

HOW TO HELP RICE PLANTS GROW BETTER AND PRODUCE MORE: TEACH YOURSELF AND OTHERS

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INTRODUCTION

The *system of rice intensification* (SRI) has already helped many hundreds of farmers in Madagascar to at least double their yields. With good management of plants, soil and water, yields can be increased possibly to 6, 8, even 10 tons per hectare, or even more.

- This self-help book will share with you the basic ideas and practices that can make this improvement possible. This information is **not** presented as a *recipe* to be followed mechanically, but as a *guide* for farmers' own testing and evaluation of new ways to help rice plants grow more productively.
- If this book and this method of production help you, we hope that you in turn will *share these ideas and practices with other farmers*, so that families and communities throughout Madagascar can become more prosperous and secure.

SRI was developed in Madagascar by Fr. Henri de Laulanié, S.J., who between 1961 and 1995 worked with Malagasy farmers and colleagues to improve the possibilities of rice production in this country. He wanted Malagasy people to have happier and more secure lives. It is now being studied and evaluated by scientists and rice growers in other countries.

SRI begins with a philosophy, that rice plants are to be respected and supported as *living creatures* that have great potential. This potential will only be realized if we provide plants with the best conditions for their growth. If we help plants to grow in new and better ways, they will repay our efforts several times over. We do not treat them like little machines to be manipulated and forced to do things that are not natural for them to do.

- Some of the things that have been done for hundreds of years by farmers in Madagascar and in countries around the world to make rice plants grow have unfortunately *reduced their natural potential*. This new system of rice intensification changes these traditional practices to bring out of the rice plant significant possibilities for increasing production.
- The yields that can be achieved by each individual farmer will depend on many things: on the careful and timely transplanting of seedlings, on the preparation and management of the soil in the field, on the control that is maintained over water, on the quality of the soil itself, on whether the variety of rice that is planted is really suitable for the growing conditions.
- **No purchase of new inputs** -- neither new seeds nor chemical fertilizers -- is necessary for farmers to get much increased yields. The increases can be very great as rice plants grown with SRI methods have a very *different structure* than usual, with several times more tillers and much larger root systems that can absorb more nutrients from the soil.

- The plants also have many times *more grain per panicle*. It has always been possible to get this different structure and this much greater productivity from rice plants. But this potential has not been elicited by the most appropriate practices to manage the plants, soil, water and nutrients.

HOW SRI CAN IMPROVE A FARMER'S PRODUCTION AND LIFE

One of the first farmers to make use of SRI methods was Honoré Randrianarasana near Ranomafana, who started working with Tefy Saina in the 1994/95 season, planting just 25 ares (.25 ha) using SRI methods. He got a yield of 9.5 tons/ha the first year, compared to his previous yields of 2 to 3 tons/ha. The next year he expanded his SRI area to 1.25 ha and got 10.95 tons/ha, which encouraged him to expand further his use of SRI methods, to 2 hectares and then 4 hectares, with still higher yields (12.7 and 13.7 tons/ha). In 1998-99, he planted 5 hectares, but his yields were around 7 t/ha because the season was bad for all farmers in the region.

In 1999-2000, Honoré planted 8 hectares with SRI, and by this time his economic situation had improved enough to buy 9 hectares of paddy land (he started with rented land) and three houses, one of them in the regional capital of Fianarantsoa. Not all farmers will be this successful or able to manage such large extents with this methodology. But Honoré has shown the potential that SRI can have to improve farmers' lives.

THE BASIC IDEAS

The system of rice intensification has discovered and demonstrated some important methods for helping rice plants to achieve their real potential. This potential has been obscured by previous practices. We begin by presenting the ideas on which SRI is based.

- Farmers should first understand these ideas. Then they should choose and evaluate specific practices that are most beneficial for their own conditions. *Every farmer is already -- or should become -- an experimenter.*
- SRI changes the structure of rice plants -- the density and number of their roots and tillers -- by changing the practices used to manage rice plants, the soil they grow in, and the water they receive through irrigation, so that the plants can become more productive

For rice plants to be more productive, they need to have:

- More tillers per plant,
- More fertile tillers (panicles) which form from the tillers that a plant puts out,
- More grains per fertile tiller, and
- Larger grains.

