The System of Rice Intensification (SRI) from Madagascar
Myth or Missed Opportunity?

Report on a study visit to the "Hauts Plateaux" region of Madagascar
(3 – 15 March 2003)

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Preface and Acknowledgements

The last few years I have been intrigued by the reports about the "System of Rice Intensification" (SRI) that originated in Madagascar during the 1980s. Starting in 1998, when still serving as interim Director of Research at WARDA in Ivory Coast, and following contacts with Dr. Norman Uphoff from CIIFAD/ Cornell University, I have at first tried to interest WARDA scientists in this subject. Later, when these efforts proved in vain, I started -with encouragement from my successor Amir Kassam- to conduct some exploratory field research at M'be. Next, during a second interim assignment at WARDA in 1999-2000, I pursued the topic further. The trials have shown some of the typical SRI features and provided some interesting information, but the spectacular grain yields as recorded by farmers in Madagascar, were never achieved.

The reason for this lack of response (in spite of the other positive features), and also why the system was not being adopted on a much wider scale in Madagascar, were questions that have continued to intrigue me. So out of scientific curiosity, I have –on personal title- established contacts with the people from the Association Tefy Saina (NGO) in Antananarivo, who together with the University were so kind to arrange a field tour from 3 to 15 March 2003. This field tour has covered both successes and failures in SRI, and therefore has greatly clarified to me both its potential and constraints.

My thanks for this extremely interesting visit are due in particular to Sebastien RAFAHALAHY (President of Tefy Saina) and his long-term collaborator Justin RABENANDRASANA (General Secretary of Tefy Saina), RAKOTOARIMANANA Dieudonné and ANDRIANAVALONA Fetra (field trainers of Tefy Saina) for their warm welcome and support. Crucial was also the support from Prof. Robert RANDRIAMIHARISOA from the Ecole Supérieure des Sciences Agronomiques (ESSA) of the University of Antananarivo in facilitating transportation for the field tour and for interesting discussions. Hopefully this visit and report will contribute to continued contacts and collaboration between us in the future.

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Executive Summary

This study visit has permitted a number of rather fundamental observations and conclusions. The potential of SRI in farmer fields was confirmed. However, there are substantial variations in the ways farmers implement the practices as well as in the agro-ecological conditions between fields (notably in the water regime and flooding risks), and therefore in the yields obtained. A major conclusion therefore is that we are dealing with largely empirical practices. Secondly, SRI is not a miracle practice that can be readily adopted by any farmer. It requires skilful farming, experience, and conscientious planning and implementation of the calendar of agricultural operations.

The implications are that there remain numerous questions to be resolved by research. First of all the basic agronomy of SRI still needs to be worked out from scratch, mainly because the water regime used (i.e. moist, aerobic soil conditions) is so totally different from the standard flooded practice. Secondly there are many fundamental issues related to eco-physiology and soil microbiology notably the possibilities for biological nitrogen fixation. Thus SRI offers exciting research opportunities, that potentially might greatly alter our perspectives about rice production systems and the optimum use of production factors in obtaining substantially higher yields than at present with the conventional methods.

The system of rice intensification (SRI) from Madagascar
Myth or Missed Opportunity?

- - modernise resolutely, but with wisdom, while safeguarding the best that you inherited; - - reject the type of modernisation that puts at risk the future of your off-spring and that would condemn a majority to misery - - (Henri de Laulanié, 1989)

1. Introduction

The System of Rice XIntensification (SRI) evolved in Madagascar during the 1980s under the guidance of Father de Laulanié and in close collaboration with farmers. In 1990, an NGO Association Tefy Saina was created to guide the further dissemination of the approach. In the period 1999 to 2001, a number of experiments were conducted by WARDA in Côte d'Ivoire to test the system's relevance for West African conditions, and to try to explain how the system functions.

The WARDA experiments have given interesting results, but the grain yields have always been far below (in the order of 4 to 6 tons/ha) those reported for Madagascar. The intriguing question is "Why?" Another intriguing question is: "If SRI is indeed so profitable, why is it not being adopted on a much wider scale by the farmers in Madagascar?"

