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Intensive Rice Farming in Madagascar

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Summary

The paper describes a technique set up in Madagascar for rice production. It is based on irrigation with a minimum quantity of water and the transplanting of very young seedlings (from 15 to 10 or even 8 days) set individually (no tuft). The spacings vary according to local conditions, from 25 x 25 cm (at 1200 m a.s.l.) to 40 x 40 cm at sea level. Yields went from 2 tons paddy per hectare to 8 or even 12 tons with local varieties. Varieties obtained by selection were not more productive than the local ones under rural production techniques in the country.

Résumé

Le système de riziculture intensive

L'article décrit une méthode mise au point à Madagascar qui a fait ses preuves depuis une quinzaine d'années en riziculture irriguée. Elle repose essentiellement sur une irrigation avec un minimum d'eau et sur le repiquage de plants très jeunes (de 15 à 10 voire 8 jours) et individuelle (pas de touffe). Les écartements varient selon les conditions climatiques locales et vont de 25 x 25 cm (plus de 1200 m d'altitude) à 40 x 40 cm au niveau de la mer. Les rendements sont ainsi passés de 2 tonnes de paddy par hectare à 8 voire 12 tonnes avec les variétés locales. Les variétés sélectionnées n'ont pas montré d'avantages dans les conditions de cultures locales.

Introduction

The present paper is the results of applied research in rice farming in Madagascar. The common practices, which varied greatly depending on the region, were based on slogans such as "water is food to rice" or "water fertilizes the soil". Moreover most farmers believed that the success of the harvest had more to do with the ancestors' and the Creator's good will than with farming practices.

Because of the author's initial technical incompetence and thus absence of conventional ideas, two facts became obvious very quickly: Rice is a plant with high tillering potential, and good harvests are linked to good soil aeration. Transplanting one by one three-week old plants coming from sparsely seeded nurseries and practicing systematic drainages, particularly during weeding, caused the harvest to double without even changing the manure or the cultivated varieties.

In November 1983, a nursery located at 1,500 m altitude, near Antsirabe, and which could not be enlarged in time, was supposed to supply the seedlings to be transplanted in rice fields that had doubled in size. As a result, two waves of seeding were carried out in one month, and the seedlings were transplanted at 15 days. This was an unprecedented practice, at least at this altitude, but the result was such that this exceptional practice became the rule. As early as 1984 two-week old seedlings were sold to rice farmers from the plateau.

Madagascar is located between 12° and 24° latitude south and 45° and 49° longitude east, 40 km off the African coast. The total surface of the country is 587,040 km², of which 5% is arable land and 58% is pasture. The population was 11,240,000 inhabitants in 1988, and the national gross income totaled $ 210. The central plateau has an average altitude of 1,200 m and is characterized by a dry tropical climate (average temperature 13°-19 °C, rainfall 1,000 to 2,000 mm per year, dry season from May to October). The coastal areas, the eastern side in particular, are hotter and more humid. The south is very dry.

Rice farming is very important as Madagascar ranks 5th in the world in terms of per capita consumption – 136 kg/year, or 0.375 kg per person per day. In 1990, according to FAO statistics, rice was cultivated on 1,150,000 ha with an average yield of 2,087 kg/ha, compared with 1,738 kg/ha in 1979-1981.

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Emerging system

Members of the group that had planted the first crop as well as some neighbors went further and transplanted 12-, 10-, 9-, and even 8-day old seedlings individually at increasingly bigger intervals in rice fields with light, aerated subsoil. The tillers increased from 20-25 to 60-80, and the yields rose proportionally.

To help rice farmers try the new system and check its possibilities, they were encouraged to keep their current varieties as well as their usual manure and to avoid using mineral fertilizers (very expensive in relation with the price of paddy). Within five years results indicated that previous yields – two or three tons per hectare, often less – were multiplied by two or three, quite often by four or five, and sometimes even by six or seven. These observations were all the more surprising that the quantity of seeds used previously were divided at least by three or four, but frequently by twenty or thirty. Besides the rice fields that used to be considered as very poor ended up producing harvests bigger than the traditionally very good harvests.

Until early 1988 no scientific explanation had been brought up to account for these results. Most often the staff working for the official services of rice farming education and research denied the results for the simple reason that these were claims from peasants and "helpers" who had "no education or scientific monitoring equipment". However they refrained from verifying those claims on the field and felt no obligation to take position. Fortunately this did not stop rice farmers from continuing their new practices.

The book by D. Moreau concerning the "analysis of rice yield" published by the GRET (Paris) in 1987 offers a first insight with "Katayama's tillering model" – named after the Japanese researcher who established this tillering model before or around 1960. Two years were necessary to transform this tillering model into statistics that could be analyzed mathematically. The rice physiology made it clear that very young seedlings needed to be transplanted in order to have many tillers. A scientific truth had finally come to light.