If rice plants are spread out and not planted very close together, they have more room to grow. They will get more sunshine and air and can produce more tillers. More of these tillers will become fertile and produce grains of rice. With more space in which to grow, rice plants' roots become larger and

are better able to draw nutrients from the soil. This enables rice plants to produce more grains, which is the reason for growing rice.

- Although it may be surprising, it is possible to get *many more grains of rice* from a field by *planting fewer plants* and by putting *them farther apart*, so that each plant is healthier and more vigorous in its growth. That "less" can be "more" seems strange, but it is true.
- For the plant to grow successfully above ground, it needs a healthy and vigorous root system below ground. The "trick" of SRI is to have both a *larger root system* for each plant below ground and *more growth* of tillers, leaves and grains above ground.

Planting rice plants densely and close together *wastes seeds*. The individual plants will be smaller and less productive. Having more rice plants is not as beneficial as having fewer plants that are very productive. Transplanting older seedlings also wastes potential.

- With SRI methods, you can easily get *50 tillers* on a single rice plant, and some farmers using these methods well have been able to get *over 100 tillers* from a single seedling.
- Farmers can get *200 grains* per fertile tiller, and the very best farmers have gotten as many as *400 grains* on a single tiller. One farmer in Sri Lanka says with SRI he has had one panicle with *600 grains*.

This is not a miracle. It results from good management of the plant and of its soil and water conditions, so that the plant's potential for growth and production gets fully expressed.

HOW CAN WE GET PLANTS TO PRODUCE MORE TILLERS?

The key to success with SRI is the *early transplanting* of seedlings, as explained below. This usually means transplanting seedlings before they are 15 days old, and as early as 8 or 10 days -- when only the first small root and tiller, with two tiny leaves, have emerged from the rice seed. When you plant older seedlings -- 3, 4, 5 or 6 weeks old -- they have already lost much of their potential to produce a large number of tillers.

- When seedlings are planted with *much delay* after being removed from the nursery, they suffer a lot. Once removed from their seedbed, seedlings should be replanted in the field within half an hour, and preferably *within 15 minutes*.
- When seedlings are *pushed* into the ground, rather than gently laid into the soil, they also must expend a lot of energy to resume root growth. This disturbs their development.

Transplanting rice seedlings early and carefully helps plants resume their growth in the field without reducing their potential for high yields by harvest time. But more must be done to capture that potential. It is especially necessary to promote strong *root growth*.

HOW CAN WE GET RICE PLANTS TO GROW STRONGER ROOTS?

The first thing is to *plant single seedlings*, one by one, rather than to plant them together in bunches of 3 or 4 seedlings, or even more, as is usually done.

- When several seedlings are planted together, their roots must *compete with each other*. This is a similar problem for rice plants as when they grow close together with weeds and must compete with them for nutrients, water and sunlight.

It is important, as discussed below, that the seedlings be spaced ***wide apart***, usually at least 25 centimeters from each other, and preferably in a square pattern. This facilitates weeding at the same time it gives the rice more access to sunlight and air above ground.

- When the rice plants are set out far from each other, and if the soil conditions are good, their roots will have plenty of space to spread out into, especially when they are not competing with each other.
- With wider spacing and with single planting, there will be *many fewer plants* in a field. Indeed, there may be only 10 or 16 in a square meter instead of 50 or 100. The highest yield has been achieved with only 4 plants per square meter, spaced 50 cm by 50 cm so the plants grow like bushes. Wide spacing *saves seed* -- as much as 100 kilograms per hectare -- at the same time that it contributes *much greater production* at harvest time because the rice plants produce many more tillers and grains.

Planting seedlings with precise spacing can be one of the more difficult aspects of SRI at the beginning, when farmers are not used to this. Two different methods have been developed.

- Farmers can *stretch strings* across their field, tied to sticks stuck into the bund at the edge of the field, spaced at 25, 30 or more centimeters, with the strings *marked* (knotted or painted) at whatever interval has been chosen (25, 30, or more centimeters), and then these sticks and strings (parallel to each other) are moved across the field; or
- A kind of "rake" that has teeth the desired distance apart (25, 30 or more centimeters) can be constructed simply from wood. It is pulled across the surface of the prepared muddy field, scratching lines onto the surface at desired intervals. Drawing the rake across the first set of lines perpendicularly (at a right-angle) to them creates the desired square pattern, on which seedlings are planted at the intersections of lines.

The first method is more precise but the second is quicker and saves considerable labor time.