The objectives of the present field study were to review and learn from Madagascar farmers and the Tefy Saina personnel involved about:
- local rice growing conditions (agro-ecological and socio-economic) on the Hauts Plateaux,
- what farmers might be doing differently and why, and
- why SRI is not being adopted more widely in Madagascar.

This report will start by considering mostly the bio-physical aspects associated with the "SRI package of practices" as observed during the field visits. From this, a number of conclusions are drawn about future research needs and about the potential for and constraints to the possible, large-scale adoption of SRI-type approaches. This leads to some observations on (national) agricultural development policies and on (national and international) research strategies that may permit the effective and wider exploitation of the assets associated with this "knowledge intensive", yet at the same time "low external-input type of technology".

2. Itinerary and organisation of the study

The study was conducted from 3 to 15 March 2003. A program of field visits was prepared by the NGO Tefy Saina in close collaboration with the University of Antananarivo (École Supérieur des Sciences Agronomiques). Some 15 farms were visited and the farmers ther informally interviewed in the regions around Antananarivo, Antsirabe and Fianarantsoa. Discussions were held with the University staff and students, as well as with the national agricultural research agency FOFIFA in Antananarivo. Results of the study were presented in a lecture to the students of the Laulanie Green University and at a debriefing session at the University. The detailed program of the visit is presented in the Appendix.

3. Background to rice farming on the Hautes Plateaux

Rice is the dominant food staple crop throughout the country; it is grown in all of the highly different agro-ecological zones ranging from sea level to 1600 meters altitude. Rice is consumed three times a day by a majority of the population, making it one of the highest per capita consumers of rice in the world (130 kg/person/year).

3.1. Agro-ecological conditions

The elevations on the Hauts Plateaux areas visited ranged from 1200 to 1600 meters. The area is rather mountainous, with fairly steep slopes and many valleys and often, wide flood plains that become inundated for shorter or longer periods of time during the rainy season. The slopes have become increasingly deforested for use in pastures and upland farming (tanety) during the last few decades. In many locations this has resulted into very serious erosion and accelerated run-off, leading to degradation of uplands and sedimentation in the lowlands and flood plains. Increasing demands for firewood and charcoal by growing urban populations continues to put heavy pressure on the natural vegetation.

The rainy season tends to start in October and end in March / April, with December and January as the peak rainfall months during which periods of extensive flooding may occur. Total annual rainfall is in the order of 1200 to 1500 mm. Mean temperatures obviously will vary with elevation, and will drop to 15C and lower during the months of May to September / early October. Detailed monthly rainfall and mean daily temperatures for three locations are presented in Table 1.

Table 1: Mean monthly and annual rainfall (mm) and mean monthly temperatures (ºC) for three zones in Madagascar where SRI has been practised; means are calculated on basis of 30 years of observations (1965-1995).

	Temperature (T: ºC) and rainfall (R: mm/month)														
Zone	Altitude		J	F	M	A	M	J	J	A	S	O	N	D	Total
Antsirabé	1500 m	R	214	189	207	81	28	20	27	26	28	65	169	289	1343
		T	19	20	19	18	15	13	13	13	15	17	19	19	
Antanarivo	1300 m	R	278	214	165	46	27	19	22	22	23	55	130	247	1250
		T	22	22	21	20	18	15	15	15	17	19	21	21	
Ranomafana	600 m	R	288	204	234	66	32	38	44	47	21	45	180	284	1483
		T	25	25	25	23	19	18	16	16	18	20	22	23	

With respect to rice farming on the Hauts Plateaux the cropping period stretches from late October to late April. That gives a potential growing season of some 180 days. At the start and at the end of it, low temperatures are the main obstacle to rice farming, while for the low-lying areas and flood plains, inundation risks are particularly high in the months of December and January. Obviously the start of the rains in October is another critical factor that determines the exact date for rice planting.

3.2. Rice cropping systems

As for any mountainous area, the diversity in rice fields in relation to the topography is huge. Broadly speaking, there are two major types of fields:

- rather extensive lowland areas that are more or less prone to flooding by the rivers, and
- small terraced plots on the lower slopes that receive water from run-off and from the groundwater flow generated in the higher (forested) areas.

