustard, eggplants, tomatoes. It seems to be working for all of them. We explore why.

And then we spend a little time with an inquisitive and leading-edge Maine farmer who has been experimenting with such techniques for several years. We learn about his discovery of these methods and then how he has applied them, with remarkable success, to beans, wheat, carrots and potatoes. He calls it SCI for the “System of Crop Intensification”.

So take a couple of hours off this winter. Grab this paper and settle down for a nice read. Open up your mind to some interesting history and ideas, and then muse about how you might be able to adapt these thoughts to make next year happier and healthier on your farm or garden!
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 Ramonafana who used SRI in 1994-95 averaged over 8 t/ha, more than four times these previous yields, 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 three 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 in 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 where compost is added to the soil, increasing soil organic matter and nourishing soil microorganisms (beyond what one’s own (water) exudation) can support, large increases, even a tripling in yield, can result. On poorer soil loam, SRI practices gave 6.39 t/ha compared to 2.04 t/ha with standard practices. Stage specific synergies, close spacing, containing surface water (flooding, NPK fertilizer). On better clay soils, yields went from 3.0 with standard methods to 10.35 t/ha with SRI (Randriamiharysoa 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 provide (of course, these resistance values have no meaning in terms of the work done against the root system). 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 provide (of course, these resistance values have no meaning in terms of the work done against the root system).

The methods raise, concurrently, the productivity of land, labor, capital and water, without tradeoffs. For example, they reduce the need for external inputs (fertilizer, pesticide, irrigation, etc.) by increasing plant root growth and functioning, and an enhanced ability of the plant to protect itself against pests and diseases (by increasing plant root growth and functioning, and an enhanced ability of the plant to protect itself against pests and diseases).

Scientifically, the most interesting phenotypic change was in the relationship between number of tillers/plant and number of grains/tiller (panicle). For standard procedures such as hoeing, tillers are not a positive rather than negative, as is widely reported in the literature. With a larger root system, SRI plants can access more soil nutrients, right through the ripening stage, when plants are getting fat, which is the time of their maximum growth. Farmer knowledge is a good starting point to understand the potential of rice plants for millennia. We must never let form triumph over substance and over vision and imagination.

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Norman Uphoff: Spreading Crop Intensification Around the World

by Jack Kittredge

The story of the discovery of SRI (System of Rice Intensification) begins in the Indian Ocean (see detailed story on the origins of SRI on page B-1).

As you learned if you read that, the French Jesuit priest Father Henri de Laulanié was sent by his order to Madagascar in 1961 to do mission work. But he figured out quickly that he needed first to deal with the local poverty and hunger, and that rice, the staple food on the island, was the key to doing that.

For twenty years he watched local farmers, studied their planting methods and their harvests, experimented on his own with various growing techniques, and slowly developed a number of unconventional ideas about rice culture that began proving themselves in larger and larger local harvests.

By 1983 he was teaching Madagascar farmers to use his SRI system, and in 1990 created an organization, the Association Tefy Saina, to spread his ideas. ‘Tefy Saina’ is a Malagasy term meaning ‘to improve the mind’. But progress was slow. In 1990 Laulanié also gave a couple of seminars on his approach at the University of Madagascar, but it was not taken seriously. He died in 1997.

Without the help of a thoughtful and determined American professor the potential of SRI in transforming small peasant agriculture would still be largely unrecognized.

Norman Thomas Uphoff, raised in Minnesota in a socialist family active in building the Democratic-Farmer-Labor party of Hubert Humphrey, graduated from the University of Minnesota in 1963 with a strong social conscience. In a climate where John F. Kennedy had recently founded the Peace Corps, Sciences, which is on the lower campus. When Cornell received a very generous anonymous gift of 15 million dollars for ten years to work on sustainable agricultural rural development, my agriculturalist friends said: ‘Why don’t you apply to be the director? You can get people working together across disciplines.’

So Uphoff did, and was selected to run the Cornell International Institute for Food, Agriculture and Development (CIIFAD).

The third year into that job he had programs started in the Dominican Republic, Indonesia, Zimbabwe, and the Philippines. Then they were presented with an opportunity to go into a USAID-funded Madagascar project.

Madagascar has notoriously poor soils. The pH is a highly acid 3.8 to 5; the cation exchange capacity is very low on all soil horizons; there is iron toxicity, aluminum toxicity, and the available phosphorus is less than 5 parts per million when ten is usually the minimum for agriculture. In many places the primary practice was to slash an area in the forest and burn it, then grow there for a few years until the nutrients in the ash were used up. Then the area was allowed to regrow while a new one was slashed and burned.

“I thought,” Uphoff says, “‘That’s an interesting challenge. How do you help farmers have an alternative to slash and burn?’ This was 1993. When I went to the villages there I remember telling my colleague: ‘We have to get the rice yields up. As long as they are only 2 metric tons per hectare the farmers are going to have to do slash and burn to supplement what they can grow on their paddies.’

“I said that,” Norman recalls, “to the project co-
ordinator, a Malagasy, and he said: ‘Yeah, you are not going to be able to stop people when they have to feed themselves. But I know a small NGO (non-governmental organization) that does something called ‘System of Rice Intensification’. Would you like to talk to them?’ I said: ‘Of course!’”

That NGO was the Association Tefy Saina, Father Laulanié’s group. Father Laulanié was trying to change the mentality of the people. The traditional religion in Madagascar is to follow the ways of the ancestors -- if you don’t follow those ways they will be angry and wreak vengeance on you. They might even punish your neighbors. That makes any kind of change difficult there. The landholdings are private and small, and they are rotated among the families. If you change how you plant crops it is obvious to everyone that you are breaking with the ways of the ancestors.

“I talked with Tefy Saina,” Uphoff continues, “and I said: ‘We really have to get these rice yields up or the forest is doomed! We need to have a more stable food production.’ I remember the president waving his hand and saying: ‘No problem. We can get five tons, ten tons, even fifteen tons per hectare without new varieties and without fertilizer, using less water.’

“I tried to mask my smile of disbelief,” Norman remembers. “But the NGO agreed to subcontract with us and we hired some young villagers and trained them as our agents. The first year Tefy Saina got 38 farmers to try these new methods. They got 8 ton yields instead of 2 tons. It made no sense to me – a four-fold increase!”

Tefy Saina used the government’s sampling protocols for measuring the yield, so Uphoff could hardly dispute the results. The farmers received the benefit of selling the increased yield, as well as paying 80% less for seed and not buying any fertilizer. The small amount of extra labor that their methods involved at first declined once the methods were learned. It seemed to Uphoff like a miracle!

But over time he has learned why the methods developed by Laulanié are so effective.

“In the 1920s and 1930s rice scientists in Japan had studied the tillering pattern of plants,” Norman explains. “They made a very interesting observation. There is a periodicity in the way plants put out their tillers and roots. It so happens that it corresponds precisely with the Fibonacci series in mathematics. (Fibonacci was an Italian mathematician who asked the question: If I have a male and a female rabbit and it takes one month for a rabbit to reach sexual maturity, and they produce a male and a female, what would be the pattern of growth? It is based on biological systems where there is a lag period. The Fibonacci series shows up in all sorts of natural systems! Each period is basically the sum of the previous two periods.)

Anyway,” he continues, “if you have good growing conditions for a plant it puts out a main root and a main tiller in the first period – which can be anywhere from 4 days to 10 or 12 days, depending on growing conditions. The length of that period, which is the interval between similar growth stages of successive leaves on the same stem, is called a phyllochron. How long it is depends on the biological clock involved. The seven factors that drive that are:

• temperature -- the plant speeds up if it is warm,
• crowding -- the clock speeds up if there is lots of space,
• shading -- sunlight speeds the plant up,
• friable or loose soils speeds up the clock and compaction slows it down,
• nutrients in the soil speed up the process, and air and water are inversely related –
• good oxygenation speeds things up as does good water, but
• too much water means not enough air and that

This diagram of the branching of rice stalks demonstrates the natural development of any monocotyledon (a plant with one cotyledon or true seed-leaf, as opposed to dicotyledons which have two) over time. The period between branchings is called a phyllochron and can be a few or many days, depending on conditions.

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The longer you wait the less growth potential there is left in the plant. Laulanié also developed methods to explain how to transplant quickly and carefully. In Madagascar farmers typically would pull their transplants up roughly, cut off some of the roots with a machete, tie them in bundles and leave them in the sun for hours where the roots desiccate, then transport them and shove them into mud under water without oxygen in the soil. So they get a 2 ton yield. If you treat them carefully, taking them out with a trowel, keeping the soil attached to the roots, laying them in gently, they will do better.