A very important influence on the size and health of the roots is ***how the tiny seedlings are placed into the soil*** when they are transplanted.

- When seedlings (or the clump of several seedlings) are *thrust* straight downward into the soil, the tips of their roots will be pointed up *toward the surface*. The shape of the transplanted seedling will be like a J, with its *root bent upward*.
- *The rice plant root grows from its tip*. If the tip is pointing *upward*, the root must change its position in the soil to get the tip pointed downward before it can resume growth. This requires a lot of energy and effort from the tiny root, at a time when it is still weak after transplanting, especially if it has been allowed to dry out by delay in getting it from the nursery and into the field.

- With SRI, one does not thrust seedlings downward into the soil. Rather, each seedling is slipped *sideways* into the soil, very gently and close to the surface, so that its root lies *horizontally* in the moist soil. This makes the shape of the transplanted seedling more like an L than like a J.
- With this shape, it is easier for the tip of the root to grow *downward* into the soil. When the plant is shaped more like an L than a J, *less energy is* necessary for the plant's root to start growing quickly downward and to begin putting out more roots at the same time that it is sending tillers upward.

A major departure from usual rice-planting practice -- an innovation as important as transplanting tiny young seedlings -- is to grow rice in soil with ***no continuously standing water***. The rice plant during its growth stage only needs to have soil that is ***moist, but not saturated***. Indeed, the field should occasionally be *dried* even to the point of cracking. This goes against what most people believe about rice, but it is true.

- An important discovery of SRI is that *rice is not an aquatic plant*. Although it can *survive* when its roots are continuously submerged under water, it does not *thrive* in this situation. Rice does not grow as well underwater as when its roots are able to get oxygen from direct contact with air.
- Rice plants that grow in standing water will adjust to this environment. Their roots develop small air pockets (known as *aerenchyma*) that permit oxygen from above ground to reach the roots. But this is not an ideal condition for plant growth. It interferes with transfer of nutrients from the soil to the plant's tillers and leaves.
- With SRI, we have discovered that the soil only needs to be kept *moist* during the period of growth when the plant is putting out tillers and leaves, before it begins to flower and to produce grains. During this reproductive stage, the rice plants should be given a thin layer of water (1-2 cm) on the surface of the soil.
- Surprisingly, rice plants' growth will benefit if occasionally, even once a week, the soil is permitted to dry out, at least on the surface. This permits more oxygen to enter the soil and reach the roots. When the soil is not saturated, the roots need to grow longer to seek out water. When the soil around rice plants' roots has abundant water, they can be "lazy" and need not grow very much. This limits their ability to acquire nutrients from the soil
- Once the rice plant reaches its flowering stage, as note already, farmers should maintain a thin cover of water (1-2 cm) on the field to support grain formation. The field should be dried completely about 25 days before harvest.

When rice fields are not kept flooded continuously with water, this will give *weeds* a chance to grow. So efforts must be made to eliminate weeds, so that they do not compete with the rice plants and cannot take away nutrients and water from the rice.

- A very simple *mechanical weeder*, called a rotating hoe, pushed by hand has been developed to enable farmers to eliminate weeds easily, quickly and early. It reduces the hard labor of pulling up individual weeds by hand once they emerge. The weeder by churning up the soil

destroys weeds before they absorb many nutrients. By leaving them in the soil to decompose, it returns their nutrients to the soil

- This weeder, which has rotating wheels mounted vertically in the metal plate that is pushed along the ground, is not expensive. It can cost as little as 25,000 FMG (US\$5) if locally made. It may take as much as 25 days of labor to weed a hectare of rice. However, *each weeding can add one ton or even two tons of production* to the yield, so that the payoff to the farmer from each additional weeding can be very great.
- The first weeding should be within about 10 days after transplanting, and at least one more weeding should follow within two weeks. This will dig up weeds at the same time that *it puts more air into the soil* for the roots to utilize.
- Doing one or two additional weedings (3 or 4 weedings in all), before the plants have completed their growth and begin flowering, will provide *still more oxygen* to the soil. This is more important than removing any remaining weeds. Extra weedings can greatly increase yields.

Because chemical fertilizer is often not available in villages when the farmer needs it, or is available only at a price that farmers cannot afford to pay, SRI recommends using **compost or manure** to add nutrients to the field.

