Technical Note #82

SRI, the System of Rice Intensification: Less Can Be More

What's Inside:

Compilation of articles from ECHO Development Notes *(Issues 70 [Berkelaar 2001], 102 [Haden 2009] and 120 [Berkelaar 2013]) and* ECHO Asia Notes *(Issues 2 [Burnette 2009] and 21 [Thansrithong; Uprety 2014]). Revised and published as a Technical Note in 2015.*

The System of Rice Intensification (SRI) is a method of raising rice that produces substantially higher yields with the planting of far fewer seedlings and the use of fewer inputs than either traditional methods (i.e., flooding) or more "modern" methods (using mineral fertilizer or agrochemicals). This approach involves various practices for plant, soil, water and nutrient management. SRI has been successfully used in more than 50 countries and has been promoted extensively by Dr. Norman Uphoff with Cornell University.

What is SRI?

SRI involves the use of a combination of management practices that optimize growing conditions for rice plants, particularly in the root zone. It was developed in Madagascar in the early 1980s by Father Henri de Laulaníe, a Jesuit priest who spent over 30 years in that country working with farmers. In 1990, Association Tefy Saina (ATS) was formed as a Malagasy NGO to promote SRI. Four years later, the Cornell International Institute for Food, Agriculture and Development (CIIFAD), began cooperating with Tefy Saina to introduce SRI around the Ranomafana National Park in eastern Madagascar, supported by the U.S. Agency for International Development. It has since been tested in China, India, Indonesia, the Philippines, Sri Lanka, Bangladesh and elsewhere with positive results.

The results with SRI methods are remarkable (see Table 1 and thoughts by Ryan Haden, p. 7-8, for added perspective on yields). In Madagascar, on some of the poorest soil to be found and where yields of 2 metric tonnes (t)/ha were the norm, farmers using SRI began averaging over 8 t/ha, with some getting 10 to 15 t/ha. A few farmers even harvested over 20 t/ha. In other parts of the country, over a five-year period, hundreds of farmers averaged 8 to 9 t/ha.

***Table 1**: Rice growth and yield performance with SRI in comparison to traditional methods. Data for traditional methods were calculated from measurements on five adjacent fields. Data for SRI methods are averages and ranges from 22 test plots. Data are from a master's thesis by Joeli Barison, 1998.*

	Traditional Methods		SRI Methods	
	Average	Range	Average	Range
Clump/m²	56	42-65	16	10-25
Plants/clump	3	2-5	1	1
Tillers/clump	8.6	8-9	55	44-74
Panicles/clump	7.8	7-8	32	23-49
Grains/panicle	114	101-130	181	166-212
Grains/clump	824	707-992	5,858	3,956-10,388
Yields (t/ha)	2.0	1.0-3.0	7.6	6.5-8.8
Root strength (kg)	28	25-32	53	43-69

With most, if not all, varieties grown using SRI, rice yields have at least doubled. No external inputs are necessary for a farmer to benefit from SRI. The methods should work with any seeds that are used. However, you do need to have an open mind about new methods and a willingness to experiment. With SRI, plants are treated as the living organisms that they are, rather than as machines to be manipulated. Yield potential of the rice plants is maximized by providing optimal growing conditions.

At first, SRI practices seem somewhat counterintuitive; they challenge assumptions and practices that have been in place for hundreds, even thousands of years. Most rice farmers plant fairly mature seedlings (20 to 30 days old) in clumps fairly close together with standing water maintained on the field for as much of the season as possible. Why? These practices seem to reduce the risk of crop failure. It seems logical that more mature plants should survive better; that planting in clumps will ensure that some plants will survive transplanting; that planting more seedlings should result in more yield; and that planting in standing water means the plants will never lack water and weeds will have little opportunity to grow.

Despite this reasoning, farmers have not found that using SRI practices puts their crops at any more risk than do traditional methods. Four "novel" practices in particular are key in SRI:

***Figure 1**: With SRI, seedlings are planted when they are 8 to 15 days old, when there are just two leaves. The plants at the left are eight days old. With traditional methods, seedlings are planted when they are several weeks old. The seedlings on the right are 31 days old. Photos by Joshua Harber.*

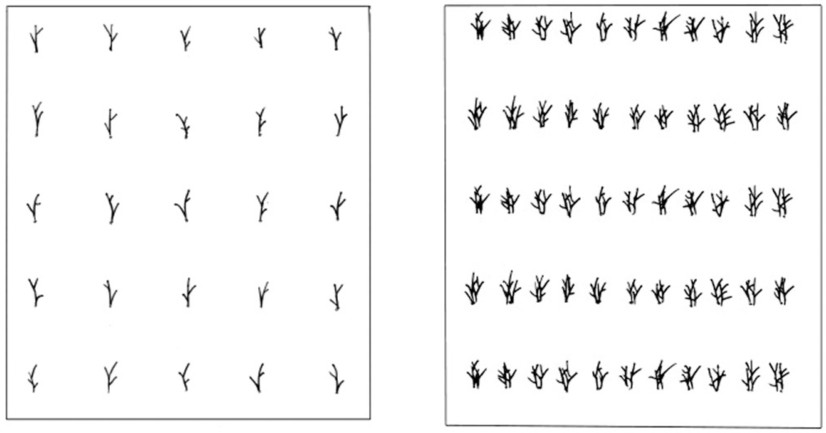
1. **Seedlings are transplanted early.** Rice seedlings are transplanted when only the first two leaves have emerged from the initial tiller or stalk, usually when they are between 8 and 15 days old (Fig. 1). Seedlings should be grown in a nursery in which the soil is kept moist but not flooded. When transplanting seedlings, carefully remove them from the nursery bed with a trowel, and keep them moist. Do not let them dry out. The seed sac (the remains of the germinated seed) should be kept attached to the infant root, because it is an important energy source for the young seedling. Seedlings should be transplanted as soon as possible after being removed from the nursery—within half an hour and preferably within 15 minutes. When placing seedlings in the field, carefully lay the roots sideways in the soil with a horizontal motion, so that the root tip is not inadvertently left pointing upward (this happens when seedlings are plunged straight downward into the soil). The root tip needs to be able to grow downward. Careful transplanting of seedlings when they are very young reduces shock and increases the plants' ability to produce numerous tillers and roots during their vegetative growth stage. Grains of rice are eventually produced on the panicles (i.e. the "ears" of grain above the stalk, produced by fertile tillers). More tillers result in more panicles, and with SRI methods, more grains are produced on each panicle.