Norman believes that a part of the secret of SRI has to do with the enormous biological life in the soil, given its focus on soil nutrition and aeration, but he has no measurements of that yet. “In one village in Bihar,” he says, “where I believe there is incredible life in the soil, although I can’t prove that, five farmers got yields of 19, 20, 21 and 22 tons per hectare. They were using hybrid seed and a small amount of fertilizer. But when they used the same seed in the same soil without these principles they got 7 tons.”

SRI is really counter-intuitive. Farmers are very scared to see a single seedling. A tiny little plant, only one, looks so vulnerable. What if something happens to it?

Norman cited one farmer in Madagascar who planted his rice 50 centimeters apart.

“We recommend 35,” he said. “But he had access to a lot of waste and was putting on something like 5 tons of compost per eighth of an acre. He got a 21 ton yield, ten times the national average. Some plants had 140 tillers on them. His average was 70 tillers.”

“If you have fertile soil,” Uphoff continues, “the roots will grow really large and need much more space. If you lack nutrients, you will do better with a denser planting and each plant will explore for nutrients as best it can. If it is good soil a huge root system will develop and that is far more efficient. A lot of microbial activity and exchange takes place. There are no good studies on this microbial aspect, yet.”

A curious aspect of SRI is that the plants seem tougher than non SRI ones.

“Why,” asks Uphoff, “is rice grown according to these principles stronger? There are lots of ideas, but we have not had much cooperation from American researchers in studying these questions. They say SRI can’t work in the first place and don’t give us the time of day. But one idea is that if you have unfertile soil, the plant will contain more silicon. So the tillers and leaves are much tougher. I first learned this when a farmer in Sri Lanka told me he couldn’t go into SRI fields with short pants on. He likes fertilized fields because the rice feels soft. But the SRI rice cuts his legs.

“An official of an Indian extension service in Andhra Pradesh,” Norman continues, “was visiting an SRI field in Sri Lanka. It was green and thriving when other surrounding rice fields were brown from...
drought. It wasn’t until he picked a leaf from the SRI rice that he realized what was going on. He ran it through his fingers and the leaf cut his finger! He said: ‘In all my years raising rice I have never cut myself on it. That is what got me to realize this is really different!’ We have also been in fields where the insects were eating non-SRI rice and leaving the SRI rice alone. That could be because the leaves are tougher as well. No one has done proper studies on this."

When weeding SRI rice, farmers go between the rows. They don’t get all the weeds, but do get most of them. Each weeding can add one-half to 2 tons of yield. It costs to provide this labor, but the returns are tremendously higher. Yield goes up enough that it more than compensates for the extra labor costs.

The number of different weederes developed for SRI are almost as various as the locations where rice is grown.

Rice is one of the few crops that will grow under flooded conditions. Maize and wheat hate standing water, but rice is a plant which can adapt to flooding and the farmer could get a crop under those conditions. Also, if growing rice under upland conditions, without flooding, rice will have to compete with weeds. So being short of labor a farmer may decide to grow it under flooded conditions and not spend so much time on weeds. This is the main reason for flooding rice now - to control weeds.

“But most ecosystems,” Uphoff asserts, “just don’t have the water to continue with this practice. We have to start growing rice in less water. Fortunately we can show with SRI that if you do the other practices you can not only use less water, but actually increase yield.

“In northern Myanmar, the southern Philippines, and parts of India,” he continues, “rice is produced as a wholly rain-fed crop. That is where they have adequate rainfall and there are no irrigation facilities. In the Indian case they introduced two ingenious principles. Farmers normally wait for the rains, but the monsoon is very unreliable in India. There is a

Inexpensive hand-weeding tool made and used by Govinda Dhakal in Morang district of Nepal, costing 20 cents. The first time Govinda utilized SRI methods on his farm the weed growth was so great that his neighbors thought he would never try SRI again. But he was determined and made this simplest of weederes out of wood and nails. This enabled him to triple his SRI area the next year to 1.5 ha as he found that the tool enabled him to reduce the labor time for weed control by 60% over manual weeding.

A weeder demonstrated in Cuba has two turning axles to disrupt weeds and aerate the soil. A ‘shoe’ in front enables the weeder to stay on top of the soil and not disrupt the rice roots.
six-week variance in terms of when it comes. So the idea is to get farmers to plant their seeds in two or more nurseries, staggered weeks apart. They use more seed, but then they have some seedlings that are young when the monsoons come.”

In that situation farmers might be tempted to hold onto their water, Norman says, but that suffocates the root and causes die back. They have to agree not to hold onto the water too long, although that is hard for farmers in water-scarce regions. Where water is a limiting factor, using less water lets more people use it.

The resistance of SRI crops to adverse climates is another strength of the system. Normally, rice is very cold-sensitive and ten degrees C is considered the lower threshold for rice. But SRI plantings have survived storm damage and cold spells, and Uphoff has seen rice crops that go 5 days below 10° centigrade and still give a 4 ton yield!

“In Manchuria,” he says, “they have independently developed a system called the “Three S System”. They start their seedlings in plastic greenhouses while there is still snow on the ground. They transplant single seedlings at 45 days, which are fairly good size. But it is cold enough that small ones wouldn’t survive. They use wide spacing, less water, more organic matter. They developed it entirely independently in the nineties. What they get in 45 days is probably more like what you would get in Africa in 25 days. But there is a huge difference in the plant size of mature 3-S rice.

“Rice will grow in many places,” Norman continues. “Two of our best cases are Afghanistan, up in the mountains in the north, and again in Timbuktu, the mountains in the north, and again in Timbuktu, in the Saharan desert. In both places we get to 9 to 10 tons, despite the adverse climate.”

There is even some evidence of greenhouse gas emissions being reduced with SRI. If you don’t flood the fields you don’t get methane, which is produced under anaerobic conditions and is 5 times more potent a greenhouse gas than carbon dioxide. But if you have aerobic soil you can have more nitrous oxide, which is 22 times more potent than methane. Uphoff says it turns out, however, that if you are using inorganic sources of fertility with a lot of nitrogen, you get a lot of nitrous oxide. But if you do SRI and are using only organic sources, there

Sidebar: A Case Study from the Sundarban Delta, West Bengal -- Paresh Das’s Field

(editor: According to Uphoff, one West Bengali farmer’s experience with SRI was particularly dramatic. Paresh Das tells it in his own words (italics), interspersed with Norman’s comments:

Last summer I started a mysterious rice cultivation practice on my land. Initially this prompted my neighbors to call me mad. Admittedly, when I first heard of the details of the SRI technology, I was pretty skeptical. However, my own analysis suggested that it may be practically possible. So I decided to put SRI in place on 10 decimals of land.

However, when I discussed the matter with my wife, she refused and reacted very strongly. She said that planting a single seedling with such wide spacing cannot produce any yield, and she objected that gambling with staple food supply is not acceptable for poor families like us. I was literally cornered within my own family and at odds with the village itself. The challenges and comments from the people around me, however, made me angry and eager to jump into the practice.

Paresh had to encounter a lot of objection from his family and the neighbors when he planted a nursery using only 400 grams of saltwater-tested seeds [this method of seed selection ensures that only dense, well-developed seeds are used]. The nursery bed was 20 ft by 4 ft. With the nursery growing nice and green, comments from other people were still tolerable. But the peer environment became worse when he transplanted single seedlings at intervals of 1 ft (30 cm) apart. The women engaged for the transplanting were very skeptical. They were not prepared to transplant single seedlings of such a young age. It took a lot of convincing and supervision to get this done, according to Paresh.

These 12 days after I had transplanted the single seedlings were the worst part of my life. In the initial couple of weeks, at least 10 times I thought of replanting the field with the conventional method. My wife who has shared with me all the pains of poverty all throughout our lives even stopped talking to me. For the first time in my life, I was afraid of a drop-off in the customers to my tea shop.

My wife never visited the plot until 15 days after the SRI transplanting (15 DAT). However, during those 15 days I used to visit my plot every night, when nobody could see me nurturing the plants. To my great surprise, after 15 days the plants started behaving differently. Distinctly I could observe that the vigor of the SRI plot was better than with the conventional practice beside it. I saw this and started thanking God for the blessings. But I did not dare to share this feeling with my wife. Still, I started believing that this rice crop can really grow.

One day – I think it was 20 DAT – I requested my wife to provide the irrigation to the SRI plot. I told her, ‘I am not well today. Can you do me this favor?’ She responded there was no point in putting further money and labor into that plot. But finally she agreed and left for the SRI field. Almost immediately, at most after some 15-20 minutes, she came back very excited and shouting in joy. ‘Have you seen the field? It has got miraculous growth. It is astonishing. How can there be more than 10 tillers from a single seedling? I could not control my tears at that point of time.