- Because the yields from SRI methods are so great, most soils need to be enriched by the addition of nutrients. But healthy rice plants with large roots can access much better the nutrients already in the soil as well as those added through compost or manure, and thus the plants can get more benefit from these.
- Soil that is enriched with compost or manure will usually have better *structure* so that plant roots can grow more easily in the soil. Compost releases its nutrients more slowly than does fertilizer so plants get more benefit from this source of nutrients.
- Making compost and working it into the soil of the field is usually a lot of work. But experience shows that this is a good investment for the farmer because the better quality soil supports better root growth and performance. Adding chemical fertilizer if it is available and the farmer can afford this can often add to yields. But fertilizer is *not as good* as adding organic material to the soil.

These are the basis ideas for transforming the production of rice. Once you understand how to help plants produce more tillers as well as how to get a larger root system, the natural result will be to produce *more grains* from your fields.

TECHNIQUES

With an understanding of the potential of rice that we want to achieve, and of the ideas behind this strategy for growing more productive rice, specific techniques make more sense. As we stated in the

introduction, these techniques should not be implemented mechanically. Instead, farmers should always keep in mind the principles discussed above, such as:

- Help the small seedling to achieve its great potential by getting it established in the field *at a young age -- quickly and in an L shape* from which the root grows easily.
- Prepare the soil so that it has a good supply of nutrients and keep the soil well aerated. SRI soil management practices -- no flooding, and the use of compost -- help microorganisms in the soil to produce more nitrogen for the rice plants, and it is well known that plant roots require oxygen.
- Avoid competition between rice plants so that each can grow efficiently because it has good access to air, sunlight, nutrients, and water.

Preparing the Nursery and Starting Seedlings

Fr. de Laulanié emphasized that the nursery for growing seedlings not be regarded as a miniature field -- to be kept flooded -- but rather it should be treated like a *garden*, where the soil is kept moist but not saturated. Watering by hand is sufficient if there is not enough rainfall to maintain moisture in the soil and for the seedlings. With SRI, the nursery is quite small. It can be only a small fraction of the size of the field to be planted. The following steps are recommended for a modified "dry bed" method of nursery development for SRI seedlings.

- Rice seeds should first be soaked in temperate water for 24 hours. Any that are irregular or float should be discarded.
- Next, put the seeds in a sack (burlap or other) and place it in a warm compost pile or in a hold in the ground that has been warmed by fire. Cover the sack completely with either compost or soil and leave it for 24 hours for slow warming of the seeds.
- The seedbed should be prepared as closely as possible to the field that will be planted, so as to minimize transport time between seedlings' removal from the seedbed and their transplanting in the field.
- Compost should be mixed into the soil of the seedbed at a rate of 100 kg per are (10 m x 10 m). Prior to seeding, lay down a fine layer of "ripe" compost or black soil in the seedbed to give the seeds good nutrient-rich material to begin their growth in.
- Farmers in Sri Lanka have found that building up the seedbed, about 10 cm, with lengths of bamboo, putting in compost or animal manure (chicken manure is very good) along with soil, gives the seedlings an excellent start and makes them easy to remove. Also, the organic nutrients are contained within the seedbed better this way.
- Broadcast the pre-germinated seeds onto the bed at a rate of about 200 grams for every 3 square meters, and then cover the seeds with a fine layer of soil.
- Water the seedbed every day in the late afternoon, or as often as needed to maintain a moderate level of soil moisture. The soil should not be saturated or kept continuously wet. If there has been rain during the day, no watering may be needed. How much to add to the bed depends on whether the soil has become dry.

- Transplanting should be done when the seedlings have just two leaves -- and before they have more. This usually occurs between 8 and 15 days.
- Seeds should not be sown all at the same time. Rather, appropriate batches of seed should be sown *on successive days*, so that the plants when they are put into the field can be all a uniform age, all between 8 and 12 days.

Field Preparation

The land preparation does not require special steps, though the soil should be well worked as it would be to get the best results from any method for growing rice.

- Make sure that there are adequate drainage canals either through the center of the field or along the edges of the field to ensure proper water control. With SRI, one does not want to have standing water in the field or saturated soil.

In general, we have found that compost is quite sufficient as a source of nutrients. Chicken manure, for example, is very rich in nutrients, but sometimes too rich. Farmers have found that they get best results by working compost made from diverse sorts of biomass into the field *during the preceding cultivation season*, when they are growing a crop between their rice crops, such as potatoes or beans or onions. The compost applied then helps that crop grow better, and the further decomposition of the compost provides adequate nutrients for the rice crop that follows.