2. **Seedlings are planted singly rather than in clumps.** This means that individual plants have room to spread and to send down roots. They do not compete as much with other rice plants for space, light, or nutrients in the soil. Root systems become altogether different when plants are set out singly, and when the next practice is followed:

3. **Wide spacing.** Rather than in tight rows, seedlings are planted in a square pattern with plenty of space between them in all directions. Usually they are spaced at least 25 x 25 cm (Fig. 2). Feel free to experiment because the optimum spacing (producing the highest number of fertile tillers per square meter) depends on soil structure, soil fertility, temperature, moisture and other conditions. The general rule is that plants should have plenty of room to grow. If you also use the other practices mentioned here, seldom will the best spacing be closer than 20 x 20 cm. The maximum yields have been obtained on good soil with 50 x 50 cm spacing, just four plants per square meter.

   To space the plants carefully (which makes weeding easier), you can place sticks at appropriate intervals (e.g., every 25 cm) along the edge of the field, then stretch strings between them. The strings should be marked at the same intervals so that you can plant in a square pattern. Leaving wide spaces between each plant ensures that roots have adequate room to grow, and the plants will be exposed to more sunlight, air and nutrients. The result is increased root growth (and thus better nutrient uptake) and more tillering. The square pattern also facilitates weeding.

Figure 2. SRI seedlings (diagram at left) are very widely spaced compared to seedlings planted with traditional methods (at right). These diagrams show seedlings at approximately one month of age, when seedlings are roughly the same size. However, SRI seedlings, having been transplanted several weeks earlier, by this time have already undergone transplant shock and may have begun to tiller. Sketches by Christi Sobel.



When farmers are more experienced, they can save time by marking cross-hatched lines on the field surface with rakes or other devices. Notice that SRI uses a much lower seeding rate than do traditional methods. One evaluation of SRI revealed that the rate of seed application was only 7 kg/ha, compared to the traditional seeding rate of 107 kg/ha—yet yields were doubled because each plant produced so much more grain!

4. **Moist but unflooded soil conditions.** Rice has traditionally been grown submerged in water. Clearly rice is able to tolerate standing water; however, standing water creates hypoxic soil conditions (lacking in oxygen) for the roots and hardly seems to be ideal. Rice roots have been shown to degenerate under flooded conditions, losing ¾ of their roots by the time the plants reach the flowering stage. This die-back of roots under flooded conditions has been called “senescence,” implying that it is a natural process. In reality, it represents suffocation, which impedes plant function and growth. With SRI, farmers use less than half the water they would use if they kept their paddies constantly flooded. Soil is kept moist but not saturated during the vegetative growth period, ensuring that more oxygen is available for the roots. Occasionally (perhaps once a week) the soil should be allowed to dry to the point of cracking. This will allow oxygen to enter the soil and will also induce the roots to grow and “search” for water. After all, when the soil is flooded, roots have no need to grow and spread, and they lack enough oxygen to grow vigorously.

   Non-flooded conditions, combined with mechanical weeding, result in more air in the soil, and greater root growth means that the rest of the plant will have access to more nutrients. When soil is saturated, air pockets (known as aerenchyma) form in the roots of submerged plants in order to transport oxygen. These air pockets take up 30% to 40% of the roots’ cortex and probably impede the transport of nutrients from the roots to the rest of the plant. More water may be applied before weeding to make the process of weeding easier. Otherwise, water is best applied in the evening (if there has been no rain during the day), and any water remaining on the surface is drained in the morning. This leaves the field open to both air and warmth during the day; flooded fields will reflect a good part of the solar radiation reaching them, and absorb less of the warmth which helps plants grow. With SRI, unflooded conditions are only maintained during the period of vegetative growth. Later, after flowering, 1 to 3 cm of water are kept standing on the field, as is done with traditional practices. The field is drained completely 25 days before harvesting.

In addition to these four principal practices, two other practices are extremely beneficial when using SRI. These practices are not controversial and have long been recognized as valuable for crops.

5. **Weeding.** This can be done by hand or with a simple mechanical tool (Fig. 3). Farmers in Madagascar find it advantageous, both in terms of reducing labor and of increasing yield, to use a mechanical hand weeder developed by the International Rice Research Institute in the 1960s. It has vertical rotating toothed wheels that churn up the soil as the weeder is pushed down and across the alleys formed by the square formation of planting. Weeding is labor-intensive—it may take up to 25 days of labor to weed one hectare—but the increase in yield means that the work will more than pay for itself.

   The first weeding should be done 10 to 12 days after transplanting, and the second weeding within 14 days. At least two or three weedings are recommended, but another one or two can significantly increase the yield, adding 1 to 2 t/ha. Probably more important than removing weeds, this practice of churning the soil seems to improve its structure and increase aeration of the soil.

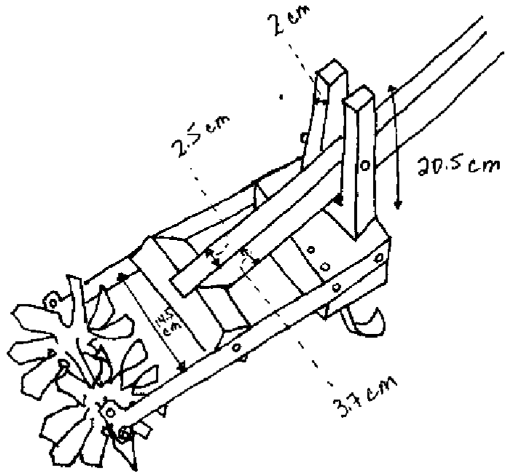


Figure 3*. One example of a mechanical weeder with vertical rotating toothed wheels, often used with SRI. Plans are available at ECHO for this weeder and for a larger weeder with five wheels. Sketches of weeders by Paya deMarken, Peace Corps Volunteer in Madagascar.*

6. **Organic inputs.** SRI was developed initially with the use of chemical fertilizers to increase yields on the very poor soils of Madagascar. But when subsidies were removed in the latter 1980s, recommendations switched to the use of compost, and even better results were observed. Compost can be made from any biomass (e.g. rice straw, plant trimmings and other plant material), with some animal manure added if available. Banana leaves add potassium. Cuttings from leguminous shrubs add nitrogen. Other plants, such as *Tithonia diversifolia* and *Afromomum angustifolium*, may be high in phosphorous. Compost adds nutrients to the soil slowly and can also contribute to better soil structure. It seems fairly intuitive that some form of nutrient input is necessary on poor soils if chemical fertilizer is not added. With huge yields of rice being harvested, nutrients need to be returned to the soil!

How does SRI work?

The concept of **synergy** appears to help explain why SRI works so well. In this context, synergy means that practices used in SRI interact in positive, reinforcing ways so that the whole is more than the total of its parts. Each of the management practices used in SRI makes a positive difference in the yield, but the real potential of SRI is seen only when the practices are used together.