Linked to the diversity in rice fields and in overall agro-ecological conditions, together with a centuries-old rice growing tradition of the population comes a huge diversity in local rice germplasm. Over the years a collection of some 5,000 entries of local rice varieties has been established (FOFIFA).

On the Hauts Plateaux, rice is being grown according to three major systems that represent progressively increasing levels of intensification / sophistication:

- the *traditional system*, inherited from the ancestors (who constitute an important cultural factor in daily life), is based on local varieties, transplanted at random and without using external inputs,
- the *improved system* (SRA) promoted by the formal research and extension services, based on improved varieties, transplanting in rows, and using mineral fertilisers, and
- the *system of rice intensification* (SRI) that has been promoted by the NGO Tefy Saina; it employs either local or improved varieties, uses very young seedlings, 8-days old (with only two leaves), transplanted singly with wide spacing (25 x 25 cm or wider) and minimal irrigation to keep the soil wet but not flooded during the vegetative phase. Frequent rounds of early weeding / soil cultivation and the use of ample rates of organic manure (compost and/or farmyard manure) are recommended.

Presently SRI is increasingly being recognised by the public sector institutions as a potential solution to reducing the rice production deficit of the country, and in achieving the national food security and poverty-alleviation policy goals of the Government.

4. Results of interviews and field observations

Even from quick and superficial field observations it becomes clear that there is an enormous diversity in rice-growing conditions and large variations between adjacent rice plots. Often one sees a patchwork (photo 1) of different, relatively small plots (varying between a few ares to several hectares), usually being farmed by different owners. An obvious question to pose is: "How can research and development cope effectively with this diversity and variability?"

Father de Laulanié stated at one time that rice production was linked to three major factors: *space*, *time* and *man*. These three factors can be restated somewhat differently: *space* is related to the landscape and topography; *time* to the annual calendar of seasons and the corresponding sequences of agricultural activities; and finally the effect of *man* is expressed through the agricultural technologies/practices he is using. A very similar concept was elaborated for the typical agricultural systems practised in the rolling landscapes of the West African savanne and sahelian zones (Stoop, 1987).

By viewing rice production / yield as the outcome of exploiting the interaction between:

Space/topographic position X Time/seasonal calendar X Man/agricultural technologies and practices

it is possible to interpret the variability observed in the field, but also to indicate where and when the actual system could be improved, or be practised more efficiently. Next this provides the basis for:
- comparisons between the three rice-growing systems (traditional, SRA and SRI), and
- comparisons between the relative performance of SRI plots in different locations and as practised by different farmers.

Through these comparisons, both agro-ecological/technological as well as related socio-economic aspects can be analysed.