The steps for preparing the soil for planting seedlings are not described here, including how best to work the compost or (if available) manure into the field. SRI does not require any special preparation, only good normal preparation for having best results. Having cattle trample the soil when it has been puddled both breaks up clods and forces air into the soil for later plant use.

Leveling the field is important but need not be as precise as when one is trying to maintain a uniform layer of water on the field. It is more important to ensure that the soil can be well drained, by constructing channels or furrows around sections within the field and around the whole field. Simply putting furrows in a fishbone pattern across the field does not evacuate water as evenly from the whole area. Keeping root zones moist *most but not all of the time* is the main requirement.

Taking Seedlings from the Nursery

Seedlings should be lifted out of the seedbed gently and WITH A TROWEL, rather than being pulled up. It is important that the seed sac remain attached to the infant root. Seedlings should be removed from the seedbed as one would cut sod for landscaping purposes. The sod cutting should then be moistened, and a single seedling (with two leaves) should be gently removed from the cutting with the thumb and forefinger.

When transplanting the seedling, the root should LIE HORIZONTALLY, so that the plant's shape (including the root) is like the letter L, with the root tip able to grow downward easily and quickly. Planting the seedling with a vertical motion, plunging it into the soil in a downward movement, is liable to leave the root tip inverted upwards. This will delay the root's resumption of downward growth, a delay that must be avoided if the plant is to reach its full tillering potential.

- Seedlings should always be transplanted from the nursery into the field within half an hour, and preferably within 15 minutes. The roots should never be allowed to dry out. They should also not be handled roughly or slammed or hit with the palm of the hand (as some farmers in Madagascar do before transplanting the seedlings).

Transplanting

To plant in a uniform square pattern, with regular spacing, one method is to use lines (strings or ropes) tied between sticks on the edge of the field, spaced 25 cm apart -- or 30 cm, or 40 cm, or possibly 50 cm if the soil is very fertile and well managed. The lines should be marked (or knotted) at similar intervals to match the width of the rows so that there will be uniform spacing that facilitates weeding. Or one can use a specially constructed simple "rake" that has teeth spaced the desired distance apart.

- Spacing is a variable to be tested and evaluated. It is usually best to start with 25 x 25 cm spacing, possibly increasing the distance between plants as farmers' gain skill and confidence, and as soil fertility is enhanced by compost.

An alternative is to use a special rake to score the surface of the field in a "grid" with a square pattern for planting seedlings at the intersections of the lines. Farmers find that this can be a faster method than using strings or ropes. Opinions differ as to whether this method of transplanting takes more time or not, and whether it is more difficult. At first it make take more time, but because so many fewer plants are put into the field, once some skill and confidence have been gained, SRI transplanting should be quicker. Some farmers have also reported that it is less arduous, with little or no back pain.

Farmers are often worried, when planting, about some seedlings dying. In fact, with SRI methods well used, we find very little mortality, maybe 2%, so that it is not worth the effort to replace them, as surrounding plants grow a little larger to take advantage of the open area. Farmers who are concerned should plant some seedlings along the edge of the field that they can transplant into any vacant spaces at the time of the first weeding.

Water Control

Little has been written about water application and management for SRI, possibly because there has been little systematic experimentation and evaluation of this. The importance of keeping the soil unsaturated to get more air to plant roots is evident. But how long can a field be left without water? How dry can they become? What is the role of rainfall in providing water for field? What differences in practice will be necessary with different kinds of soil?

The addition of water should occur on or about a week after transplanting, and then the first weeding (using the rotary hoe) should be done after soil is sufficiently moist, within the first 10 days. If there is intermittent rain, sufficient to keep the soil moist, no water additions are needed. The best time to add water is before the periodic weedings.

During the growth phase, roughly the first three months, water should be applied only to the fields for weeding purposes, being left to dry out even to the point of surface cracking. This will contribute to

soil aeration. This drying should be done at least 3 or 4 times before the phase of flowering and panicle initiation.

We find that an increasing number of farmers who practice SRI are following an *alternating* schedule for water application. Instead of trying to keep the soil continuously moist but aerated (well-drained), with some periods of complete drying, one can flood the field for 3-5 days and then drain it and keep it dried for 3-5 days. We do not have any research to show what is the best length of time for wetting and drying under such an alternating pattern of water application, and in any case, what is best for a particular field will depend upon soil texture and other factors.

