A very productive System of Rice Intensification (SRI) is being developed in Madagascar. Over the past four years, some hundreds of farmers around Ranomafana have increased their irrigated rice yields from 2 tons/ha to up to 8 tons/ha and more. Instead of relying on the 'Green Revolution' recipe, which they could scarcely afford, they have followed innovative soil, plant, water and nutrient management practices. They continued to use their own seeds and compost and even though these intensified management practices costs them 40-65% more labour, they had a very high return.

Justin Rabenandrasana

The system was developed in 1983 by the late Fr. Henri de Laulaníe, who observed a strong increase in tillers and yield after an accidental early transplanting of rice. He went on to combine early transplanting with other practices that provided an optimal rice plant environment. In 1990, Fr. de Laulaníe helped to establish Association Tefy Saina (ATS), a NGO to promote and improve SRI in Madagascar.

photo: Association Tefy Saina

Close-up of well-developed rice plant

Revolution in rice intensification in Madagascar

Basic principle: strong plants

With SRI, practices are followed that make a positive contribution to increasing production and, by combining them, production is increased still further. The success of SRI is based on the synergetic development of both the tillers and roots. With a more vigorous root growth, plants can become fuller and taller, and get better access to the nutrients and water they need to produce tillers and seeds. With more growth above ground to carry out photosynthesis, more energy is available for root growth and the stronger the plants, the more resistant they are to attacks by pests and diseases. In Madagascar, where soils are deficient in nutrients, a dense and extended root system gives plants many advantages.

Capture full potential for tillering

One of the "tricks" in SRI is that it capitalises on an in-built pattern of development in rice that had been identified many years ago by the Japanese researcher T. Katayama. He studied the patterns of growth and development in rice, wheat and barley and found that these plants put out tillers in a regular sequential pattern. In rice, each tiller produces another tiller two phyllochrons later (a phyllochron is an interval of plant growth, usually about 5 days but it can be longer or shorter depending on temperature and soil conditions). When soil and other conditions are favourable, the rice plant can go through as many as 12 phyllochrons (or more) before it moves from the vegetative growth phase to the reproductive phase (marked by panicle formation and flowering). The number of tillers can increase exponentially with as many as 84 or more forming on a single plant. The full potential for tillering can be captured by:

Early transplanting

Transplanting after the fourth phyllochron begins (after 12-18 days) sets back the growth momentum of rice plants so that their full potential for producing tillers, roots and grains is not achieved. If the 10th through the 12th phyllochrons of growth does not materialise because of late transplanting, 75% of a rice plants' potential tillering is lost. If transplantation is done poorly and the first two tillers get damaged, one cannot expect more than 16 tillers to grow. Transplantation should be carried out carefully and early, about 8 to 12 days after sowing when the seedlings have only two leaves. It should be done very soon after removing the seedlings from the seedbed and within 15 to 30 minutes after the tiny plants have been gently uprooted. The tiny roots should be placed horizontally in the soil so that the tip of the root can easily resume its downward growth. In this way the leaves of the seedlings will not become yellow and the plant will start to grow again within a few hours. The plants have time to adjust to their new environment before the first tiller starts to grow.

Planting one by one

If two, three or more plants are transplanted together in a clump, competition among their roots limits tillering to 5 per plant at the most. The close planting common in traditional rice cultivation could be considered anti-tillering rice cultivation. To enhance the development of roots and tillers and minimise competition between plants, seedlings are planted one by one in SRI.

Wide spacing

Farmers often believe they can boost their yields by planting rice more densely with 50 or more than a 100 plants per square meter. However, wider spacing encourages more rooting, more tillering, and more grain filling. In SRI, spacing follows a square pattern of between 25x25cm and 50x50cm. In this way a considerable amount of seed can be saved. In SRI, 5 to 8kg of seed is sufficient for one hectare of transplanted rice, whereas in Madagascar it is quite normal to use

100 to 200kg/ha. Rice plants grown under SRI management have between 50 and 80 tillers and routinely produce 150 to 200 grains or more per fertile tiller.