The game started since then. Every day I paid a visit to my field and could see more and more tillers. Gradually I discovered people were commenting favorably on the SRI plot, and they were paying more number of visits to my plot than me. As the crop was growing, many a times I felt like applying urea and NPK to enhance its growth, but there was very strong recommendation from Goutam (NGO man) not to apply anything apart from 20 kgs of mustard oil cake and 6 bags of cow dung.

I feel proud whenever unknown faces come up to me and ask: ‘Paresh, how could you do this?’ I never thought Paresh would become a known name in the area, even as a farmer.

At the end of the season, the plot ended up having on average 40 tillers per plant, as compared to the 10 tillers with conventional practice. It became a topic of discussion in the village. What is miraculous in the new technique? What produced the 240 kgs of rice instead of 115 kgs that people are used to getting through the conventional system? How could Paresh get doubled yield using such a minimum of nutrients, instead of the conventional 20 kg of NPK (10:26:26) and an added dose of 10 kg of urea which farmers generally use for this same size of plot?

These stories are real. I’ve seen situations where it was the wife who supported SRI and the husband laughed at it. For an agronomist, perhaps these yields are too far off the plausible screens and they won’t accept these as valid information. Since I’m a social scientist, though, I’ll take these stories as data.

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Patna: An upbeat Chief Minister on Wednesday proudly displayed the potatoes raised by a farmer in his home district of Nalanda who has earned the honor of setting a new world record in potato production using only organic farming techniques.

The farmer, who happens to share the name of Chief Minister Nitish Kumar, has managed to raise 72.9 tons of potatoes per hectare beating the previous world record of 45 tons per hectare established earlier in the Netherlands.

“This is a very proud moment for all of us that further bolsters our resolve of a second green revolution in the state. Nitish has proved that with proper knowledge and technique, Bihar could attain this goal in not so distant future,” the Chief Minister said.

Sanjay Kumar Agrawal, the Nalanda District Magistrate, said experts and senior officials have verified the legitimacy of the new record, and the farmer would soon be honored at a function held in the coming days.

After Paddy Feat, a Nalanda Village Looks at Potatoes

Five farmers of Darveshpura village in Bihar’s Nalanda district created a world record last October when they produced 220 quintals (ed: a quintal is 100 kilograms or one-tenth of a metric ton) of paddy rice per hectare using SRI (System of Rice Intensification) methods.

The feat has inspired other villagers to write history. A set of young farmers are growing potatoes — each weighing between 800 g and 1 kilo — that they send to potato chip factories through local traders. Hordes of agricultural scientists who had visited the village last year to meet paddy growers, too, had encouraged these farmers to excel in potato and wheat production.

Nalanda, the home district of Chief Minister Nitish Kumar, is already the leading potato producing district in Bihar with farmers growing the crop on over 27,000 hectares.

Nitish, who recently visited Darveshpura village to felicitate paddy farmers, said that the state had a huge potential in potato production and could attract food processing factories.

Bihar is the highest potato producing state after Uttar Pradesh and West Bengal.

Sanjay Prasad Singh, a farmer in his mid-thirties, said: “We have been growing potatoes of big sizes for quite some time now, but we often do not get good markets. Now that our village is in focus, we are growing more potatoes and hope to reap good benefits.”

The village that has about 1,200 bighas of land generally produces three crops a year. (ed: A bigha is a unit of land, but its exact size varies considerably. In different parts of India it can range from less than an acre to more than a hectare.) The new crop will be ready in February.

Sunam Kumar, who is one among the paddy production record holders, said the village land that often gets loamy soil from a seasonal river is suitable for several crops, including the potato.

“Even a farmer with three bighas of land is happy. We do not think of migrating to other states anymore,” said Kumar.

Nitish Kumar Singh, another farmer, said the only problem with big potatoes is that they are not considered good for everyday consumption. “At times, farmers have to sell it very cheap, for as low as 3 rupees per kg,” he said.
is no excess or free nitrogen and you don’t see the increases. So you get a net improvement in global warming potential -- one study found a 78% net reduction in global warming with SRI methods.

SRI methods are being adopted throughout Asia and increasingly in Africa. It is slower in Latin America, but one Cornell alumna has brought the methods to Cuba and is using them with a sugar cooperative there.

“But their scientists have been very hesitant,” Uphoff remarks. “I’ve visited four times and given talks. But SRI doesn’t look sexy! The Communists generally love mechanized, agrichemical things. They have a love affair with technology. So they haven’t been very quick on this. But the sugar cane version of SRI has taken hold and they are getting interest from the government for that. Cane is a grass, too, like rice. Same principles – wide spacing, young seedlings. It is called SSI!”

Peasant farmers aren’t stopping at the rice family, either. Mustard has been grown with SRI methods very successfully. The final plants are huge and the number of pods and size of the grains are way up from conventionally grown mustard.

Tef, the cereal grain of Ethiopia, is another success. Normally tef yields one ton per hectare, but using SRI principles farmers are getting 7 tons.

“Tef, the cereal grain of Ethiopia, is another success. Normally tef yields one ton per hectare, but using SRI principles farmers are getting 7 tons. "There is an Ethiopian agronomist who grew up raising tef on his father’s farm,” says Uphoff. “Somehow he got a fellowship and spent 10 months with Norman Borlaug in 1970. He went on to get his PhD at Nebraska. He was the first scientist to hybridize tef. In 2008 I was invited to Ethiopia by some Indian colleagues now in Ethiopia wanting to bring SRI in. So I spent 2 hours with this agronomist and his staff. He understood what I was saying. I said why don’t you try it with tef? We knew millet would work. The next June I got an Email from him saying he was going to be in the states and wanted to report his results to me. He said his normal controls were all doing 1 ton per hectare, but his tef intensification plantings were doing 3 to 5 tons. Then he said when he used some micronutrients -- man-
ganese, magnesium, sulfur, copper and zinc, he was getting 8, 9 or 10 tons! He said: ‘I’ve never seen plants like that before!’

“So I got some money from Oxfam America for him to go and do really proper trials,” Norman continues. “He got brought into a project which the Gates Foundation is funding to develop tef and rice with these methods. So our big breakthrough may come not in rice but in tef. I say breakthrough because the Gates Foundation is funding it and they will want to take credit for it, but my friend the agronomist is calling it the System of Tef Intensification!”

Despite the number of people who have adopted SRI techniques for rice or other plants, the methodology is poorly known. Uphoff estimates there may be 5 million farmers currently using these methods, and he is adding new people to his network every week. But recognition by Western agencies has been sparse indeed.

“We have been shunned,” he says, “by much of the western scientific establishment. Their scientists would be obsolete if we are right! Suppose I went to them and said: ‘I have an innovation, which I will give you free, which raises yields, uses less water, less chemicals, lowers costs, brings higher profits, is quicker maturing, has higher milling recovery (SRI has a better milling recovery than paddy rice because there is less shattering and you get more edible grains and less chaff or unfilled husks – instead of 8% or 10% unfilled grains, we have 2% in SRI.) Also, the grains themselves are often heavier. They are larger and denser. Do you think they would be happy to find such an answer, or angry that they didn’t find it?”

Norman works mostly with the farmers and the local country’s agricultural establishment. As such, he can do a lot with a little bit of money. SRI doesn’t need expensive fertilizer or new breeds of crops. In some sense it is a threat to the donors because it can do what they want to do without all their money. In addition, Norman came into this work from the wrong background.

“I am a political scientist,” explains Uphoff, “not an agronomist, at least by formal training. That makes a huge difference in how well scientists in the agricultural college will listen to me. They have actually said: ‘It’s not fair what you are doing. You haven’t paid your dues!’

“I edited a book on Biological Approaches to Sustaineable Soil Systems,” he continues, “published by CRC Press, 102 contributors, from 28 countries, forward by a respected agronomist, 10 co-editors who are scientists, of whom are directors of international research centers and two are World Food Prize laureates. It is incredible. This has not had one review in the agriculture literature or journals. But I don’t want to sound too grim – in India, China, Indonesia, Thailand, we have strong supporters at the national level.”

The two leading rice scientists in the world have looked at SRI, tried it and endorsed it, he says. They are Indian and Chinese, respectively – both World Food Prize winners. They have both independently published SRI results, but it does not seem to register with the USDA or western researchers.

One academic at UC Davis in California actually told Norman that the opposition argument to SRI being used here has been: “If our farmers used these methods they would use less water and then they would lose their water rights.” “That shows you how irrational our system is,” Uphoff observed. “California desperately needs that water for other purposes, but the farmers continue to use it.”