- If farmers want to save labor, they may adopt such an alternating wet-dry schedule. We do not know whether or how much this might lower yield below an optimum with moist but aerated soil. We encourage farmers and others to experiment with different water application methods, noting what serves best the plants' growth needs.

The physical design of fields for good control over water -- drainage as well as inflow -- needs to be considered, matching design to soil, water and topographical conditions, as well as methods for getting greater aeration of water, e.g., applying water to the field through a bamboo pipe that lets water fall onto the field. Farmers are encouraged to experiment with water management according to their understanding of the desirability of *ensuring aeration of the soil for better root growth*. Rather than recommend a specific schedule, we emphasize the principle for farmers to adapt to their needs.

Weeding

The justification for this has been discussed already, but the techniques need to be made clear. How does one use the weeder to get best effect for both weed removal and for soil aeration? The practice of planting seedlings in a square pattern (25 by 25 cm or wider) permits weeding in both directions, up and down rows and across them. This should be done until the growth of plants' canopy makes it difficult to pass the weeder between them.

We can show the benefits of weeding from the resulting yields for farmers using SRI in Ambatovaky during the 1997-98 season, comparing yields with the number of weedings done. Under the growing conditions in that community (high elevation, well-drained soils), there were dramatic benefits from doing more than two weedings, adding about 2 tons/hectare for each additional weeding. Two farmers did no weedings and got 6.0 tons/ha.; eight farmers did one weeding only and got 7.7 tons/ha.; the 27 farmers who did two weedings got about the same (7.4 tons/ha.). But the 24 farmers who did three weedings averaged 9.1 tons/ha., and the 15 farmers who did four weedings got 11.8 tons/ha. This information gives justification and encouragement for doing more than the minimum recommended number of weedings.

Pest and Disease Control

Pest and disease problems appear to be less with SRI methods, perhaps because the fields are kept less humid. It is known that healthier, more vigorous plants have more capacity to resist pest and disease attacks. Farmers in Bangladesh, Cambodia, the Philippines, Myanmar and Sri Lanka, as well as Madagascar, have reported fewer pest and disease problems with this method, making use of agrochemical not necessary or economical. More needs to be known about how farmers using SRI can best deal with any pest or disease outbreak affecting crops.

Management after Flowering

SRI focuses most of its efforts on getting the rice plants well established in the soil and on encouraging their active increase of roots and tillers during the vegetative growth stage. The water management strategy changes once flowering begins, with a thin layer of water (1-2 cm) being maintained continuously on the field, though there can be some interruptions in this. It is recommended that farmers drain their fields about 25 days before harvesting, to let the soil dry out and encouraging the plant to transfer as much of its nutrient supply to the grains as possible. Some scientists think draining should come later than this. Farmers are encouraged to experiment to see what works best for their soil and other conditions.

Harvest

SRI rice is harvested just like any other rice, except there should be much more rice to harvest. This makes the farmer's task more difficult, but this is the kind of difficulty everyone should wish for: a bountiful harvest. Some farmers find that the way rice grows with SRI management makes harvesting easier. For one thing, there is almost never any lodging, even with larger panicles. Also, the panicles are easier to collect off the plants.

Experimentation

Throughout the whole process, farmers should be observing their rice crop and their rice field carefully, looking for any signs of stress or poor growth. Farmers should feel free to make some adjustments in practices like timing, spacing, soil preparation, weeding, or to try any other thing they think might give their rice a better chance to grow vigorously. Innovations should be tried first in small areas rather than for the whole field.

One of the main things that needs to be evaluated by each farmer according to his or her particular field conditions, is the *spacing* of the rice plants. What density of rice plants per square meter will produce the best total yield from that area will depend on the farmer's soil, on temperature and climatic conditions, as well as the variety of rice used.

We suggest starting with plants set out in a square pattern 25 by 25 centimeters. Sometimes wider spacing is more productive (even with fewer plants) depending on soil structure, nutrient and drainage conditions. Sometimes narrower spacing produces more total rice, though probably plants should not be closer than 20 by 20 cm, or 25 x 14 cm. Enough space must be left for the weeder to be passed up and down the rows between plants in both directions. With good soil and water conditions, very wide spacing is likely to be most productive -- 40 by 40 cm, or even 50 by 50 cm.