A seminar held in Tananarive in December 1991 and focusing on rice cultivation in low-lands helped to explain why the SRI (*Système de Riziculture Intensive*, or Intensive Rice Farming System) can find fertilizing elements in the soil that other systems cannot tap.

Less than ten years after its first set-up (April-May 1984 harvest), the SRI can be said to have grown into adulthood. It has conquered the high lands of Madagascar since it has been declared the official rice farming system in June 1982 and its mission is to bring the country to self-sufficiency by 2000. Rice farmers are still enthusiastic, and application tests have started on the coasts where the climate is warm and tropical.

SRI and Rice Farming around the World

Until 1972 rice farming research was carried out in Madagascar but without being very much advanced. The Research Institute in Tropical Agriculture pursued research mostly in the area of mineral fertilization. From 1972 on the agricultural research in Madagascar, just like scientific research in general, was choked. Many French researchers left and the Madagascans who wanted to work with a minimum of freedom – theoretical or practical - went into exile while a heterogeneous yet greedy Nomenklatura seized the power and obliterated all previous progress. All the financial efforts consented by international organisms failed due to embezzlement of all kinds and at all levels of power. There ensued a time of nearly total isolation from international research for those who worked at national level, and even more so for those cooperating with peasants.

Today, as soon as SRI is mentioned, the answer is automatic: "Your system is well-known and used around the world. Katayama's model has been the focus of articles since the 1960's. In fact it has become outdated and has been improved by Japanese researchers. Today the IRRI (International Rice Research Institute) has become the world leader in rice farming research. You need to address this institute if you wish to be updated in this sector."

The IRRI has a branch in Madagascar and is aware of SRI's existence. Unfortunately many prominent international experts read only superficially the documents that are submitted to them – whether by lack of time or because they do not think that major progress in agriculture can be initiated by simple peasants.

Therefore the reader is encouraged to follow very exactly the precise instructions given below before judging and criticizing them. Thus, transplanting shoots one by one means that every rice plant that has been transplanted comes from a single paddy seed. If two paddy seeds, and thus two plants, are transplanted at the same time, this is not SRI. "How important is this? If one dies, the other one will take over. In fact that advice is given by Vergara in the rice farming practical manual from IRRI." Although that book is full of good advice and Mr. Vergara is very competent, the SRI contradicts him on several points as can be seen from many rice fields in Madagascar by whoever wants to look and see without preconceived ideas.

First let's compare scientifically the transplanting of very young shoots (eight days after seeding), one by one and at great intervals (less than 20 per m^2) with any other system, all other things being equal and under the condition that the rice field soil be permanently aerated.

Presentation of the system

The first essential condition for SRI to be successful is to apply minimal water irrigation. The rice plants must have all the water necessary for their physiological and nutritional maintenance, but nothing more. “Saturating” water, i.e. water that stays in the ground without being fixed and that runs off because of gravity whenever possible, is unnecessary and even harmful as it can prevent roots from accessing the oxygen from the air. The ideal irrigation is rainwater, because it fills up with oxygen as it crosses the atmosphere and it pushes even further into the rice field the air oxygen that had found its way into the loose soil. In order to be defined precisely this minimal water irrigation should be studied scientifically.

As a matter of fact the tables concerning the water needs of rice that are found in manuals are quite insufficient. Rice is indeed a very plastic plant, which can resist a 24-hour (and more) total immersion in water as well as several day-long droughts. In the case of parasites, the farmers themselves should consider whether to flood the field in order to eliminate the latter or not depending on the risks linked to present parasites and those due to flooding the field.

The second crucial condition for successful SRI is transplanting very young seedlings one by one. The distance between seedlings seems to depend on the temperature. Apparently the soil quality does not play an important role, maybe because tillering allows roots to explore greater soil volumes and thus to ensure better plant nutrition.

To date no difference between varieties has been noticed despite such statements in the literature, but this does not mean that future differences might not appear with a more precise technical follow-up. Above 1,200 meters of altitude (1,500 m at the equator), the novice SRI rice farmer is advised to transplant seedlings at a distance of 25 cm X 25 cm, which makes 16 plants per square meter, and 160,000 per hectare. At 25 g per thousand seeds (very often exceeded in Madagascar) this makes 4 kg of paddy used and roughly 5 kg seeded in a nursery for 1 hectare. At 30 g per thousand seeds, 5.5 or 6 kg are seeded in nurseries. Later on the rice farmer should plant every 30 cm X 30 cm (11 plants per m^2) or even every 33 cm X 33 cm (9 plants per m^2).

At sea level, in hot tropical climate, 30 cm X 30 cm spacing is required, especially in summer, but the farmer can even try 40 cm X 40 cm spacing (6.25 plants per m^2). To obtain 600 panicles per m^2, 40 tillers are needed on average with 16 plants, 55 tillers with 11 plants, and 70 with 9. Vergara’s manual recommends 350 panicles as maximum.