The actor Jim Carrey has set up his own foundation and is supporting SRI. He heard about it from a friend and decided that was a way to do something really significant. He studied Norman’s website and then met him in Hollywood to get answers to his questions about it. He is now supporting SRI work with a generous 3-year grant.

“Carrey went to Haiti already,” Uphoff observes, “and I’d like to get him to Bihar, India. But apparently the security costs when a major star goes somewhere like that are staggering! Celebrity has its downsides!”

One question many observers ask about SRI is: “Why are farmers just discovering this stuff? Why did they not learn it many years ago?”

Uphoff answers: “These ideas are not new! They are both Japanese work on tilling and was published in 1951. But it was in Japa- nese, right after the war.

“There are probably 15 or 20 elements,” he continues, “that all go together synergistically to make this work. Better roots give you better canopy, better canopy gives you better roots. There is a positive feedback between canopy and roots and ideally you work on all these things at once! Even Father Launàine started with fertilizer because everyone used it, but when the government took the subsidies off it in the late 1980s he found that if you do all the other practices, compost will work fine. In fact it comes out ahead of fertilizer.”

Uphoff feels the really crucial aspects of SRI are the importance of root growth to the ability of the plant to fulfill its genetic potential, and the development of microbes and other organisms in creating a healthy soil food web. If these aspects of the planting are satisfactory, the individual plants will have a different architecture – leaves will not be shaded by neighboring plants and they will all be photosynthetically active. The tillers will also be more horizontal and the leaves more erect. One study calculated a 15% increase in system leaf area index and light interception with the same varieties and same soil, just changing to a SRI management.

As far as western farmers go, the Soil Association in England has invited Norman to talk about SRI at their annual meeting this year. They are particularly interested in the process of farmer-led innovation.

“And we have a few farmers in the US who are doing SRI this year,” Norman says, “so I think it will take hold here, too. They aren’t large scale, but we don’t want large scale yet.”
Compared to 10 years ago, there are many more persons – 4 to 5 million, most of them farmers – who can answer the question ‘What is SRI?’ However, most of these persons will not have yet very detailed knowledge of this subject, and many would like to know more about this agricultural system for raising the crop yields of rice and of many other grains, legumes and vegetables just by changing the crops’ management, with minimal reliance on purchased inputs.

Many times more persons than 4-5 million have by now at least heard of SRI and its benefits for producers, for consumers, and for the environment. Presumably many of these persons would like a systematic introduction to this phenomenon that has shown positive results in more than 50 countries around the world.

This is written for both groups of potential readers, bringing together in one place much of the accumulated field experience and scientific research that makes the System of Rice Intensification (SRI) – and its derivations grouped under the heading of System of Crop Intensification (SCI) -- such an important opportunity for improving people’s lives in the 21st century.

The ‘modern agriculture’ that has been productive and significant for our populations in the 20th century is going to have to change considerably in this century. Our land and water resources are diminishing in quantity, quality and reliability, certainly in per-capita terms but in many places also absolutely. With the added complications and compulsions of climate change, there is even more reason for us to rethink and revise our agricultural practices, even if they have in the past served much if not all of the world’s population reasonably well.

Ensuring food security for all households in our respective countries, raising crop productivity so that our food needs can be met with fewer rather than more of our resources, and maintaining the healthfulness of our food supply as well as the robustness and quality of our environment, are all imperatives. While meeting these objectives will not solve all of the world’s problems, we know that unless we satisfy these essential requirements, our chances of resolving other major problems in this world will become much more difficult and more unlikely.

The components of SRI were first assembled by Fr. Henri de Laulanié three decades ago in Madagascar. And it is only two decades since I first learned about SRI from the NGO that he founded, Association Tefy Saina. It has been a decade and a half since I felt comfortable with the conclusion that SRI is ‘for real’ and began to share SRI knowledge as widely as possible, to encourage its testing and evaluation in other countries.

Map indicating the spread of SRI since 1999. The years indicate when information that confirmed ‘the SRI effect’ was received at Cornell. Before 1999 – Madagascar; 1999- 2000 – China, Indonesia; 2001-02 – Bangladesh, Cuba, Laos, Cambodia, Gambia, India, Nepal, Myanmar, Philippines, Sierra Leone, Sri Lanka, Thailand; 2002-03 – Benin, Guinea, Mozambique, Peru; 2004-05 – Senegal, Pakistan, Vietnam; 2006 – Burkina Faso, Bhutan, Iran, Iraq, Zambia; 2007 – Afghanistan, Brazil, Mali; 2008 – Rwanda, Costa Rica, Ecuador, Egypt, Ghana, Japan; 2009 – Malaysia, Timor Leste; 2010 – Kenya, DPRK, Panama, Haiti; 2011 – Colombia, Korea, Taiwan, Tanzania; 2012 – Burundi, Dominican Republic, Niger, Nigeria, Togo; 2013 – Liberia?, Malawi? Solomon Islands? Work with SRI methods usually was begun in these countries before confirming results were reported.

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A picture about SRI was sent to me by Dr. Rena Perez, the volunteer catalyst for SRI evaluation and spread in Cuba.

This picture helped me and subsequently thousands of other persons to understand better the phenomenon of SRI that I learned about in Madagascar 10 years earlier. Rena had gotten Luis Romero, the farmer whose hands are seen in this picture and whom she knew from her previous work as an animal nutrition advisor for a government ministry, to try out SRI methods in 2002.

When she visited Luis 52 days after he had sown his nursery, she had her camera with her and could take a picture of a representative rice plant pulled up from his nursery as he was about to start transplanting in his main rice field, to be managed with standard practices. (About 50 days after sowing is a typical time for transplanting in Cuba.) The picture compares this ‘usual’ rice plant with an SRI plant that had been removed from the same nursery when it was just 9 days old, to be transplanted into an SRI environment, as a single seedling, widely spaced, with organic matter added to the soil, and with soil-aerating weeding.

The two plants shown are the same rice variety, VN2084 known locally as Bollito, and the same age, 52 days. The ‘typical’ plant on the left had 5 tillers (stalks) and a meager root system, probably reflecting overcrowding and flooding in the nursery, while its SRI ‘twin sister’ on the right had 42 tillers, and a very large, healthy root system. The same genotype had produced utterly different phenotypes, with the differences attributable simply to the modifications which Luis made in crop management. His first season, Luis got a yield of 14 tons per hectare on one of his plots. In a subsequent water-short season with late planting, he got yield of 4.5 tons compared to his neighbor’s yield of 3 tons.

The questions below cover the interests and concerns most often expressed regarding the System of Rice Intensification (SRI). Short answers are given to each.

- What is SRI?
- What are its key practices?
- Why isn’t SRI considered as a new technology?
- What and where are the origins of SRI?
- How has SRI spread around the world?
- Does SRI spread need favorable political and other conditions?
- How does SRI benefit poor, resource-limited households?
- Can SRI also benefit larger farmers?
- Can SRI outperform what are called ‘best management practices’?
- Why is there so much variability in SRI results?
- Are the super-yields reported with SRI practices credible?
- What is the impact of SRI on greenhouse gas emissions?
- Does SRI have anything to do with genetically-modified crops?
- What are the requirements for practicing SRI?
- Does SRI always require more labor?
- Can SRI be successful without irrigation?
- Is there need for new or special rice varieties with SRI?
- Is SRI necessarily an ‘organic’ system of production?
- What are limitations for utilizing SRI methods?
- Where can we expect that SRI is unlikely to succeed?
The System of Rice Intensification, widely known as SRI and in Latin America as SICA, is a management strategy for crop improvement. It is a set of ideas, insights and modifications in agronomic practices that are based on validated knowledge for increasing the production of irrigated rice—and now also many other crops. SRI does not require or depend on improved or new varieties or on synthetic fertilizers and agrochemical crop protection to get higher output. These can be used with SRI management practices, but they are not needed for greater crop productivity and vigor.

By reducing farmers’ needs for seeds and water, and often even for labor, SRI gives greater returns to available resources of land, labor and capital. This improves farmers’ incomes while also being beneficial for the environment. SRI plants are less easily affected by water stress, storm damage, and pests and diseases, as they demonstrate increasingly-needed resilience to the growing hazards of climate change. This capability is likely to be increasingly important.

What are its key practices?