Farmers are also encouraged to experiment with different *varieties* of rice. Sometimes certain improved varieties respond very well to these management practices, but sometimes, under other conditions, certain local varieties will produce more. We have seen some varieties such as x265 and 2067 perform very well at higher elevations (over 1,000 meters), producing 11 to 12 tons per hectare. But when these varieties are planted at lower elevations (400 to 600 meters) just 20 to 25 kilometers away, their yield may be only half or a third as much. (Variety 2067 produced rice at a rate of 21

tons/hectare for the farmer Ralalason in Soatanana, Madagascar, who used all of the SRI methods to their best advantage, including excellent compost, applying 5 tons to his 1/8 hectare. He applied it to the vegetable crop that he grew between rice crops, so it had a long time to decompose.)

- Farmers can often get a *much greater return from their land and labor* if they can find one or more varieties that are very well suited to their growing conditions. This requires experimentation and evaluation by farmers and will be more efficient if a number of farmers cooperate in evaluating varieties. If a large number of them operating rice fields under similar conditions test many different varieties, they can usefully share information about their experience with each.

LABOR REQUIREMENTS

One of the main reasons cited by farmers and others for not adopting SRI methods is that SRI requires more labor. This is true in the sense that any *intensification* will require more work and certainly more management effort. However, the increased labor requirements for SRI are not simply a matter of needing to invest more labor, and in some respects, farmers will find that SRI requires *less labor*. In fact, some Sri Lankan farmers now report that SRI requires *fewer days of labor per hectare* than their conventional methods, which include time for spraying their fields with insecticides, no longer needed.

First, when any new method of production is used, there is some time required for *learning* how to use the method correctly and quickly. Some of the increased labor needed for SRI is simply a matter of learning time. This is an investment that should be repaid within the first season.

- One study of SRI labor requirements found that it required about two-thirds more days of labor per hectare when using the methods in the first or second year. But after farmers had become better acquainted with the methods, and had become more comfortable with them (particularly the transplanting), the labor requirement dropped by about one-third, so that SRI required only about 25% more labor per hectare. A more recent study with 108 farmers in Madagascar who used both SRI and conventional methods on their farm found that the difference in labor requirements for SRI was 25% greater. *Since yields with SRI were at least doubled, the amount of rice produced for each day of work invested was increased greatly.*
- The field preparation is essentially the same for SRI and usual methods of production. As the nursery is much smaller, there can be a saving of time on this part of the process.
- The amount of time initially spent in setting up a field for planting with SRI is greater, as lines need to be laid out for planting seedlings in rows carefully and well-spaced. Although the amount of time spent for putting each seedling into the field is several times greater, there will be many fewer seedlings to be planted. *The number of seedlings transplanted with SRI is only one-tenth as many as with conventional planting, and possibly even fewer if wider spacing is used.*
- Once farmers are skilled in organizing SRI transplanting -- which requires a handful of seedlings for a field where before a headload full of seedlings was needed before -- *the transplanting may take no more time or only a little more.*

The biggest difference in terms of labor required is for *weeding*. But doing the minimum of two weedings with a weeder take little more time than two hand weedings -and this work is much less difficult and tiresome than bending over to pull up weeds. Some farmers consider weeding for SRI to be easier than with traditional methods.

- How many weedings a farmer will do beyond this minimum is for each to decide for himself or herself. Farmers should experiment to see how much increased yield they get from doing additional weedings. We know some farmers who have been able to get one ton or even two tons more rice from each additional weeding.
- There can be a *very great return* from the labor invested, worth 10 times and even 20 times more than the cost. So each farmer can decide for himself or herself how much effort to invest in raising his or her production.

One big difference in labor requirement between SRI and conventional rice production can be for *harvesting* because yields are so much higher. But no farmers complain about having to bring in more rice from their fields and thresh it, since this means that the household will get much more benefit from the labor they have already invested. Also, because the panicles are bigger and sturdier, with less dropping of rice, some farmers find that harvesting even for a larger volume of grain is easier with SRI.