No fear need arise concerning the rice ears as the panicles are thicker and the seeds heavier with SRI than traditionally. This is the reason why each plant needs to be transplanted one by one to avoid competition and to help each and every seedling to use up its nutrients for production. In SRI tillers do not regress, but each plant regulates the number of panicles it can grow.

Using very young seedlings is required because of the phyllochron, which is the time interval separating the successive emergence of two leaves on the same stalk. In Madagascar the phyllochron is estimated at 5 days at sea level, 6 days at 750 m altitude, and 7 days at 1,500 m altitude for precocious varieties. The first leaf emerges out of the coleoptiles 4 to 7 days after germination depending on temperature conditions.

The first tiller from the first level, out of which a third of all tillers will grow, emerges after 3 phyllochrons, i.e. about 19 to 28 days after germination. Crucially the growth of the first tiller should not coincide with a traumatizing event, such as transplanting the shoot or even – though this is less obvious – weeding. Thus we believe the deadline for transplanting corresponds to the end of the second phyllochron, about 14 to 21 days (depending on the phyllochron length) after sowing and hence 11-12 to 18 days after seeding in the nursery. However the younger the seedling, the faster it recovers from transplanting (healing of wounds, replacement of root elements left in the soil, rebuilding of plant reserves necessary for first tiller growth).

The physiological trauma induced by transplanting and its recovery have not been studied thoroughly. Consequently one ought to transplant rather too early than too late, and the experience of workers on the field confirms this. This explains also why late transplanting (in SRI) can lead to excellent results, if the transplanting was done with great care.

Complementary techniques

In our opinion SRI as such is restricted to the very two techniques described earlier. The following techniques are not essential, but SRI followers choose them almost spontaneously because they consolidate the results of the system.

A traditional technique from the mountains of central Madagascar, the **garden nursery** consists in seeding pre-germinated paddy on a garden plank (or the equivalent) and watering it every night. The seed is covered with a thick layer of matter that holds back humidity and protects against temperature variations. There is no consensus whether this nursery needs to be fertilized. New studies should be carried out to examine the rice plant’s progressive autonomy from the seed during germination. More importantly, however, this nursery can be started anywhere, to the extent that it is well cared for and protected. The seeding density can reach 5 to 10 kg per are, with 7 to 8 kg being a good average. As a result, half an are to one are of nursery is sufficient to transplant one hectare of SRI paddy.

Transplanting **“fully dressed” seedlings** is another technique. Increasingly the soil of the seedling bed – up to 4 or 5 cm thick – is taken with the seedling and transported to the field where the seedling is

transplanted with the soil of its bed. The transplanting is done in sticky mud. Very skilled rice farmers might be able one day to use a dibber, but it has not been the case yet.
A first round of **early weeding** is recommended one week after transplanting and must be continued every week until the field has not been covered. The rice field will be all the cleaner if it has been prepared with care (stomping). Instead of the traditional rotary plow, farmers use a forked hoe, which is cheaper and closer to gardening equipment.

Some trouble spots
SRI brings less trouble to the rice farmer than can be thought at first sight. It requires more care but fewer efforts. Nurseries are four- to six-fold smaller. The seedlings are light and do not weigh much in the hand. The well spaced transplanting requires fewer seedlings.

Square or rectangular transplanting however is a real difficulty. It must be done either with a row marker or with a system of ropes and marking.
Mechanical weeding in both directions can suppress completely the need for manual hoeing, except during jointing (Echinochloa, Carex, etc).

Leveling. Previously rice fields were easily leveled within a 5- to 10 cm- range. The thick water cover concealed the differences. However a more precise leveling is required when only one or two centimeters of water are used – outside drainages – in order to get the best use of rainwater, although this has not become mainstream among Madagascar rice farmers.

Controlling water also means that valleys need to be drained differently than with irrigation canals. The water must arrive directly to each parcel and not flow from one plot to the next. Although this was an old recommendation, it was never put in practice. SRI demands it, and this will be beneficial in any case. Draining during the whole vegetative period is an important element for roots to oxygenate. Channeling water during the reproductive season depends more on climatic conditions and needs to be studied.
Finally **strict management** and **continuous attention** are vital. This is the big revolution. The time is gone when rice farming was a haphazard job, when rice fields overflowed, when they were weeded one to two months late, transplanted carelessly with tufts ranging from 2 (very rarely) to 10 or more per m^2, and spaced variably depending on the transplanting machine. As far as transplanting depths were concerned, these reached very often 8 cm in high altitude rice fields although they were claimed to be only 2 to 3 cm deep. Such practice is no longer possible with 3- to 6-cm seedlings.
SRI is as much a revolution in farming methods as a cultural revolution in the rice farmers' minds.