SRI is based on certain principles that are expected to be adapted in practice to local conditions. SRI is most concretely explained in terms of certain changes recommended for altering standard rice-growing practices. But the principles that buttress these practices are always to be kept in mind, understanding SRI as more than just designated practices. For best results when growing irrigated rice:

- Transplant young seedlings, preferably 8-12 days old and as a rule less than 15 days old. These small plants should be grown in an unflooded nursery and then removed gently, with minimum trauma to the roots, being replanted in the main field carefully, quickly and shallowly (1-2 cm)
- Wide spacing between plants, with seedlings planted singly, one per hill instead of 3-6, and in a square pattern, usually 25 x 25 cm. This reduces plant density in the field by 80-90% and gives the plants’ roots and canopies more room to grow and to acquire nutrients and sunlight.
- Soil in the field is kept moist but not continuously flooded, intermittently wetted and dried so that the soil is neither anaerobic nor hypoxic (i.e., lacking oxygen). Neither plant roots nor the aerobic soil organisms that can provide many beneficial services to the plants should be suffocated.
- Control weeds with frequent use of a mechanical hand weeder as this can aerate the soil better than will manual weeding or herbicide. Active soil aeration can enhance the yields of paddy rice by 1-2 tons per hectare.
Why isn’t SRI considered as a new technology?

Unlike most current agricultural technologies, SRI is not based on material inputs. Instead it involves mostly mental changes and new thinking. SRI is a work in progress, continuing to evolve. Promoting something as a technology makes the innovation seem static, with farmers becoming adopters rather than adapters. SRI emphasizes adaptation and continuing improvement by farmers and others.

What & where are the origins of SRI?

SRI was developed in Madagascar by a remarkable French priest, Father Henri de Laulanié, S.J., who spent 34 years working with farmers there (1961-1995) to help them improve their rice productivity and rural livelihoods without having to rely on purchased inputs. Most of its main practices were synthesized by the 1983-84 season, some 30 years ago.

With Malagasy friends, Laulanié established Association Tefy Saina, a local NGO, in 1990. ATS has promoted SRI knowledge and its use as part of a holistic rural development strategy. Progress with SRI dissemination was at first very slow because SRI goes against strongly-held traditional beliefs that enjoin Malagasy people to ‘follow the ways of the ancestors.’ Adopting SRI practices is a very public and visible departure from those ways, risking the ancestors’ wrath. Still, SRI use has become wider in Madagascar and is now accelerating there.

How has SRI spread around the world?

In 1994, Tefy Saina and the Cornell International Institute for Food, Agriculture and Development (CIIFAD) began working together on a USAID-funded project to conserve the Ranomafana rainforest. Laulanié was still working there. The starts of SRI in Madagascar were small, but the benefits were so obvious that it grew quickly. The higher productivity attainable with SRI management practices was first validated outside Madagascar in China and Indonesia in 1999-2000.

Then similar results were reported from Cambo-
dia, Philippines, Cuba, Sri Lanka, India, Myanmar, Gambia, Sierra Leone, and other countries. By 2002, SRI methods had been further validated in 15 countries; 11 years later, there are 52.

Does SRI spread need favorable political and other conditions?

Yes, because SRI is capitalizing on biological processes and potentials that already exist in rice genomes and in plant-soil-microbial interactions. Its application is thus scale-neutral. Its benefits are available to any producers who make appropriate adaptations in practices to suit their own conditions. Efforts to mechanize various operations in SRI practice are going on in several countries. We expect that SRI ideas will soon be utilized across a full range of scales as they are now being applied within a wide variety of agroecosystems.
Can SRI outperform what are called ‘best management practices’?  
Yes. Some have argued that SRI only improves upon farmers’ ‘unimproved’ practices – but not upon the best practices that rice scientists can propose. Now that a SRI paddy yield of 22.4 tons/ha in kharif season 2011 has been reported by Dept. of Agriculture technicians in Bihar state of India, the idea that SRI offers ‘nothing new’ or presents ‘no new opportunities’ should be dropped. SRI is becoming established as the best management practice.

Why is there so much variability in SRI results?  
By following the basic SRI practices, one can expect yields in the range of 6-8 tons per hectare, 50-100% above the world average. But sometimes there are yields of 10, 15, even 20 tons per hectare, well above the ‘biological maximum’ proposed by some scientists based on computer modeling.

But the yield gains from SRI do not come from a genetic blueprint or from the application of chemical inputs where results are fixed or proportional.

Instead, SRI management practices increase the number and mobilize the services of beneficial soil organisms. Since the soil biota can vary by orders of magnitude, much variability in SRI results should be expected.

Are the super-yields reported with SRI practices credible?  
SRI has been dismissed as not worth considering or evaluating because the very high yields occasionally reported with SRI management are beyond what scientists have produced in their on-station experiments (ignoring the effects that their soil and nutrient management practices will have on the soil biota). The super-yields reported show what potential exists within rice genomes if given optimizing growing conditions. But we are more interested in increases in average yields than in outliers, because it is averages that feed people and make their lives better. This said, I have confidence in the high yields reported, knowing the farmers and the methods used for measurement.

How can SRI benefit the natural environment?  
By reducing irrigated rice crops’ requirement for water, SRI relieves the pressure of agriculture on ecosystems’ water resources. Moreover, raising crop yields substantially reduces pressures to expand the area under cultivation at the expense of natural areas. By reducing or eliminating farmers’ dependence on chemical fertilizers and agrochemical crop protection, both soil health and water quality can be improved compared to what is happening now with input intensive practices. Reducing excess stocks of reactive nitrogen in the soil and water helps counter one of the greatest threats to the health of the environment.

What is the impact of SRI on greenhouse gas emissions?  
Because SRI stops continuous flooding of rice paddies, there is no disagreement that it can significantly reduce the emission of methane (CH4) from rice fields. With no flooding, on the other hand, an increase in nitrous oxide (N2O), a more potent greenhouse gas, might be expected according to current thinking. However, when soil is fertilized with organic material rather than with synthetic nitrogen fertilizer, there is less excess N available for microbes to convert to N2O.

Evaluations in Nepal and Korea have found that with SRI management, there was no significant increase in N2O that offset the decreases in CH4 emissions or even some reduction in N2O. These studies should be continued and replicated. Evaluations have not been yet done on SRI impacts on the ‘carbon footprint’ of rice production. With less production, transport and use of inorganic fertilizer, the emissions of the CO2 associated with rice-growing should be lessened.

Does SRI have anything to do with genetically-modified crops?  
SRI gains are achieved through modifications in crop management, not deriving from any particular genetic traits or potentials, although it is clear that some genotypes always perform better than others under SRI management. Genes are important factors in crop productivity. SRI is not directly competitive with GM crops; their performance would probably be enhanced by being grown with adapted SRI methods. However, to the extent that SRI yield improvements and other beneficial effects are greater than are likely to be achieved by modifying
Using a simple mechanical weeder actively aerates the soil, uproots weeds and churns them into the soil to decompose. By enhancing yields by one or more tons per hectare, this becomes a benefit rather than just a cost. Rice plants’ genetic traits, SRI presents a different approach to agricultural improvement. SRI’s benefits are already available without needing further research; they entail little cost and raise no evident environmental issues. So in this way one can infer that SRI results make the development and use of GMOs less urgent for meeting world food needs.

What are the requirements for practicing SRI?

As noted already, SRI does not require a change in rice varieties or the purchase of fertilizers or agrochemical protectants. It does require water control so that smaller amounts of water can be provided reliably during the growing season; all crops require at least some water. There must also be sufficient labor available for skilled crop management, and enough access to biomass, starting with rice straw, to make compost or do mulching to maintain soil organic matter. Fertilizer can be used if not enough biomass is available for compost.

Although SRI plants are usually more resistant to pests and diseases, some crop protection measures may be needed, such as IPM or organic pesticides. Having access to a weeding implement that aerates the soil as it controls weeds will enhance crop yield, although it is not necessary. The most important requirements are the motivation and aptitude for careful crop management as SRI is more of a mental innovation than a material one.

Does SRI always require more labor?

Not necessarily. While the new methods of management are being learned, more time is needed to complete the operations. So SRI is often considered to be ‘labor-intensive.’ However, as experience and confidence are gained, the labor requirements per hectare usually decline. The length and steepness of the learning curve varies. In countries where rice farmers are used to making adaptations in practices, such as India and China, or where rice production is already relatively labor-intensive, farmers report reductions in the number of days of labor per hectare required for use of SRI already in their first season.

Can SRI be successful without irrigation?

Yes. Although SRI was developed to improve production of irrigated rice, NGO’s and farmers have adapted SRI methods also to upland or rainfall cultivation in the southern Philippines, northern Myanmar, eastern India, and southern Mali. In some places their yields are as high as 7 tons/ha. Water management, timing, and spacing need to be adjusted, of course; but SRI principles are adaptable to producing rice without irrigation.