When used together, SRI practices result in a rice plant structure that is different from what results when traditional approaches are followed. Rice plants under SRI have many more tillers, greater root development, and more grains per panicle. In order to tiller, plants need to have enough root growth to support new growth above ground. But roots require certain soil, water, nutrient, temperature and space conditions for growth. Roots also need energy from the photosynthesis that occurs in tillers and leaves above ground. Thus the roots and shoots depend on each other. In addition, when growing conditions are optimized, there is a positive relationship between the number of tillers per plant, the number of tillers that become fertile (panicles), and the number of grains per tiller.

SRI fields look dismal for a month or more after transplanting, because the plants are so thin, small and widely spaced. In the first month, the plants are preparing to tiller. During the second month, prolific tillering begins. In the third month, the field seems to “explode” with rapid tiller growth. To understand why, you need to understand the concept of **phyllochrons**, a concept that applies to members of the grass family, including cereals like rice, wheat and barley.

A phyllochron is the period of time between the emergence of one phytomer (a set of tiller, leaf and root that emerges from the base of the plant) and the emergence of the next (see Table 2). The length of phyllochrons is determined particularly by temperature, but it is also affected by things like day length, humidity, soil quality, exposure to light and air, and nutrient availability.

If conditions are favorable, phyllochrons in rice are 5 to 7 days long, though they may be shorter at higher temperatures. Under very good conditions, the vegetative growth phase of a rice plant may last as long as 12 phyllochrons before the plant begins initiating panicles and starts its reproductive phase. This is possible when the rate of biological growth is sped up, so that many growth intervals are completed before panicle initiation.

Table 2*: The increase in number of tillers that can be produced by the rice plant in successive phyllochrons (from De Laulaníe 1993). The first and later tillers send out more tillers which send out still more tillers. By the end of the series, plant growth becomes exponential rather than additive.*

	Phyllochrons											
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th
New Tillers	1	0	0	1	1	2	3	5	8	12	20	31
Total Tillers	1	1	1	2	3	5	8	13	21	33	53	84

Conversely, under poor conditions, phyllochrons last longer, and fewer of them will be completed before the flowering phase begins. Here is the most important consideration: only a few tillers are put out during the early phyllochrons (and none at all during the second and third phyllochrons), but during each successive phyllochron after the third one, each tiller already growing puts out a new tiller from its base (with a lag time of one phyllochron before this process starts) (see Table 2). During the latter part of the vegetative growth period, with ideal growing conditions, the plant's production of tillers becomes exponential rather than additive. (It corresponds to what is known as the Fibonacci series in biology.) Instead of a "maximum period" of tiller production being reached some time before panicle initiation (PI), as happens with standard cultivation practices, with SRI both PI and the maximum production of tillers coincide.

This is why it is best to transplant seedlings during the second or third phyllochron, so as not to disrupt the rapid growth which begins in the fourth phyllochron. Seedling roots are traumatized when they are exposed to the sun and dry out; when they are plunged into an airless environment; and when feeder roots, put out from the first root, are lost or damaged during late transplanting. This trauma slows subsequent growth, and not as many phyllochrons are completed before PI. Many transplanting methods set plant growth back by one or two weeks and also slow subsequent growth. For maximum tillering, plants must complete as many phyllochrons as possible during their vegetative phase. If seedlings are three or four weeks old when transplanted, the most important (late) phyllochrons when tiller growth is multiplied will never be reached.

Contrary to popular expectation, more tillering does not mean less panicle formation or grain filling. With SRI, there is not a negative correlation between the number of tillers produced and the number of grains produced by each fertile tiller. All yield components—tillering, panicle formation, and grain filling—can increase under favorable growing conditions.

This sounds too good to be true. What is the catch?

SRI requires more labor per hectare than traditional methods of growing rice. When farmers are not familiar and comfortable with transplanting tiny seedlings with fairly exact spacing and depth of planting, this operation can initially take twice as long. However, once farmers are comfortable and skilled with the technique, transplanting takes LESS time because there are so many fewer plants to put in.

With SRI, more time is spent applying water carefully than when fields are kept flooded all the time. This means that fields should initially be constructed with appropriate irrigation systems that allow water to be "put on" and "taken off" the field at regular intervals. Most rice fields are not set up like this (i.e. they were designed to hold the maximum amount of water), so some reconstruction of fields may be necessary before initiating SRI production systems.

Weeding takes more time if there is no standing water. However, the yields may be increased several-fold due to the increased soil aeration which results from weeding with the rotary push-hoe. The extra yield more than pays for the extra expense of weeding.

At first, SRI can take 50% to 100% more labor (and more skilled and exacting labor), but over time this amount is reduced. Experienced SRI farmers say it can even require less labor once techniques are mastered and confidence is gained. Since yields can be two, three, and even four times more than with current practices, the returns to both labor and to land are much higher, justifying the greater investment of labor.

Some farmers are skeptical of SRI's benefits. It seems almost like magic at first, though there are good scientific reasons to explain each part of the process. These farmers should be encouraged to try the methods out in a small area, to satisfy themselves about the benefits and to start gaining skills on a small scale.

Planting and weeding are initially the most labor-intensive aspect of SRI. Many families are constrained by the amount of available labor, either within the household or for hire. If someone does not have enough labor available to plant and tend all the rice fields using SRI, he or she can cultivate just part of the land with rice using SRI methods, getting higher returns for both labor and land. Then other crops can be planted on the remainder of the land at times when labor is available.

Is SRI sustainable? How can you get such high yields?

Scientists are not certain, and many are very skeptical, about how such high yields can be obtained on such poor soil as that found in Madagascar. Fortunately, SRI methods have been found to produce much improved yields in other countries (China, India, Indonesia, the Philippines, Sri Lanka and Bangladesh, for example), so we know that it is not a methodology with success limited to one country.

Systematic research by plant and soil scientists is ongoing. Here are a few proposed explanations for which there is some basis in scientific literature:

- Biological nitrogen fixation (BNF). Free-living bacteria and other microbes around the roots of rice may fix nitrogen for the plants. The presence of such bacteria has been documented for sugar cane, which is in the grass family along with rice. Where nitrogen fertilizer had not been applied (since this suppresses production of the enzyme nitrogenase required for BNF), microbial action fixed 150 to 200 kg of nitrogen per ha for the cane. However, less nitrogen fixing occurs where chemical fertilizers have previously been applied. It is known that about 80% of the bacteria in and around rice roots have nitrogen-fixing capability, but this potential will not be realized where inorganic N has been applied, or possibly in anaerobic, water-logged soil.

- Other research suggests that plants can grow very well with extremely low concentrations of nutrients, as long as those nutrients are supplied evenly and consistently over time. We know that compost furnishes a low, steady supply of nutrients.
- Plants with extensive root growth have better access to whatever nutrients exist in the soil. Extensive root growth can result when the roots of young seedlings have a lot of space and oxygen, and when water and nutrients are scarce enough that roots need to "go looking" for them. Such extensive roots may be able to extract more balanced nutrients from the soil, including some scarce but necessary micronutrients.