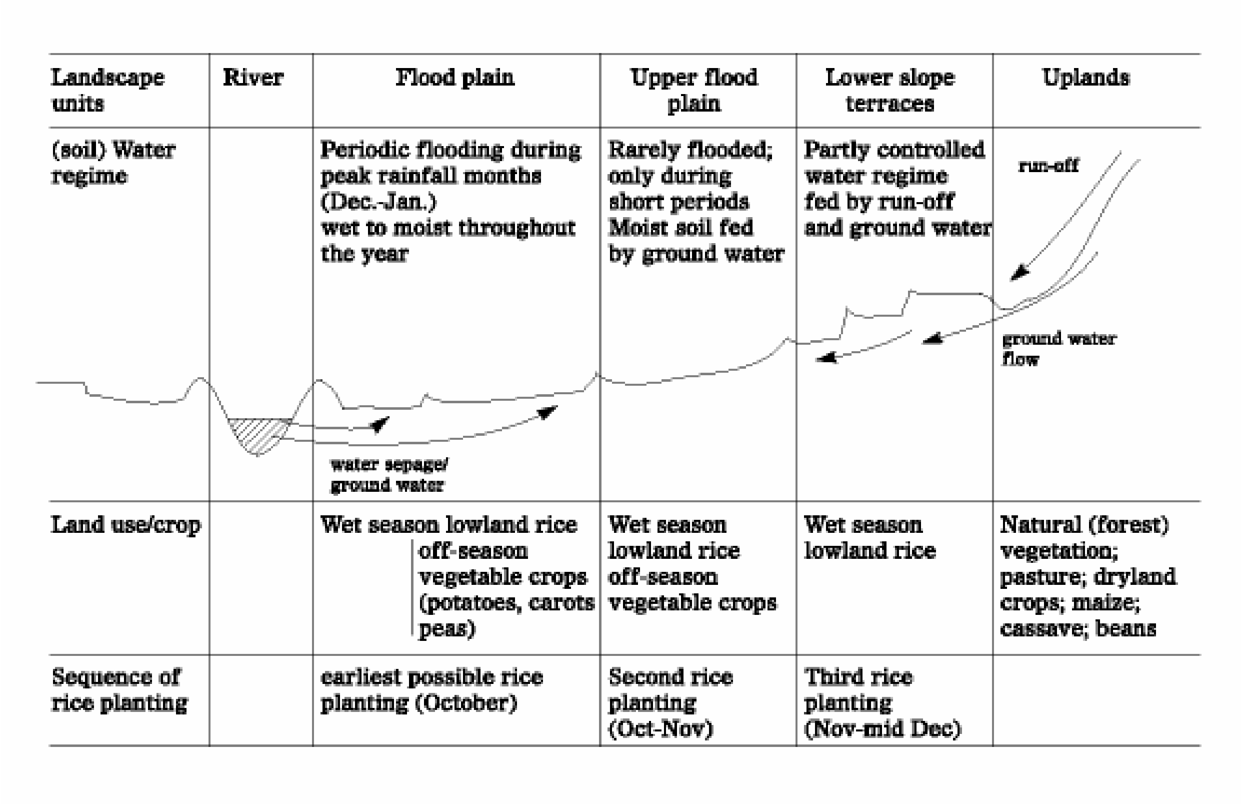
4.1. Agro-ecological and technological aspects

On the Hauts Plateaux a major source of variation in rice-growing conditions will derive from differences in elevation (ranging from 1200 to 1600m) and the associated effects on (micro) climatological variables such as daily mean air temperatures and rainfall (rates and distribution over the rainy season). These factors will greatly affect the rice-cropping system in terms of the approximate duration of the cropping period. Obviously, major adaptations to these very location-specific (micro) climatological conditions, can be achieved through the use of traditional varieties that have been selected locally to meet the specific temperature and maturity cycle requirements.

Another variable that is readily visible in the landscape, are the different types of rice fields:
- relatively large fields in the lowest parts, constituting the river floodplains and valley bottoms, and
- often rather small plots generally adjacent to the former and created as terraces on the lower slopes.

This very common field situation is schematically represented in figure 1. The topographic position of a rice field has a direct effect on its soil water regime, and the extent to which the water can be controlled through either irrigation and/or drainage. Obviously, the lowest fields will always be the wettest and will be the first to be planted at the start of the rainy season (October); these are, however, also the fields with the greatest flooding risks during the peak rainfall months of December and January. On the other hand, the small terraced plots of the lower slopes rely for their soil moisture supply on the run-off and the subsoil groundwater flow that are both generated on the uplands. These plots tend to get sufficiently wet once the rainy season is fully established and therefore can only be planted at later dates (November till mid December).

Figure 1: Schematic presentation of a typical transect for the “Hauts Plateaux”, indicating major landscape features, land use types, types of rice fields and associated soil water regimes