Is there need for any new or special rice varieties with SRI?

No. SRI methods have been found to enhance yields from practically all rice varieties with which they have been used – high-yielding or traditional, improved or unimproved, hybrids or landraces – although some varieties clearly respond better than others to SRI’s modifications in crop management.

Is SRI necessarily an ‘organic’ system of production?

Not really. SRI was initially developed with chemical fertilizer, but when subsidies for fertilizer were withdrawn and poor farmers could no longer afford it, Fr. Laulanié switched to recommending use of compost. Factorial trials have shown that organic fertilization with the other SRI practices can outperform the use of inorganic fertilizer. However, highest yields often come with an optimizing combination of both sources of nutrients for the soil, in what is called integrated nutrient management (INM). Farmers should decide whether to grow SRI rice ‘organically’ or not depending on labor availability and cost relationships, e.g., prevailing costs of fertilizer, and the market price offered for ‘organic’ rice.

What are limitations for utilizing SRI methods?

Where there is not sufficient water and water control for maintaining aerobic but moist soil conditions, good SRI results will not be obtained, although the control need not be perfect. Insufficient labor and time and skill can also be a constraint. Certain crop pests can limit the utility of SRI, e.g., yield will be reduced if rootfeeding nematodes are endemic and thrive in unflooded soils. Temperatures must be within an appropriate range for rice crop growth. Part of the SRI methodology is to make appropriate adjustments in practices to deal with limitations such as these, e.g., making raised beds within paddies where water control is limited, and modifying irrigation schedules to cope with nematodes.

Where can we expect that SRI is unlikely to succeed?

Following from these requirements, we can say:

• Where temperatures are too low for growing rice (or excessively hot), SRI will not be feasible. But SRI plants, once established, have been seen to tolerate more cold and more heat than conventionally-grown plants.
• At least some minimum of water must be reliably available, with enough water control to prevent continuous flooding and plant inundation (which suffocates the roots). While rice can survive under flooding, it does not thrive.
• Results have often been better on acid or neutral soils than on alkaline soils; and saline soils are a problem for all rice crops. Sufficient compost can neutralize the adverse effects of soil salinity in many instances.
• Where there are serious labor constraints so that farmers cannot afford to invest time (household labor or hired labor) in the learning process to master SRI methods.
• Where there are negative attitudes toward trying new methods or adopting practices, either from the farmer side or from the scientists, extensionists and administrators who work with them. SRI being more a mental than material innovation requires open minds and a willingness to experiment with and evaluate new ideas.

Average SRI yields of 9 tons/ha are reported from the cold climate and high elevations of northern Afghanistan as well as from the Timbuktu region of Mali on the edge of the Sahara Desert. Thus, SRI methods are adaptable to a wide range of growing environments if not to all circumstances.

Do all of the SRI methods need to be used fully and precisely?

Best results can be obtained by using the recommended practices all together and as close to the recommendations as possible. They represent an ‘ideal type’ of SRI. But each of the practices makes a contribution to improving the growing environment for rice plants. If using really young plants, there does need to be enough water control so that they are not continuously flooded and suffocated. Otherwise, SRI should be understood and practiced as a matter of degree, giving plants the best growing conditions possible under farmers’ circumstances.

Are there any significant problems of disadoption?

An early report (2003) identified disadoption among very poor households in Madagascar, not able to afford investment of family labor in using SRI even if...
they knew that this could give them higher yield, as a barrier to the spread of SRI. Disadoption has been reported in some states of India where irrigation water or rainfall is not reliable enough to risk starting a crop with young seedlings. In Southeast Asia, snails have been a deterrent to continuing with SRI practices, but some farmers have found solutions to control this pest, while others are not successful. Where disadoption has been studied, in most cases this has been at most a few percent, and usually attributable to factors beyond farmers’ control.

What are reasons for changing current rice-growing practices?

There are good agronomic justifications for each of the recommended practices. However, farmers should learn the principles that justify the practices, not just the practices themselves. For example, crowding together of rice plants prevents some of the plants’ leaves from getting enough light for maintaining photosynthesis. Also, it is the lower leaves that send most of the carbohydrates (energy) to the roots for carrying out their metabolic processes. So close spacing of plants reduces their productivity of energy for supporting plant growth and grain production, and also deprives the roots of the energy for supporting plant growth and grain production, and also deprives the roots of the energy that they need for their functioning. Elementary agronomy.

What are the important economic, social and other benefits with SRI?

The simplest and most evident benefit is increased yield per hectare, but most important for development is the greater factor productivity that SRI methods elicit from the land, labor, water and capital invested in rice production.

- Water saving in irrigated rice production and lower costs of production are also very important benefits for farmers.
- Also, there is no need to make any purchases if farmers are able to make and apply sufficient compost. This is important for the poorest households.
- Higher returns to labor, per hour or day, are also important, as is reduction in labor requirements (including for women) once SRI methods are learned.
- Increased net farmer income and greater profitability of rice production are quantifiable economic benefits, as is reduced risk of economic loss.

Because rice plants are more robust, there are reduced losses to pest and disease and is also greater resistance to climate hazards such as drought and storm damage, which are becoming more frequent and severe with climate change.

More resistance of lodging, being knocked down by wind and/or rain, is an important feature with weather events becoming more frequent and extreme. Reduction in greenhouse gas emissions has been discussed above.

Other environmental benefits, noted above, include less water consumption which reduces the agricultural sector’s competition with natural ecosystems, and better soil and water quality from reduced use of agrochemical inputs. These effects should improve environmental quality and also contribute to the conservation of some biodiversity.

Other benefits that farmers are receiving from SRI management:

- SRI management usually shortens the crop cycle by 1-2 weeks (with higher yield). This frees up land for other uses and reduces rice crops’ exposure to biotic and abiotic stresses.
- When SRI paddy (unmilled rice) is milled, there is usually higher outturn of polished rice, by at least 10% and up to 20%, which further adds to food production. Also, grain quality is commonly enhanced by SRI management, e.g., this reduces the chalkiness of rice grains, an undesirable quality.

That there are so many benefits has contributed to the idea that ‘SRI is too good to be true’. However, this inference is itself untrue, because all of these benefits listed are real and documented.

What are the gender implications of SRI?

This will depend on what is the prevailing gender division of labor in rice production in the local situation. Most reports have said that women’s labor burdens are reduced when SRI is introduced, because rice transplanting becomes quicker once the new methods are learned (because plant populations are reduced by 80-90%), and because men often take over the task of weeding (in many places culturally classified as ‘women’s work’) when mechanical weeding (‘men’s work’) is introduced. There have also been some health benefits particularly for women reported from India and the Philippines.

Can SRI ideas and practices be applied to other crops?

One of the most promising developments is the extension or extrapolation of SRI concepts and methods – making appropriate modifications in accordance with SRI principles – to a wide range of other crops: wheat, finger millet, sugarcane, mustard, legumes (black, green and red gram, and soy), and vegetables (tomatoes, chilies, eggplant), even rhizome crops like turmeric and ginger.

A world-record potato yield in Bihar state of India has been ‘inspired’ by SRI experience in the farmer’s village. And farmers in Cambodia and in Jharkhand state of India have adapted SRI concepts to improve their production of chickens and of lac, respectively.

What is the significance of phyllochrons?

The profuse tillering of SRI rice plants can be explained in part by understanding the pattern and extent of tiller and root emergence in rice plants that is similar to what is observable in other grass-family crops (wheat, barley). The phyllochron concept, developed in Japan before World War II, has had little explanation in English, so it has received little attention from non-Japanese scientists.

How has SRI been disseminated among and within countries?

For the most part, SRI has been spread by a growing network of interested persons and institutions, from NGOs, from universities or research institutions, sometimes from government agencies or the private sector, and most of all, at the grassroots involving farmers themselves.

The SRI website maintained at Cornell University by the SRI International Network and Resources Center (SRI-Rice) (http://sri.ciifad.cornell.edu) has supported widespread distribution of information on SRI – experience, problems, solutions, innovations, etc – amplified by voluminous e-mail communications among members of an informal SRI international network.

The Better U Foundation supports the work of SRI-Rice to catalyze worldwide spread of SRI ideas and practice. Within many countries, networks of SRI users and proponents have been formed, with their own list-serves or websites or blogs. All information is freely available, with no Intellectual Property or other restrictions.

What has been the response of scientists and policy makers?

Initially there was skepticism regarding the higher yields reported with a reduction in inputs and not using new or improved varieties. A number of critical articles were published in the mid-2000s, but the push-back against SRI has been diminishing as more and more agricultural scientists have taken an interest in SRI, particularly in China and India, documenting the effects of SRI management and the merits of its component practices.