Skeptics have downplayed SRI because it can be labor-intensive and because it requires careful water management. However, work to demonstrate the benefits of SRI has continued. In the July/September 2001 issue of *Appropriate Technology* (Volume 28, No. 3), Norman Uphoff described an experiment carried out in Madagascar by Jean de Dieu Rajaonarison and his advisor, Professor Robert Randiamiharisoa, in the Faculty of Agriculture (ESSA) at the University of Antananarivo. Two rice varieties—a high-yield variety and a traditional local variety—were compared. Both showed the same patterns of response. Uphoff wrote:

> The SRI practices compared against conventional methods were: age of transplanting (8 days versus 16 days); number of plants per hill (1 versus 3); water management (aerated soil versus flooded soil); and fertilization—compost versus NPK (16-22-11) versus no fertilization.
>
> The high-yielding variety produced 2.4 times more rice with SRI practices compared to conventional methods. The local variety yielded 2.8 times more. These results can be analyzed several ways to ascertain how much contribution each practice made towards yield differences, all else being equal, under these particular soil, climatic and other conditions.
>
> For these particular varieties and growing conditions, planting young seedlings contributed most to yield—an extra 1.35 t/ha. Careful water management, using a minimum of water and keeping soil well-drained and aerated, was next most important, adding 0.85 t/ha. Planting single seedlings added 0.46 t/ha. Using compost increased yield by 0.27 t/ha over what was obtained, on average, using NPK fertilizer.
>
> That adds up to a total of just under 3 t/ha increase in yield, but when the four practices were used altogether, yields increased by 4 t/ha. This shows…an interaction or synergistic effect of over 1 t/ha. It is, therefore, in the farmer's interest to use all the SRI practices instead of picking and choosing.

Much more remains to be studied about and learned from SRI, but scientists are starting to take an interest in it as reports of superior yields multiply. SRI should be seen not as a technology to be applied mechanistically, but rather as a methodology to be tested and adapted to farmers' conditions. Farmers need to be good observers and good learners to make the best use of the insights that SRI provides.

Dr. Norman Uphoff's responses to questions concerning SRI

Mr. J. B. Hoover of the Asian Rural Institute in Japan wrote to us with a few questions about SRI. To answer his questions, we contacted Norman Uphoff from Cornell University. His colleague Erick Fernandez (who has done a lot of work in Madagascar where SRI was developed) also responded. Here are the questions and their responses:

Question 1: Has SRI been tried in temperate monsoon climates like Japan? If so, is there any documentation?

> UPHOFF: I don't know of any application of the SRI set of practices in temperate monsoon climates; however, since SRI is not a technology but a set of principles to be adapted to local conditions, there is no reason why it should not work under those circumstances. We do know from Madagascar that yields are greater in higher elevations with cooler climates. The problem with a monsoon climate may be that it is hard to keep the soil well-drained during the height of the monsoon, though this may be done by growing the rice on raised beds, as is now being done increasingly with wheat, to reduce irrigation requirements (furrow rather than flood irrigation) and raise yields. For best SRI results, indeed for ANY SRI results when there is continuous flooding under monsoon conditions, the soil needs to be kept at least intermittently well drained.
>
> FERNANDEZ: As Dr. Uphoff points out, SRI should apply across the range of rice-growing sites (tropical to sub-tropical/temperate). We should not, however, be too surprised to find that SRI is better for some climates versus others. There are still many unknowns about the interactions and synergies.

Question 2: As to the weeding "problem" raised in the article, we at ARI, like many organic Japanese farmers, use Aigamo ducks in the field. Using Aigamo has virtually eliminated the need to weed the paddy, and they rid the paddy of most harmful insects. However, we have used Aigamo in conjunction with typical flooded fields. Do you have access to any documentation about using Aigamo or other flightless ducks as part of the SRI system?

> UPHOFF: I know of no experience or documentation. We have found, however, that pests (and diseases) are fewer with SRI compared to other cultural practices, so maybe the ducks would not be as well-fed with SRI? That is a nice thought.

FERNANDEZ: Ducks are common in the rice systems of Madagascar. Although SRI seems to reduce rice pests, nothing is known about the impact on other beneficial insects and aquatic fauna/flora that make up a large part of the "à la carte" duck menu! Another point to consider: by paddling around and "dibbling" around the rhizosphere, ducks help aerate the root zone.

[Mr. Hoover wrote to us with more information about Aigamo ducks, a crossbreed of wild and domestic ducks. Mr. Hoover says the ducks do not touch the rice leaves but must be removed from fields just before rice plants head. Fences or nets are kept around the fields to prevent wild animals from reaching the ducks and to keep the ducks contained within the rice fields. Ducks are given a small amount of crushed rice in the morning to supplement their diet of weeds, weed seeds and insects. Fifteen to thirty ducks are used per 1/10th of a ha, or 0.25 acres.]

Dave Askin in Papua New Guinea wrote to Norman Uphoff with a question on SRI and stem borer:

Question 3: Dear Norman, Greetings. I read the SRI article in EDN*. Very interesting. I wondered about the wisdom of very low populations of rice where considerable stem borer problems exist—and no insecticides—I am referring to some places in Papua New Guinea where I work. My concern is that the farmers could end up with no crop as each tiller is destroyed. At least with lots of plants established some deaths is not too bad. I am interested in your comments.*

UPHOFF: Dear David, Your question further illustrates why we say that SRI is a set of principles to be tested and adapted rather than a technology to be implemented mechanically. I would suggest trying this out. Farmers in Bangladesh told me in December that they had less of a problem with stem borer using SRI methods because of the plants' health and vigor. Generally farmers report that SRI rice is more robust and resistant to pests and disease. But this is always an empirical question. Good luck, and keep us informed on any experience, good or bad.

Can a consensus be reached on the benefits of SRI?

Ryan Haden, a former ECHO intern, went on to study SRI as a doctoral student at Cornell University. We asked him to give an update on SRI since ECHO's 2001 EDN *70 article. His response was published in* EDN *102 in January, 2009. Ryan's article is reprinted below.*

Rising food costs

Rice has been featured prominently in the news lately. The price of rice has more than doubled over the last few years, and the world's poor are feeling the crunch. While a multitude of factors have contributed to this price hike, the most important is that the demand for rice is increasing faster than production. The world once again needs to place a priority on increasing rice production. Unfortunately that is easier said than done in the post-Green Revolution world.