Capturing full root growth potential

For centuries rice farmers have kept their paddy fields inundated when their rice is growing. In this way they suppress weeds and reduce the amount of labour needed. This lead farmers and scientists to believe that rice plants benefit from being continuously flooded. However, rice is not an aquatic plant, and although it can survive with its roots submerged it does not really thrive. During its reproductive phase, when plants go through flowering, panicle initiation, grain filling and maturation, maintaining 1 to 2 cm. of water on rice fields has a beneficial effect. But during the preceding growth phase, rice plants grow better in unsaturated soil. The reasons are simple. When there is no standing water and there is air in the soil, the roots can acquire oxygen much more easily through the *aerenchyma* (air pockets) in the root cells. Lack of oxygen in the root zone leads to soil acidification that causes the destruction of *aerenchyma* and hampers nutrient up take, assimilation and plant growth. The nitrogen cycle in the soil is disturbed as well, and all kinds of toxicity will develop. Scientists from IRRI have identified the problems caused by anaerobic decomposition in continuously irrigated rice systems as one of the main causes of yield decline (Pingali et al, 1997). The full potential for root growth can be captured by:

Alternative wetting and drying of the field modifies the growing environment of rice: improves soil structure, gets more oxygen into the root zone, and enhances active soil life. As the soil dries air replaces water and when it rains or irrigation is applied this air is pushed downwards. Periodic water stress and the availability of oxygen facilitate root growth, and the volume of soil penetrated by the roots increases. In rice production, an effective drainage system to evacuate excessive rainfall and irrigation water from the field is as important as the irrigation system itself.

Minimum irrigation

At the beginning of tillering, there is still not much vegetative growth and the plant only requires a small amount of water. When the root system has been developed, 3 or 4 days of superficial dryness should not cause alarm even if some cracks develop in the field. During growth irrigation will only be needed if rainfall is inadequate and then should be applied in moderate amounts and at favourable times - preferably at night. In this way, irrigation requirements can be reduced by up to 50%.

Early and frequent weeding

Whatever the crop, early weeding is always important for a good return. In rice paddies, where traditional methods are used, hand weeding is usually done one and a half months after transplanting. This is far too late for two important reasons. Not only are weeds replacing half the expected harvest by this time, but farmers also loose the opportunity to bring oxygen into their soil. Aeration of soil by weeding may be even more important in rice cultivation than the removal of weeds. With SRI, simple mechanical push-weeders are used and these churn up the soil. In Ambatovaky, the community near Ranomafana where SRI has been adopted most enthusiastically, 75 farmers experimented with weeding during the 1997-98 season. The two farmers who did not do any weeding got almost 6 tons/ha; the 35 who did the recommended minimum of 1 or 2 weedings averaged between 7 and 7.5 tons/ha; while the 24 who did three weedings averaged 9 tons and the 15 who did four weedings averaged over 11 tons. This showed how early and frequent weeding is very important in enhancing the development of the root system and the entire rice plant. The extra labour needed for additional weeding more than pays for itself at harvest time.

Application of compost

SRI was first developed in the 1980s using chemical fertiliser. But after the price of fertiliser skyrocketed in the early 1990s, Fr. de Laulaníe began experimenting with compost. He used cattle manure where this was available, but mostly he used any sort of decomposed biomass, including rice straw. Cuttings from leguminous plants and shrubs proved particularly beneficial. He found that using organic sources of nutrients could help achieve levels of production that could not be obtained using conventional practices. In the north of Madagascar, a private company conducted trials to determine the best levels of chemical fertiliser for rice. It reported achieving average yields of 6.2 tons with modern methods and seeds. At the same time 27 farmers using SRI in the same area averaged 10.2 tons/ha.

It is still uncertain how and why these high yields are possible on such poor soils. Around Ranomafana, pH values are between 4.2 and 4.6 with extremely low levels of exchangeable bases [Ca, Mg and K] and phosphorus levels that average between 3-4 ppm, which is considered very deficient. Possibly this can be attributed to the large volume of soil penetrated by roots and the high activity of soil-life brought about by aerobic soil conditions and organic fertilisers.

Approach not package

In the past 10 years, SRI has been used with similar success in many places in Madagascar and under different production conditions (elevation, temperature, soil types). Currently, SRI is being promoted by several development programmes. The University of Antananarivo's *Ecole Superieure des Sciences Agronomiques* (ESSA) has supported field studies to evaluate and analyse the method. The Cornell International Institute for Food, Agriculture and Development (CIIFAD) has been working with ATS since 1994. Outside Madagascar interest in SRI is growing and SRI as a methodology is still being evaluated. ATS insists that it be treated as an approach, a strategy, even a philosophy, rather than a "package". It is the combination of practices that is important, more than any specific single method. These practices need to be tested and, if need be, adapted when introduced to new environments.

Even if such high increases in yields cannot be obtainable everywhere because of constraints such as water control, substantial gains in rice production should be possible by applying SRI insights and practices. By mobilising the experimental capacity of thousands of farmers to adapt the technology to different conditions, SRI could become one of the most beneficial innovations in agricultural practice this century.

From: oral presentation by ***Justin Rabenandrasana****, Association Tefy Saina*
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Additional information came from:
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- **Association Tefy Saina** (ATS), B. P. 1221, Antananarivo 101, Madagascar (only in French).
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photo: Association Tefy Saina