Problems to be solved
Naturally some problems have yet to be solved in SRI, as in other systems. The ones described hereafter are often mentioned by specialists as well as practitioners. Discussing them will help circumscribe what SRI is.
SRI and dapog nurseries. Dapog nurseries are traditional in the Philippines and consist in seeding at high density (20,000 seeds per m^2) banana leaves (or plastic sheets) covered with humidity-retaining material. They are named after the Philippine tribe that uses this technique habitually.
The SRI garden nursery is similar to the dapog nursery in that seedlings are watered every day, they are transported directly to the rice field with the surrounding soil, and they are transplanted at a very young age. However seedlings in SRI are transplanted one by one whereas dapog seedlings have entangled roots and thus are transplanted in clumps. Dapog seedlings that would be transplanted one by one at the same age and with the same spacing would be considered SRI. The entangled roots would likely make the transplanting operation more difficult than with the garden nursery.

Direct planting of pre-germinated seeds
Nothing really prevents the farmer from transplanting pre-germinated seeds instead of very young seedlings; it would mean in fact transplanting at the earliest possible age. However this operation runs into practical problems. The seeds have to be sorted out after germination to remove those that have not germinated – a possible yet time-consuming and even tedious stage for some individuals.
Putting in the ground the seeds collected from the previous operation and maintained under proper humidity conditions turns out to be difficult. When few-day old seedlings are transplanted with the soil around their roots, they remain close together thanks to the dirt clump while easy to identify thanks to the budding green leaves. The body bends in a similar way when a seedling or a seed is put in the ground, but the latter is less easy to keep in the palm of the hand. Once it has fallen, the seed is hard to spot in the mud of the rice field. Moreover when the operation is stopped accidentally and can be resumed only after some time, the farmer will have more trouble in identifying the last spot that was seeded than when a shoot – even as little as 3 cm long – is apparent.
Another objection regards the delay in weeding due to the difficulty in seeing the planted lines. Consequently the rice fields need to be prepared more carefully and weeded more thoroughly. At that moment putting in the ground pre-germinated seeds at regular intervals would likely be the most efficient system to produce very

high tiller rates and, with total watering control, record yields. In countries with high mechanical technology, among which countries with Mediterranean climate, high precision seeders should be designed to plant one by one the pre-germinated seeds. The remaining obstacle would be sorting out the pre-germinated seeds mechanically or electronically.

Applying SRI in rainfed rice fields

The seeders described in the previous paragraph would be more suited for rainfed than for irrigated rice farming. SRI, on the other hand, can be used without problems in rainfed rice farming in two situations: The first one requires regular and sufficient rainfall for a month and a half, until the rice plant roots are deep enough to resist a period of drought. The second one entails an irrigation system capable of compensating insufficient rainfall for the same time lapse. The latter situation is hard to apply in Madagascar countryside, but the first situation could be possible on the east coast provided that rainfed SRI be integrated in a farming system with improving pulses protecting against erosion and maintaining fertility.

Selecting cultivars

The SRI practice in Madagascar for the last eight years has not indicated so far that the selected varieties are superior to the traditional ones. In altitude there is only one rice harvesting season, and phenomena of photoperiodism can be observed, but their impact is low. The so-called "early rice" is seeded in April – May and transplanted in August – September, but it is found almost always in rice fields with no water control, which are unfit for SRI. The priority in those paddies is to harvest the rice before the rain season's floods (from late December to early January).

Surprisingly all varieties, traditional or selected, responded to SRI similarly, with yields reaching over 10 tons per hectare, without adding any mineral fertilizers. A natural selection will occur over time undoubtedly, particularly when fertilizing becomes a necessity to maintain such high yields, but this will take some time – 15 to 20 years. However problems occur quickly at low altitude, where double or triple harvests are expected: The traditional varieties, probably originating from Indonesia, are sensitive to photoperiodism as flowering is linked to the equinox. Those varieties follow a fixed yearly pattern, and other day-neutral varieties are necessary for the second and third harvest.

The high yields observed with local plants in fact contradict an article published in Madagascar in 1988, which stated that rice farming in Madagascar could not produce intensive results because of the absence of selected varieties that could bear such results.

This position is unfortunately often widespread although many examples are there to show that we need to master production techniques first before calling on to genetics. Improving the management and the methods leads almost always to increased yields, until a ceiling has been reached. At that moment selecting higher performance varieties makes sense, but these will develop their full potential only if the techniques have been totally mastered, so that mastering production techniques ought to be the first step. The name *Système de Riziculture Intensive* was chosen because it has used local as well as improved varieties (some of them present in Madagascar for over 20 years) with success.

The SRI projects were made possible thanks to the NGO Tefy Laina, B.P. 1221, 101 Antananarivo, Madagascar, whose aim consists in developing the Madagascar rural environment by training the men and women living in it.