In the past, production was increased either by allocating more land to growing rice or by increasing the yield per hectare, The first option has an immediate impact on production, but suitable land that can be converted to new rice paddies is becoming increasingly hard to find. As a result, most current efforts have been aimed at boosting yields through improved varieties or better agronomic practices. Despite these efforts, average yields in the world's most important rice growing regions have begun to plateau. Water supply in many areas limits increased production and may be polluted. Inputs like fertilizers and fuel are becoming too costly for most poor farmers, and their overuse by others puts further strain on the environment. In the face of such challenges there is only one viable option. Rice farmers must produce "more with less".

Background with SRI

In 2001, *EDN 70* featured an article titled "SRI, the System of Rice Intensification: Less Can Be More," which described a new approach to rice production that its advocates claimed could help achieve this goal. Since that article was first published, a lot has happened in the area of rice research and extension. Over the last 7 years, my work and studies on rice, which I began as an ECHO intern, have taken me across Asia and allowed me to see first hand the activities that are taking place—both in farmers' fields and on experiment stations. As a result, staff at ECHO thought it was time for an update on SRI.

Since ECHO's resources are largely geared toward those working in rural development, I try here to focus on the issues that directly impact small farmers. That said, I do touch briefly on a few of the theoretical issues that have been raised.

Are SRI yields better than what farmers get normally?

In many cases the answer to this question has been yes. In fact there is a growing consensus among governments, NGOs and researchers that SRI can increase rice yields ***relative to existing farmer practices***. A recent study published by researchers from the International Water Management Institute observed that adoption of SRI practices by farmers in West Bengal, India, improved yields by 32% and increased net returns by 67% (Sinha and Talati, 2007). The World Wildlife Fund, which has helped sponsor SRI dissemination in India, reports that they see grain yields increase by an average of 20% to 30% with SRI methods. I have personally witnessed similar yield gains by many farmers in West Java, Indonesia (Fig. 4). There are also instances where improvements with SRI have been even higher, in some cases doubling or tripling grain yield over existing farmer practices. This usually happens when farmers' yields are notably low

Figure 4: *A family in Indonesia planting rice according to SRI principles.*

to begin with. For example, dissemination of SRI in Myanmar via the Farmer Field School approach increased average rice yields from 2.1 to 6.4 t/ha among the 612 farmers studied (Kabir and Uphoff, 2007). These are not record breaking yields, but the gains certainly make a big difference to farmers and their families.

The main problem is that "farmer practices" often fall far short of the optimal practices recommended by scientists, particularly in the areas of soil, water and pest management. Rice has always been a crop that responds well to intensive management. The practices prescribed by SRI—such as planting in straight rows, thorough weeding, addition of manure or compost and, in certain situations, younger seedlings and intermittent irrigation—all have a sound agronomic basis. In some places they may already be part of the local recommendations. It is also true that when a support system is established to promote SRI practices, the improved access to information, seed, and credit can also positively impact yields, irrespective of SRI techniques. This is all good news for farmers, but has confounded accurate comparisons in at least a few NGO reports. Generally speaking, the SRI approach amounts to improvements in rice management over usual farmer practices. Therefore, it should come as no surprise that SRI helps to close the gap between what is normally harvested from farmers' fields and what is possible given better management.

Are SRI yields better than what is possible in the conventional system?

This is where the real battles have been fought between advocates of SRI and the conventional system recommended by many in the international research community. Table 3 offers a comparison of conventional and SRI practices.

Some of the early literature on SRI reported nine cases of extremely high rice yields in Madagascar ranging from 15 to 23 t/ha, figures which were circulated widely in the NGO literature as well as by *EDN*. Some hailed this as evidence that "synergy" between SRI's practices may have unlocked previously untapped yield potential in the rice plant, essentially allowing the plant to exceed the hypothesized yield limits. However, many in the scientific community were considerably more skeptical and a few expressed serious doubts that SRI could live up to these claims.

In the field, grain yields of 13 to 15 t/ha are sometimes achieved in Australia and China using modern conventional methods, which shows that yields in the 15 t/ha range are already possible in some locations. Theoretical models which take into account how the rice plant harvests sunlight and converts it to both biomass and grain suggest a maximum of 18.5 t/ha in temperate climates and around

Table 3*. Comparison of Conventional and SRI practices.*

Management Practice	Conventional	SRI
Land preparation	Bunded fields are puddled and leveled just prior to transplanting.	Bunded fields are puddled and leveled just prior to transplanting.
Seed requirement	50-80 kg/ha	5 kg/ha
Seedling age when transplanted	15 - 30 days	8 – 12 days
Seedlings per hill	3 - 4	1
Spacing	Ranges from 10 x 20 cm to 30 x 30	25 x 25 cm or greater
Establishment	Transplant seedlings in square pattern or direct seed pre-soaked seed in rows at a rate of 80 kg/ha.	Using a square pattern, carefully transplant a single young seedling so as not to damage the root system.
Water management	Maintain 5-10 cm of standing water in field from transplanting to maturity. In direct seeded fields soils are kept moist but unflooded for 2 weeks after seeding. Intermittent irrigation is sometimes recommended in water scarce areas.	Irrigate intermittently every 5-8 days in order to maintain moist but not saturated conditions (commonly known as alternate wetting and drying or AWD).
Nutrient management	Mineral fertilizers applied at rates recommended by Leaf Color Chart* and/or Site Specific Nutrient Management* (SSNM) protocols. Addition of organic matter is recommended if available.	Preference for organic inputs such as compost, manure, leaves, straw, or ash. Add mineral fertilizers on a supplemental basis.
Weed control	Manual or mechanical control 1-2 times prior to canopy closure, or apply herbicides. Continuous flooding also controls weeds.	Mechanical control using a rotary weeder 3-4 times prior to canopy closure.

*For information on the use of Leaf Color Charts or Site Specific Nutrient Management visit www.knowledgebank.irri.org

12.5 t/ha in the tropics. Thus, most experts feel that the largest yields reported for SRI are highly unlikely. I recommend that we be wary of such high yield figures for SRI, particularly when they are not accompanied by detailed methods. We should also be very careful in how we report them in our publications. Small-scale farmers in the tropics are unlikely to ever see yields in this range, so quoting such figures only diminishes the more modest but real improvements that can be seen with improved crop management, be it via SRI or conventional methods.

...the most interesting...for me is the possibility that low input systems like SRI have the potential to rival the productivity of conventional systems, which are often overly dependent on costly fertilizers and pesticides.

So to answer our initial question directly: right now there is not much firm evidence to support the claim that SRI offers a significant yield advantage over the conventional approach, assuming optimal water, nutrient and pest management practices are being used. That said, the most interesting question that the SRI debate raises for me is the possibility that low input systems like SRI have the potential to rival the productivity of the best conventional systems, which are often quite dependent on costly fertilizers and pesticides.