One study of SRI experience on the west coast of Madagascar found that for farmers who were reasonably acquainted with the methods, using them required about 500 hours per hectare. Given the prevailing price/cost of labor, an increase in yield of 500 kilograms per hectare, at low harvest-time prices, would repay the extra labor. Average yield increases with SRI were about 2,000 kilograms per hectare. If the farmer could wait to sell his rice for three months, when the price had gone up, yield would need to increase by only 250 kilograms per hectare to cover the increased labor cost, producing 2,000 more kilograms per hectare. (The reference is to research by Frederic Bonlieu during the 1998-99 season.)

Some farmer households will not have enough labor to be able to cultivate the full extent of their rice fields with SRI methods. In this situation, they should experiment with SRI on a small area to satisfy themselves that this technique will increase their production by a substantial amount. We suggest that they then cultivate *only part of their available fields* with SRI, reserving the rest of their land for growing other crops at some other time when they are not limited by the amount of labor time available.

- If farmers can get *much greater returns* from their land and their labor by using SRI methods, it is a waste of their land and their labor to continue cultivating the whole extent of their fields with less productive methods. It will be more profitable to cultivate just part of their land with SRI methods, and then to grow other crops on the remaining land when time permits.
- If there is a particular operation for which a farm household does not have enough labor to use SRI methods, it will be worthwhile to hire additional labor to assist with this operation. If the household does not have enough money in hand to hire labor, it can offer to share the greater harvest with those who provide labor or to pay for the labor with rice after the harvest rather than with money.

Farmers should not let labor limitations keep them from experimenting with and using SRI methods. There should be some way that they can benefit from this new technology by making the kinds of arrangements described above. SRI is one of the few technologies that can increase simultaneously the productive of land, of labor, and of water. The goal is not so much to increase yields by several times as to make all of the factors of production more productive, so that farmers can get more return from whatever resources they have, starting with labor.

CONCLUSIONS

SRI was developed by Fr. de Laulanié with farmers as friends and as students. Their purpose was to improve the quality and security of life for all people in Madagascar who depend on the soil for their livelihoods. Others will also benefit if rice can become more abundant and available at a lower price.

The essential initial step toward success with SRI is to *think about the rice plant in a new and different way*. The previous ways of understanding and cultivating rice have served millions, even billions of people well for many centuries. But with some new management practices, it will be possible for farmers to get *many more grains of rice returned for every grain they plant* by doing this carefully and by providing better conditions for the growing plants.

There is now experimentation going on to adapt the concepts of SRI to growing upland (unirrigated) rice. One initial experiment at Zahamena, not using fire as an agricultural practice, produced *16 times more grains of rice per rice seed planted* -- double the yield with only one-eighth as many seeds -- as with traditional slash-and-burn production. During the 1997-98 season, some trials were undertaken adapting SRI methods to upland conditions. By using compost instead of burning, and by planting seeds widely spaced, 30 by 30 cm, with leguminous plant cuttings (tephrosia and crotalaria) used as a *thick mulch* to suppress weeds, unirrigated fields yielded 4 tons/hectare. The mulch conserved water in the soil as well as suppressed weeds, almost totally, and provided some additional nutrients. We think that other crops may also be able to benefit from drawing on these concepts for improving plant growth.

FOR MORE INFORMATION ON SRI

Association Tefy Saina is a non-governmental organization established to improve agriculture and the human condition in Madagascar. Tefy Saina, which was established by Malagasy colleagues of Fr. de Laulanié, has been promoting and evaluating SRI in many different parts of the country since 1990 (B. P. 1221, Antananarivo; Tel: 222-0301; e-mail address is: tefysaina@simicro.mg) Please address inquiries to: Sebastien Rafaralahy, President; or Justin Rabenandrasana, Secretary.

The Institute de Promotion de la Nouvelle Riziculture (IPNR) based in Antananarivo is also involved in experimentation and demonstration of SRI and is another source of information on SRI (B.P. 8417, Antananarivo; Tel/ Fax: 227-8660; e-mail: ipnrg@simicro.mg) Patrick Vallois is the director of IPNR.

The Cornell International Institute for Food, Agriculture and Development (CIIFAD) has been working with Tefy Saina since 1993 and cooperating with IPNR since 1997 to achieve a better

understanding of this new method for increasing rice production. CIIFAD can be contacted in Ithaca, New York, through its director, Norman Uphoff (Tel: 01-607-255-0831; Fax: 01-607-255-1005; or e-mail: NTUI@cornell.edu), or through CIIFAD's representative in Madagascar, Glenn Lines (e-mail: GAL@chemonics.mg).