Governments in China, India, Indonesia, Vietnam and Cambodia – where two-thirds of the world’s rice is produced – now support SRI dissemination encouraged by their own good results. There should not be much controversy about SRI anymore, although more research still needs to be done to understand better the potentials and limitations of SRI.

What are future directions for SRI?

The ideas that created SRI and their applications will continue to evolve, being applied to many crops beyond rice. We anticipate a convergence between SRI practice and conservation agriculture. Initiative and innovation to modify farmers’ crop management practices should continue, with productive cooperation among farmers, researchers, extensionists, government agencies, and the private sector. This could possibly transform the current one-way ‘linear’ model of agricultural development, moving from research to extension to adoption, to establish more interactive and reciprocating relationships.
My Experiments with Crop Intensification

by Mark Fulford

I have long been interested in growing grain crops in New England. Grains, crops, including wheat, used to be grown here abundantly, but with the settlement movements west in the 1800s local production of grain fell off. Now, however, many young farmers in this region are again interested in growing grains. I started in 1980 with winter wheat in Monroe, Maine.

As I dug, looking for information on growing grain, I came across articles by Norman Uphoff at Cornell. I found his website and read about the results coming from this strange method of growing rice, called SRI (System of Rice Intensification). I was fascinated and eventually connected with Dr. Uphoff, converging frequently by email and directly later when he presented by invitation in Bangor at a Heart of Maine soils conference that was very well received. While on an agricultural study tour in the Pacific region in 2008 I followed up on some connections he shared with me. I visited a number of places where SRI was being tried, spending most of a month on three different islands of the Philippines, and learned as much as I could about the methods of SRI.

When I got back I tried growing winter wheat using these methods and was blown away by the results. I have grown a lot of different wheat trials and even a few acres from time to time on borrowed land but I have never seen a single wheat plant with 55 or 60 tillers. Yet my first attempt averaged that I planted a trial plot at something like one-tenth the density of normal planting, with single plants 12 inches apart both ways. I conservatively estimated the crop yields would be at least two to four times what I would normally get.

Of course this is preliminary and needs more trials, but it is consistent with what Norman has been reporting and what I saw was possible in Asia with many grains and other crops.

It is an important distinction to note that the source of this phenomenon is not necessarily just the attributes of fertilizing inputs, but the focus of energy in the plant itself when given the proper conditions for optimum growth. These include careful selection for seed quality, spacing with much lower plant densities, using young very transplants, timing and weed cultivations, neither of which westerners would normally do for grains other than Maize.

I further experimented with this method of growing for carrots, potatoes, onions, and dry beans. I focused on a lot more spacing, some weed techniques -- like stale bed seeding -- and much lighter seeding rates. This approach is both space- and timing-sensitive. Many of our currently accepted soil practices inherently create limitations. Our typical tillage almost always tends to create compaction.

Wheels and heavy implements usually roll over most of the soil we use every year. We tend to feed crops only once, at the beginning, and crowd them. Those limitations could be removed.

Baby plants, not unlike humans, need food in small frequent doses at first and as they grow and flower they tend to have the increased appetites and space needs of teenagers. Side dressing with biologically enhanced dry or liquid amendments as they grow has paid off over the years. I suggest to other farmers that they find ways to reduce compaction and to feed at least 2 or 3 times, especially during cultivation opportunities. I would also suggest making one’s own mineral-enriched composts.

I like to use the term ‘biological leveraging’ since soil tests are chemically oriented with very little attention towards biology. People often miss the point that chemistry cannot be efficiently delivered if there is inadequate biology and humus in the soil. Mycorrhizae and microbes require food, water, gas exchange and space. For example, if we limit the air supply we shut down the system. When you till or cultivate, don’t beat up the structure too badly – just enough to aerate the soil – and put some microbial food in there while you’re at it. You can see where cultivation combined with soil feeding has happened, the plants grow more vigorously.

I inoculate -- both seed and soil -- with matching crop appropriate microbes at any opportunity I can. You can buy (or make on your own) any number of liquid and dry inoculants. There are hundreds of products available for organic growers. There are some crops like the brassicas that don’t have a direct mycorrhizal need, but it doesn’t mean you can’t inoculate with bacterial composts and worm castings. Berries are much more fungal or ericaceous adapted. For example, you wouldn’t do very well using a vegetable row crop inoculant on blueberries or conversely, a berry inoculant for vegetables.

2012 - Potatoes Intensified - When I grew potatoes a couple of years back we opened up the row width and spacing. The conventional system is to plant in rows approximately 3 feet apart with cut seed placed 9-12 inches apart. Well, we changed all that. We planted a month or more later than usual to let the soil warm up and to avoid the Colorado Potato Beetle and Potato Leaf Hoppers. We also seem to have avoided the blight, Phytophthora infestans, two years in a row -- possibly due to the timing.

In one method we didn’t cut the seed potatoes but went directly into the field with them at 3 feet apart and 2 feet apart in the row. (In hindsight it could have been more space. See Potato Intensification article.)

I like to measure plot sizes and weights carefully. It was a small area of only 4 rows, each 82 feet long, but the yield of 887 lbs, when extrapolated, was the equivalent of 261.77 hundredweight (CWT) to the acre. That is pretty high for New England these days! Some places of Aroostook County, in Maine, struggle to get 100-150 hundredweight and often much of their crop has hollow heart. That is avoidable if the soil has a fully functioning mineral and biological system in place. These potatoes wholesale for $1.25 to $1.50 per pound.

2013 - 254 lbs of carrots on 150 square feet! We did a greater spacing on stake bed planted carrots as well that same year. This was another eye opener. (see Carrot Intensification article.)

I show these methods to all the farm clients and classes I visit in New England. We talk about what successful SRI farmers have done and how they can do it themselves. Quite often they pay attention. Some don’t and think they can’t make their system adapt because of equipment or infrastructure shortcomings. But if they can take a small 1/4 acre plot or less, there are always some aspects of SRI that one can adapt to any crop.

2013 - Potato Buttons, This year we tried a method inspired by the recent records from India for potatoes using very small transplants grown from single eyes, started in worm castings, spaced at 2 feet in both directions. At first they looked pathetically small. They soon proved to be too crowded, however. We should have gone 3 feet by 3 feet or more.

If your plants are too crowded they change their behavior and compete with each other, blocking some...
of the photosynthesis that might take place. Perhaps a person could take a long season and a shorter sea-son crop and double crop a space even in a wet late starting year like 2013. We succeeded, for example, to get a very nice crop of potatoes from a July 15th planting which could have directly followed, in the same beds, our main garlic crop which had just been harvested. If the potatoes were pre started as plants from ‘buttons’, the farmer gains a couple of weeks lead time.

2013 - Dry Beans. We did plant dry beans this year and the results so far are encouraging but not yet quantified. It was miserable weather for planting corn and beans. We have a limited amount of time up here in Maine for beans to mature. We started them out in tree tubs (a desperate move) and let them grow for three weeks in a homemade potting soil with charcoal, minerals and worm castings. For a week when it was cold we had them under row cov-er. Dry beans as seed planted directly on the same sowing date pretty much rotted in the cold, damp soil. Getting the plants up and not rotting is half the battle.

When we planted the bean seedlings we used beds to avoid compaction. We put them in rows 2 feet apart, with the bean plants 1 foot apart in the row. I would say that was still way too tight. Given the size of the plants by the time they reach the bed corners, it would be better to go 3' by 3'. We used a landscape fabric covered bed method to plant into, 2 rows in a single bed. Not a single plant was lost in transplanting, which is good for a cold, wet year. All plants were fed a mild liquid mineral and seaweed brew two times.

We have also used vinegar and soap to weed stale-bed-plant dry beans in open soil. As long as there is no serious weed competition, the beans really take off. When you see the first blossom, get out there and feed them again, but go lightly on nitrogen. Be careful not to disturb the root zone. Use shallow cultivation.

For dry beans we are looking for a more productive plant with less overlapping foliage and a greater reduction of mold. We avoided almost all fungus diseases in the cold wet early soil and got more air drainage with more solar gain per plant. Also the flowering period was quite extended.

There was a much higher percentage of pods on the plants than on past crops. By conservative estimate, increasing the quality of fewer plants in a given area by cutting plant density at least in half, one can increase the growth of pods on a given area by cutting plant density at least in half. Fewer pods showed any mold damage and the pod set was greater in number per plant.