Input Dependence vs. Self Reliance

One of the major barriers to technology dissemination and poverty reduction is the economic isolation which stems from poverty itself. People caught in this "poverty trap" have been largely by-passed by the agricultural innovations produced in recent decades. This is particularly true for things like fertilizer, fuel, and pesticides, since these inputs have prices that are driven by volatile international markets. The typical approach to breaking this cycle of poverty has been to subsidize inputs or improve access to credit so that poor farmers are less isolated from beneficial new technologies. Unfortunately the ability of government and NGO initiatives to make these technologies more affordable is usually constrained by funding.

Given these limitations, an alternate approach is to develop and disseminate technologies like SRI which foster greater self-reliance and less dependence on external inputs. For example, when Indonesian farmers faced rising costs for urea following the 1997 Asian financial crisis, some shifted to SRI and the local production of compost as a means of reducing fertilizer costs. I have worked closely with these farmers, and after ten years many are still practicing modified versions of SRI and are increasingly involved in farmer-to-farmer training and outreach. Moreover, when fertilizer prices returned to affordable levels, farmers did not stop producing and using compost, but rather incorporated mineral fertilizers into their regime as needed. (Realistically, it is often difficult for farmers to supply enough N to sustain high yields using compost alone.) In my view, programs that help farmers gain access to improved technologies need to be expanded, but the importance of strategies which reduce input-dependence and promote greater self-reliance should not be overlooked.

But isn't SRI more labor intensive?

The question of SRI being more labor intensive has been the primary criticism raised on the practical level and in some reports has been cited as the main reason for farmers abandoning SRI once they have tried it. For farmers who are just learning the approach, careful transplanting of young seedlings will often require more time and energy, and this can be problematic when it coincides with the labor bottleneck that often accompanies the planting season. However in most cases the additional labor can be drastically reduced with a bit of practice, sometimes to the point where SRI can even save labor on transplanting because of the reduced planting density.

Weeds pose a bigger labor problem. Due to the drier soil conditions, wider spacing and younger plants, farmers generally have to weed SRI fields three to four times per season, whereas conventional flooded rice requires only one or two weedings. To address this issue in different settings, a number of labor-saving technologies have been integrated into the SRI approach. These include powered or hand-drawn weeders (for examples of different designs you can visit: <wassan.org/sri/documents/Weeders_Manual_Book.pdf>), judicious use of herbicides and even the selection of cultivars which grow vigorously enough to compete with weeds. Ultimately, while labor constraints may make SRI impractical in some areas, there are many other regions where this is not the case.

If you are interested in pursuing more compatible rice varieties (e.g. varieties that compete better with weeds, produce lots of tillers or tolerate periods of drought), I recommend that you start by contacting the agricultural extension departments in the country in which you work. Most Asian and many African countries have rice breeding programs with well-informed individuals that development workers can seek out and talk to directly.

The International Rice Research Institute (IRRI) can also be contacted for very small amounts of seed that are provided free of charge for research and development purposes. Recipients of seed from IRRI must be willing to submit legal documents such as a Material Transfer Agreement, but this process is not too difficult so do not let it intimidate you. Website: <http://irri.org/our-work/seeds>.

Another source of information is the Africa Rice Center, also known as WARDA <www.warda.org>. They might have NERICA (New Rice for Africa) lines, which have been geared specifically for the constraints faced in Africa.

Is SRI better for the environment?

This question is actually quite complex. Given the information available, it is probably impossible to say whether SRI or the conventional approach is more sustainable in the long term. That said there are a few benefits to SRI that in light of current environmental concerns will grow increasingly more relevant. At present, flooded rice accounts for almost 50% of all fresh water used in Asia; thus it is accurate to say that flooded rice both contributes to and is affected by water scarcity. Consequently there is a vital need for alternative technologies which reduce water use and enhance grain production per unit of water used. Alternate wetting and drying, which can be practiced alone or as a component of SRI, is an excellent way to save water over the course of a season. Other water saving practices include: direct seeding or growing rice on raised beds. Since this environmental problem is only likely to grow, so too will the scope for SRI and other water saving technologies.

The anaerobic soils in flooded rice fields are a major source of methane gas, which has 20 to 30 times more global warming potential than carbon dioxide. Since SRI prescribes intermittent irrigation, which keeps the soil moist but not flooded, methane emissions are greatly reduced. The potential savings in methane are partially offset by an increase in nitrous oxide (an even more potent greenhouse gas), but early research indicates that with better timing and more judicious use of N fertilizers there could be a net benefit of intermittent irrigation on total emissions. Whether or not these environmental benefits can actually be achieved by farmers who use SRI has not been adequately explored, but the potential is certainly encouraging.

Matching practices to environments

As we have gained more experience with SRI, we have learned that there are environmental and economic scenarios where certain components of SRI are a great fit and others where they can cause major problems (Table 4). We already discussed the labor issues which are tied to the transplanting and weeding operations. Another example is the trade-off associated with intermittent irrigation. When managed properly intermittent irrigation can certainly save water. But it is also an ideal strategy to cope with soils that have excessively high levels of iron, arsenic or sulfides, since these toxins are more available to the plant under flooded conditions. Unfortunately, intermittent irrigation can just as easily exacerbate problems associated with saline soils or parasitic nematodes. Furthermore the cycles of wetting and drying can increase the rate of organic matter oxidation and aerobic decomposition. In the case of organic muck soils this can often lead to rapid soil degradation and loss. Even in mineral soils the same processes may also lead to a decline in organic matter levels if sufficient organic amendments are not applied. Soil is like anything else in life, you can't get out what you don't put in.

As you can see, sorting out the pros and cons of SRI versus conventional rice production is no easy task. Thus far both systems have shown that they can help farmers boost production, yet both face very real challenges when it comes to technology transfer and implementation. Given these challenges, perhaps the best way we can assist rice farmers is to cast aside strict adherence to one system or the other and attempt to match individual practices to the environments in which they are best suited. Fortunately farmers tend to adapt technologies to suit their own needs anyway. Our job then is to provide them with a larger basket of options and perhaps a bit of guidance regarding when and where they should be used.

Table 4. *Matching practices to different natural and economic environments.*

SRI Practice	Ideal Situations	Non-ideal Situations
Alternate wetting and drying	-water scarce areas -soils prone to iron toxicity -acid sulfate soils which cause sulfide toxicity when flooded -soils high in arsenic, which can have adverse agronomic and food chain effects	-saline soils -soils affected by root knot nematode -flood prone areas -areas with poor water control -organic muck soils with high potential for oxidative loss of organic matter and subsidence
Lower seedling density	-reduced seed requirement helps cut costs on expensive hybrid seed	-low tillering varieties are unable to compensate for the wider spacing
Compost and crop residues	-areas where mineral fertilizers are cost prohibitive or where manure, crop residues, and biomass are abundant	-more difficult to implement in cultural situations where manure and crop residues are intensively used for fuel and feed
Intensive weeding	-additional aeration caused by soil mixing may help reduce risk of iron or sulfide toxicity on certain soils	-impractical in areas with labor shortages

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Stoop, W.A., Uphoff, N., and Kassam A. 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. *Agric. Syst.* 71:249–274.