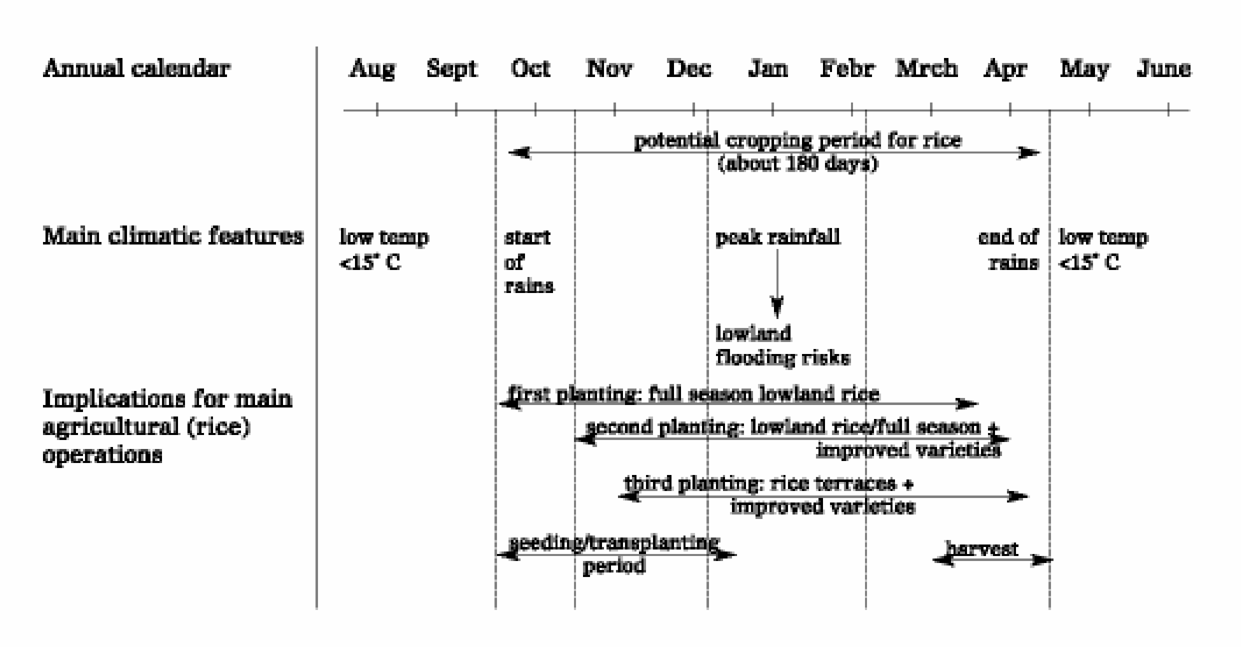
Rainfall and soil water regimes are not the only factors affecting potential rice growth. Mean daily temperatures are another. The early, vegetative development of rice is hampered by low temperatures (< 15 C) in September and early October, likewise the grain-setting and grain-filling processes are seriously reduced when that development phase occurs in late April or May due to a delay in planting.

The various temperature and rainfall constraints to rice farmers on the Hauts Plateaux have been schematically represented in Figure 2. It follows that in planning and successfully growing a rice crop in this region, one has to reckon with rather unique combinations of climatological and topographic conditions.

Obviously, the chances to succeed will be greatly enhanced by the varieties used and their adaptation (in terms of maturity cycles) to particular plots and field types. The strategy dictated is to exploit the available time/growing period to the maximum possible. This is achieved by early planting of robust full-season varieties (generally local materials) in the lowest plots, so that the vegetative / tillering development will be already fairly advanced by the time that the flooding risks get most serious. By contrast on the terraced plots of the slopes, planting needs to be delayed for the soil moisture content to build up. This leads to the use of varieties of short to intermediate maturity cycles (local or improved materials) that can still mature before the start of the cold season.

Field observations confirmed that farmers generally stick to this strategy. At the time of the visit in early March, the lowest fields were being harvested, whereas the higher fields were reaching the flowering stage. It was also observed, however, that a substantial number of plots both on the plains as well as on the terraces were still in a relatively early vegetative phase and therefore will probably be affected seriously by the end of season cold (see photo 1). Late planted fields on the lowest parts of the plains, in addition, had suffered greatly from this year's prolonged inundations.

Figure 2: Annual calendar in relation to climatic (temperature and rainfall) features, and its consequences for the agricultural calendar of operations for rice production on the Hauts Plateaux; additional location-specific variations will occur due to elevation (1200 to 1600 m) and topographic effects



4.2. Observations on SRI fields

During the field trip, some 15 different locations/farms were visited. At each location, SRI plots were compared with the adjacent fields that employed the SRA or traditional technology. Differences were analysed in discussions with the responsible farmers. Plot sizes ranged from a few ares (mostly terraced plots) to several hectares in the lowland plains. Farmers mentioned repeatedly that the 2002/3 season was difficult because of the abundant rainfall up till early March, which had caused serious and prolonged flooding (up to 1 meter) in the lowlands. As a result the performance in the respective SRI plots varied greatly between farmers and locations.