Onion observations - We have done onions a couple of ways – direct seeding in stale beds (they have ple of ways – direct seeding in stale beds (they have widespread use), transplanting seedling onion sets which was greater in number per plant. by these ideas yet, but I have posted a “heads up” on SRI practices to a bunch of potato and grain growers. It may catch on. It is in the early stages in this country. The US may be the last country to adopt SRI methods of mixed crop intensifica-

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In retrospect - We may have had our priorities backwards for a few generations. Nourish the needs of the soil microbial community. In regard to recent developments in Systems of Crop Intensification, when soil and plants are taken care of properly in this manner, it returns the favor many fold.

SRI and other Systems of Crop Intensification are of such potential that they have and will increasingly continue to make socio - economic changes on a very wide, grassroots scale.

Mark Fulford Is a farmer and 20+ years indepen-
dent farm consultant and educator whose range of topics and expertise includes transition from conven-tional to organic and biological agriculture; soil, crop, and forage nutrition; and preparing ag-
riculture for peak oil, climate change and economic drif. He also teaches non-electric water technolo-
gies, hands-on skills in organic orcharding, organic no-till, commercial and small scale composting, as well as fundamental rural skills.

Mark has studied and corresponded with some of the greatest names in biological agriculture: Dr Arden Andersen, Neal Kinsey, Dr Dan Skow, Gary Zimmer, Dr Elaine Ingham, Jerry Brunetti, Dr Nor-man Uphoff among others.

In more recent travels, he has spent time in Aus-
tralia to attend the world renowned Graeme Sait’s certificate course in Sustainable Agriculture from Agri-Tech Solutions LTD Australia, a company that specializes in relationships between soil, animal and human health, to become a recognized world leader in biological agriculture.

A trip continuation to the Philippines further ex-
panded his knowledge of biological practices and now he has brought back detailed information about the latest, possibly most important, biological farm-

ing practice known as SRI (System of Rice Intensi-
fication), a cross over methodology, which can be adapted to improve grain and row crop production in the U.S. It focuses on minimizing water use, maxi-
mizing biological soil function and nutrient transfer, photosynthesis, timing and crop spacing.

Further abroad projects in mainland China include establishment of free range egg production, com-
mibed with inter-pasture orchard corridors and in-
tensified vegetable / mushroom and fish production for a commercial organic oriented farm in Guan-
dong Province. He works closely with his son’s Bio-
matrix Water Co. based in Scotland, on watershed repair and aquatic ecosystems.

Mark addresses audiences from a wide range of backgrounds and philosophies embracing common sense, science and cultural wisdom for the times we live in. His lifelong study of the natural world and immersion in agriculture on his own farm and abroad, grounds his practices in experience. Mark and his wife Paula own and operate Teltame Farm in Monroe, Maine. He can be reached at Mark@ lookfar.org.
Notes on Carrot Intensification in Monroe, Maine (Waldo County) Oct. 2012

Notes by Mark Fulford

*Using ‘stale bed’ method for closely timed weed control
*Concentrated fertility
*Thinly spaced seed
*Deep aeration

Early June, 2012: A 5’ x 30’ plot was prepared by top dressing 35 lbs of a broad spectrum mineral, fish and seaweed dry blend on the surface. This was incorporated to a 16” depth with a broad fork usually used for harvesting root crops.

The soil was carefully hand sown from a mid season carrot variety (Yaya - Fedco Seeds), with the edge of a sharp spade in the weed growth. Weeds had germinated, reaching the seed cotyledon quickly. After 18 days a thick growth of summer weeds had germinated, encouraging summer weed seeds to sprout evenly and more weed germination. The resulting harvest at 70 days was of significance enough to record. From 150 square feet of a 4 row carrot bed, we harvested 254 lbs, (1.693 lbs per square foot)

An acre is 43,560. Divide that by 150 square feet = 290.4 x 254 lbs = 73,761.6 lbs yield / acre!

That seems like an awful lot of carrots, which could have been sown even thinner. The recorded US average carrot yield per acre in 2010 was 26,800 average, with 33,750 lbs / acre considered as excellent.

Of the 254 lbs, just under 20% were blemished in some way and so were 2graded to seconds for processing.

The lower grade carrots were due to a small amount of carrot rust fly damage, and some minor splitting from excessive rainfall near the end of the crop cycle.

73,761 lbs, total yield = 14,752 (20 % culls and seconds)

Estimate of value of marketable carrots per acre @ organic wholesale price .80 -1.00 lb using intensified methods described above.

Inputs :
*The organic amendment fertility minerals would amount to just about 5 tons per acre at an estimated cost of $625 per delivered ton or $3,125 (2012 prices)
*2 days to plant, flame weeding or vinegar soap weeding is 1/2 day

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" **From Northeast organic farmers to Northeast organic farmers "**
In late June, a small trial plot of Carola potatoes, saved from our own seed over the last 8 years, was pre-sprouted to 1-2" green tips with abundant root hairs developed.

The seed was left whole and uncut with the reasoning that with our increasingly wet springs, cut seed potato is often lost to rot in the fields. Even with conventional fungicides, many early potato crops have to be replanted.

Four rows roughly 5 feet on center, with whole seed approximately 24 inches apart, were planted in a plot measuring 18' x 82' (1476 sq. feet).

One acre is 43,560 sq.ft. Divided by 1476 (plot size), this equals 29.512 parts of an acre. Multiply this by the total yield of 887 pounds = 26,177 lbs per acre (or 2617.7 CWT) as it is often referred to in the US potato industry. This is not necessarily much compared to the new yield records being recorded with crop intensification techniques, yet it is by far the highest yield this farm has ever achieved.

The break down of the crop in grades is as follows:

* Very large chef size 380 lbs (43%)  
* High quality medium > large 300 lbs (34%)  
* Small seconds < 2.5 inches 60 lbs (7%)  
* Culls, (scab, rhizoctonia & slugs) 147 lbs (16%)

887 lbs.  
- 207 lbs. seconds

680 good to excellent marketable lbs.

The acre extrapolation below may be useful when figuring inputs and labor.

Dry blended soil amendments for organically grown potatoes here were about $2,500 per acre (considered high). They were applied twice, once at planting, and again at the only hilling, (about bloom time). Just prior to hilling, a commercially available, organic liquid soil drench of compost extracts, concentrated microbes, seaweed, fish emulsion, humates vitamins and enzymes was also applied.

All aspects of labor for this crop would average about $2,000 / acre if hours were paid well at $10 hr. as outside hired help.

Very dilute, sprayed on foliar nutrients (same as the drenched product), were combined with any needed insect and disease controls, which were surprisingly few, and were applied twice. These protective and growth promoting sprays averaged out to just less than $500 / acre.

Cut tests of random oversized tubers showed no hollow heart in spite of erratic wet then dry then wet then dry years. Culls were accounted for in the highest yield this farm has ever achieved. The weight of seed planted per area may be significantly reduced by obtaining as many as a dozen plantlets per seed potato. Once rooted well in a plug or open nursery bed, these plants avoid the seed piece rot window so common in the cold wet Northeast US conditions.

The use of selected seedlings from fruited potato seed balls of an isolated variety may also be nursery started as foundation seed. This is the practice of foundation seed farms in Maine and other northern states that use a Florida farm site for winter propagation of true seed, which is then grown out on its second phase in the north before being certified as true and disease free, then released to the market.

Another opportunity in the potato growth stage is to make a significant contribution to the reach of the root zone by using the same subsoliling/feeding tactic just on either side of the young plants at the time of bloom and tuber “hooking”. This is the point when many farms just don’t bother to fertilize and simply hill, often with a compaction effect rather than a root enticing effect.

In our observation, more fertilizer is not always better – it depends on the quality of that fertilizer, which can be ideally a home made product.

Reducing damage to the crop by use of disease suppressing cover crops such as Sorghum Sudan and/or a fast, well fed oil seed mustard or rape seed species, chopped and tilled in about 10 days prior to planting can greatly reduce the commonest of soil pests and diseases. The addition of Neem cake as a fertilizer/disease inhibitor is also suggested as a way to improve the bottom line yield of marketable tubers, when tilled.
In a move decried by consumer and environmental groups as severely weakening the meaning of the organic label, the U.S. Department of Agriculture announced in September that the agency had changed the process for exempting otherwise prohibited substances (such as synthetics) in food that carries the “organic” or “made with organic” label. No public comment period was provided for the changes to this policy, which had been in place since 2005.

Under the federal organic law, and prior to the surprise announcement, there was a controlled process for allowing the use of substances not normally permitted in organic production because of extenuating circumstances. These exemptions were supposed to be made for a five-year period, in order to encourage the development of natural (or organic) alternatives. The ex-

(continued on page A-3)