Ryan added: For those willing to slog through the scientific literature, I recommend reading both Stoop *et al*. (2002) and Dobermann (2003). These authors cover at length what I could only address briefly in this article.

Examples of home innovations developed to make SRI more user-friendly

Figure 5: *Paddy preparation (top) and dart transplanting (bottom).* Photos taken from the *Natural Agriculture Journal*, March 2014.

This section and the next were taken from articles written by our ECHO Asia Regional Impact Center.

As discussed previously, SRI has a learning curve; farmers need some time to learn how to prepare the field, plant, weed and care for the rice according to SRI principles. As they have incorporated SRI principles, a number of farmers have adapted tools or found easier ways to perform specific tasks. Not all these innovations will be possible for or useful to all farmers, but they show good examples of farmers taking what resources are available, adapting them for use in their SRI fields, and making their tasks easier in the process.

In Nakorn Sawan, central Thailand, Wanpen has been practicing SRI for several years, along with her daughter Pijarinee. Wanpen initially prepared their fields for transplanting using a rope and knots to show where the rice should be transplanted, then she planted individual seedlings by hand. Over time, she began developing a system to speed up her work. She designed a “roller planting marker” out of steel bar, built to be light-weight so that pulling it through the field would not be difficult (Fig. 5a). The tool marks the field with a grid so that the rice can be transplanted in straight lines, making it easier to weed between rows with a different tool later in the season.

Wanpen also started seeding rice into trays in order to use them in a “dart transplanting method”. For SRI transplants, she and her daughter seed the rice into plastic trays with 434 holes, filling them only half full with forest soil and transplanting them after 12 days. In the dart transplanting method, the transplants are thrown into the field, aimed at the marks made by intersecting lines that are left by the roller planting marker (Fig. 5b). This reduces the time spent transplanting, and preserves farmers from the back-breaking work of bending and planting each station by hand.

The flooding that is typical of traditional lowland rice production helps to lower weed pressure. SRI production, by contrast, alternates between wet and dry periods; this has huge benefits for the rice plants, but also enables weeds to grow, making weed suppression quite labor intensive. Chunawat Phana-Ngam is a “weekend farmer” in Thailand. He has adapted two tools that he uses regularly to help weed his fields. The first is a weed cutter, based on a widely-available grass cutter. Phana-Ngam covered the modified blade of his cutter with a bent shield, to protect the rice while weeding between rows (Fig. 6a). The second tool is a rotary weeder (Fig. 6b). Rotary weeder designs are commonly found in rice-growing areas, but they are often expensive or not built to the specifications of individual fields. Phana-Ngam designed his to fit between his rows and to turn the weeds back into the soil, aerating the soil at the same time.

Figure 6: *Phana-Ngam’s grass cutter (left) and rotary weeder (right).* Photos taken from the *Natural Agriculture Journal*, March 2014.

It has been a process for Phana-Ngam and Wanpen to design these tools to their liking. They modified their first designs several times. They asked other farmers to test the tools and give feedback on ways to make them better. Designing tools does not merely mean building them, but also includes a cycle of trying prototypes, altering the design, and re-building. It takes a lot of time and effort. But when the final product allows a farmer to work more efficiently, the effort can be well-worth the time.

More details about these farmers and designs for their tools can be found in *ECHO Asia Notes*, Issue 21.

Can SRI make a difference on a country scale? Case Study from Cambodia

In 2009, Rick Burnette, ECHO’s Director of Agriculture/Head of Agriculture Training and former director of ECHO’s Regional Impact Center in Thailand, wrote an article about the widespread adaptation of SRI by Cambodian farmers. Burnette interviewed Yim Soksophors, Junior Program Officer for CEDAC (Centre d’Etude et de Developpement Agricole Cambodgien). At the time of writing the article, “there were 104,750 households in 4,200 villages on 58,290 ha (2.7% of the country’s total rice area) using SRI methods” (Burnette, 2009).

Soksophors shared several reasons for SRI’s success in Cambodia. Initially, participatory action research was used to collect data and ensure that SRI was a system that could be adapted to local conditions. SRI was introduced in 1999, but by 2005 , other organizations (both governmental and non-governmental) helped extend the knowledge to rural areas. Farmer-to-farmer extension was used as one approach, with training days where farmers were invited to a fellow farmer’s field to participate in transplanting or harvesting or other significant days during the rice growing season. Farm visits occurred throughout the growing season, giving opportunity for farmers to see the difference between SRI fields and traditional fields. Farmers practicing SRI were also taught to collect data from their rice. Some farmers were invited to participate in training days where they could share their own experiences, successes and difficulties. SRI methods were taught in a way that adapted some of the practices to fit individual farmers or locations (rather than as an "all or nothing" proposition).

Since Burnette's interview with Soksophors, SRI has continued to be promoted and adopted throughout Cambodia. According to the CIIFAD/Cornell website (2014), "during the 4th National Farmers Conference (April 4, 2013), Chan Sarun, Minister of Agriculture, Forestry and Fisheries said that national paddy productivity increased from 2.74 t/ha in 2008 to 3.13 t/ha in 2012, with a good part of this increase attributable to wider use of SRI methods. The Ministry reports that at least 101,719 hectares are under SRI crop management, which means 150,000 to 200,000 households." There are questions about how many SRI practices need to be adopted in order for a farmer to be labelled as a practicer of SRI. However, the national rice yield has increased significantly, especially for a country whose main staple is rice and in which most families grow some quantity of rice for their household.

Cambodia's example does not mean that SRI would or could work everywhere else, because each country is different. For example, in Nepal, despite wide adoption of SRI, people have generally grown more interested in high-value vegetables, fruit trees and cash crops, while rice has become a lower priority on individual farms (Uprety, 2014). In your area, pay attention to the context and to factors already in place that could enable SRI to work well in an area or that might impede its ability to make a difference.

For further reading:

Burnette, R. 2009. Lessons Learned from the Spread of SRI in Cambodia. *ECHO Asia Notes* 2.

SRI International Network and Resources Center (SRI-Rice). 2014. Cambodia. Retrieved February 2, 2015 from http://sri.ciifad.cornell.edu/countries/cambodia/index.html.

Uprety, R. 2014. Learning from Farmers. *ECHO Asia Notes* 21, 14-15.