SRI plots on both plains and terraces were evaluated. The soils ranged from rich, heavy (smectite) clays to poor silty or sandy loam soils. In either location, local as well as improved (mostly X 265) varieties were employed. A fairly wide range in the various practices was noticed. Particularly the water regime management varied greatly between farms and plots. It was obviously linked to the uncontrolled flooding and run-off resulting from high rainfall, but also to the different degrees of control over drainage and irrigation and the personal strategies followed by individual farmers.

Some practise intermittent drying; others maintain 2 to 3 cm water, which is raised to about 5 cm during the flowering and grain-filling stages. The most successful farmers had applied large quantities (10 to 20 tons/ha) of compost mixed with farmyard manure to the off-season vegetable crops (potato, carrots or peas) that in most locations preceded the rice, which thus could benefit from the residual fertility effects. Others that farmed large areas (6 ha by Jean Honoré Ralainandrasana in Ambatovaky) supplement their organic manure with mineral fertiliser (12:22:16); urea topdressings were never reported. All farmers followed strictly the recommendation to use single transplants of 8-day old plants at the 2-leaf stage. The spacings used varied considerably among farmers, ranging from 20 x 10 to 30 x 30 and 40 x 15 cm, with 25 x 25 cm the most common. The frequency of soil cultivation/ weeding varied between 3 (most common) and 6 rounds with the rotary hoe.

During the field visits, two really outstanding plots - with estimated yields well above 10 tons/ha - were visited (a possible third plot had already been harvested); both were on the lowland plains. The plot of farmers Eugène and Théodore RAMAROLAHY near Fianarantsoa (photo 2) employed an impressive full-season local variety; the other plot by farmer Roger Martin RANDRIANJATOVO near Ilaka Centre (photo 3) used an intermediate-maturity, improved variety (X 265). Both these fields had escaped the serious mid-season floods and had benefited from large compost/farmyard manure applications (some 10 to 20 tons/ha). Nearly all of the other plots visited were still mostly in a (pre-) flowering stage, which indicates a delay in the seeding/transplanting operation. This delay is subsequently compounded by a sub-optimal water regime (due to uncontrolled flooding / inadequate drainage), reduced compost applications, and/or excessive plant populations.

By comparing the various fields visited, a tentative conclusion is that "drainage" and maintaining a moist soil during the vegetative phase (or for that matter by escaping/minimising flood damage by planting early in October) had been the critical factor in realising the very high yields. This effect is compounded considerably by the soil fertility and the wide spacing factors.

4.3. Farmer' comments

Apart from the attractive grain yields, farmers emphasised two other major advantages:

- Large savings on seed requirements: they need as little as one-tenth of the usually required rate, thereby also reducing the cost of reseeding in case of unfavourable weather conditions for transplanting,
- SRI was reported to be much more tolerant to drought than either the SRA or traditional technology,
- Early weeding and soil cultivation were recognised as critical operations, but were not felt to be a major (labour) constraint.

Large savings in the use of irrigation water are an obvious other advantage. But, under the partially controlled water regimes used on the Hauts Plateaux, this has not been a major issue.

4.4. Socio-economic aspects

The field interviews with farmers have revealed some interesting, mostly socio-economic, insights on household characteristics and on "why" the SRI approach is not being practised more widely in spite of its obvious potentials. First of all, rice farming in Madagascar is a centuries-old practice that is surrounded by many traditional and cultural beliefs in which the "ancestors" play a dominant role. Changing traditional practices inherited from the parents is not readily done. There is, however, more to it.

Farmers practising SRI most successfully had used it since the early nineties. They tend to have a number of typical characteristics in common: above average intelligence, having sometimes even completed a university education; very keen observers, well organised, and very motivated/interested in farming. They always had at least some carefully managed cattle around the house to produce ample supplies of farmyard manure. In all cases, their SRI plots were located relatively close to the house, thereby permitting regular observation and maintenance. Often the farmers remarked that they still had additional plots further away (several km), where they used the official SRA recommendations or followed traditional practices.