Beyond SRI: The System of Crop Intensification

The management practices used with SRI have also now been tried with many other crops. Here we present an update about crops that have demonstrated increased yields using similar management practices.

The System of Crop Intensification (SCI) is the term being used to describe the principles of SRI when applied to other crops (Table 5). In India, the term System of Root Intensification (another SRI) is sometimes used. These principles are:

Early establishment of healthy plants, with care taken to protect the root growth potential of seedlings.

Sufficient space between crops, as influenced by planting densities, to allow for optimal capture of soil nutrients and sunlight.

Enrichment of soil with organic matter, which slowly releases nutrients to crop plants and provides aerated conditions conducive to root growth and soil microbial life.

Controlled water management to avoid anaerobic conditions in the soil, a principle especially relevant to irrigated crop production.

These principles are the basis for the above-mentioned SRI practices, which can be adapted for other crops, local conditions and available resources.

Why do these crop management principles and practices work? It seems that setting up the proper environmental conditions helps plants reach their genetic potential. An organism's genotype is the actual genetic information of that particular species and variety of plant. With plant breeding, changes are made to the genotype, so that the resulting plants will have desirable characteristics (such as increased yield). Plant breeding is important, but is a slow and often expensive process. And if plants are grown under suboptimal conditions, they will not reach their full growth and yield potential.

Many farmers and scientists have been surprised at the extent to which a combination of improved management practices can alter a plant's growth and development, regardless of the variety that is used. This is an extremely important and encouraging idea, which seems to be holding true for many crops in addition to rice!

Table 5 in this article gives examples of crops now being grown using SCI, condensing information from a report by Norman Uphoff called "Raising Smallholder Food Crop Yields with Climate-Smart Agroecological Practices." (The report is available online at http://sri.ciifad.cornell.edu/aboutsri/othercrops/Other_Crops_Brochure_Uphoff101012.pdf)

The comparisons listed in the table are not from a single carefully controlled scientific experiment. Despite that, the substantial and multiple instances of yield increases illustrate the powerful effect that management practices can have on production levels. The column on the far right of the table includes links to manuals (or, in some cases, presentations) with more detailed information, where available. A more general booklet by an NGO in Ethiopia, Institute for Sustainable Development (ISD), can be found here: http://www.agriculturesnetwork.org/magazines/global/sri/sci-planting-with-space

***Table 5**: Summary of crops that have been grown using System of Crop Intensification Principles. From a report by Norman Uphoff.*

Crop	Location	Yields (t/ha) Local Practices	Yields (t/ha) SCI	Notes	Planting Guide / Manual Available?
Wheat (*Triticum* spp.); System of Wheat Intensifica-tionor SWI.	Bihar State, India	1.6	3.6-4.6	Widespread adoption of SWI by tens of thousands in India! Seeds are primed before planting. Net Effect on Income: from Rs. 6,984 to Rs. 17,581	Yes
	Northern Ethiopia	1.8	4.7-10		
	Timbuktu Region of Mali	2.25	4.26-5.4	Spacing of 15 cm x 15 cm gave greatest yield response in Mali.	
	Western Nepal	3.74	6.5	These yields were using a modern variety.	
Mustard (*Brassica* spp.); System of Mus-tard Intensification or SMI.	Bihar State, India	1	3-4.92	Costs of production have been reduced by half, from Rs. 50 per kg of grain to Rs. 25.	Yes
Sugarcane (*Saccarum officinarum*)	Hyderabad, India			WWF and ICRISAT launched “Sustainable Sugarcane Initia-tive” (SSI). Using a new method of propagation, the bud from a sugarcane plant is cut from the stalk and planted in coconut pith packed into plastic trays.	Yes
Finger millet (*Eleusine coracana*)	Karnataka State, India	1.25-2	4.5-5	System is called Guli Vidhana (square planting). Two tools are used, one to stimulate tillering and root growth and another to break up topsoil. Spacing 45 cm x 45 cm ; 2/hill	Yes
	Jharkhand State, India	.75-1	3-4	Costs of production reduced by 60%, from Rs. 34.00 to Rs. 13.50.	Yes
	Bihar State, India				
Maize (*Zea mays*)	Northern India	2	3.5	Spacing of 30 cm x 30 cm (some 30 x 50); direct seeded with 1 to 2 seeds/hill. Three soil-aerated weedings. More experimentation needed!	Yes
Turmeric (*Curcuma longa*)	Tamil Nadu State, India			Spacing of 30 cm x 40 cm. Net income doubled, due to 25% higher yield and much lower costs of production. A variety of organic fertilization methods are used.	Yes
Tef (*Eragrostis tef*); System of Tef Intensi-fication (STI).	Ethiopia	1	3-5	Seed is traditionally broadcast. Tef seeds are very tiny (2500 in only 1 gram), but worth it to grow and transplant! Spac-ing of 20 cm x 20 cm. Yields could be almost doubled again with small amendments of micronutrients including zinc, copper, manganese and magnesium.	Yes
Pigeon pea/red gram (*Cajanus cajan*)	Karnataka State, India	.35	.6	Planting of 30- to 35-day-old seedlings spaced at 75 cm x 105 cm.	Yes
Mung bean/green gram (*Vigna radiata*)	Patna, India	.625	1.875		
Lentils/black gram (*Vigna mungo*)	Uttarakhand State, India.	.850	1.4	1-2 seeds are sown per hill, with spacing of 20x30 cm, 25x30 cm or 30x30 cm (15x30 or 20x45 for peas). Two or more weedings are done, preferably with soil aeration. Farmers use a mixture of indigenous organic fertilizers. The production strategy is “intensive”.	
Soya bean (*Glycine max*)	Uttarakhand State, India.	2.2	3.3		
Kidney beans (*Phaseolus vulgaris*)	Uttarakhand State, India.	1.8	3.0		
Peas (*Pisum sativum*)	Uttarakhand State, India.	2.13	3.02		
Vegetables	Bihar State, India			“Women farmers in Bihar have experimented with planting young seedlings widely and carefully, placing them shallow into dug pits that are back-filled with loose soil and organic soil amendments such as vermicompost. Water is used very precisely and carefully. While this system is labor-intensive, it increases yields greatly and benefits particularly the very poorest households.”	Yes
Chillies		1.5-2.0	4.5-5.0		
Tomatoes		3.0-4.0	12.0-14.0		
Eggplant (Brinjal)		5.0-6.0	10.0-12.0		

SRI surprised farmers and scientists. It seemed counterintuitive that fewer inputs (of seed, water, etc.) could result in vastly larger yields. Now we are perhaps surprised that the phenomenon goes beyond just rice. Careful, controlled management can have a dramatic impact on the development and growth of many different crop plants, ultimately resulting in much higher yields. That is good news for all, but perhaps especially for resource-poor farmers.

For More Information

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