The arguments by the non-adopters included the obvious ones: time and labour constraints, excessive weed problems, no or inadequate control over irrigation water and an increase in perceived risks, due to the use of very small 8-day old transplants. Another feature was, however, that many of these people were living in town (having no cattle), while visiting their fields only occasionally (once a month). This information is backed up by some statistics that show the share of average farmer income attributed to sales of rice to be only 7%, while the commercial and salary share was 54% (UPDR/FAO, 1999). This would confirm that rice is grown largely to cover the family food requirements, while many farmers have other major preoccupations and sources of income.

5. Discussion and Conclusions

Field observations and discussions with farmers have confirmed that SRI has indeed the potential to produce extraordinary grain yields (even way above 10 tons/ha), provided the farmer has adequately mastered the techniques, and in particular the calendar of operations (**conclusion 1**). SRI has often been presented as a very sophisticated and labour-intensive approach. Apart from a strict control over water (irrigation as well as drainage) to be applied whenever needed, perfectly levelled land, ample supplies of compost/farmyard manure, and last but not least, abundant labour to ensure timely transplanting and frequent weeding have all been considered as critical production factors. On that basis, many rice scientists / specialists have proclaimed out-of-hand that SRI is unsuitable for a vast majority of farmers and therefore doesn't merit any further research.

The Madagascar field realities, however, differ rather substantially from this presumed "ideal" image. In particular, the control over water is generally rather limited. What was identified as a key factor is above all, "agricultural professionalism", notably in minimising the risks of flood damage and of the end-of-season cold. A pre-condition for that is the effective mastering of the calendar of agricultural operations.

5.1. Elements of the SRI approach.
The initial publications by de Laulanié (1993a and b) and the review article by Stoop et al. (2002) together with the present field study have revealed a relatively large number of different factors that in one way or another affect the performance of SRI. The following list of critical factors was established:

- soil and climatic factors (mostly temperature and rainfall),
- nursery preparation, and seed rates,
- field preparation for transplanting,
- transplanting of very young seedlings (2 leaves), only 8 to 10 days old,
- transplanting as single plants,
- wide spacing between individual transplants, ranging from 25 x 25 to even 50 x 50 cm,
- responsive rice varieties with respect to their maturity cycle and tillering ability,
- controlled soil water regimes at different stages of crop development; irrigation and drainage requirements,
- frequency of soil cultivation and weeding,
- soil fertility and plant nutrient management: organic manures and/or mineral fertilisers (rates, composition),
- preparation of organic manures (quality/origin of materials), and
- rotations / preceding off-season crops.

In addition to these mostly bio-physical factors, come a number of crucial, more general issues:

- farmer intelligence, motivation, interests, and overall educational level, and
- ability to control and correctly manage the calendar of operations from the initial land preparation and nursery phases through to the harvesting operations in dealing with the various biological/technical factors mentioned above.

All of these elements appear to be essential "building blocks" of a SRI type approach. Yet the relative importance of each separate "block" is far from resolved, and none of these can be considered independent from the others in ultimately realising a high yield. Therefore, assessments of certain features of SRI in isolation from the complex of other factors will easily lead to unrealistic results. For instance, economic assessments will be totally irrelevant in the (relatively frequent) case that the calendar of operations has not been adequately mastered (by the farmer or by the scientist when conducting his field research). This will apply to many other issues as well, like the time/labour requirements and therefore costs of weed control, but also the effectiveness of (mineral and/or organic) fertiliser use and possible contributions by soil micro-organisms to the uptake of plant nutrients (nitrogen in particular).

Comments by farmers, development personnel and scientists confirmed that SRI should be considered a mostly *empirical* approach (**conclusion 2**). This by no means decreases its significance, but in order to exploit it, to disseminate it, and to adapt it efficiently to other agro-ecological environments, it is imperative for research to clarify the mechanisms and processes involved, in other words the general underlying principles. The observations on farmer fields tend to indicate that the SRI potential is rarely fully exploited for reasons of sub-optimal varietal choices, water and fertility management, plant spacing/density, and the various interactions among these factors.

5.2. A great need and opportunity for additional research
The full potential of SRI is only realised by a relatively small group of farmers, that has indeed completely mastered the approach and the calendar of operations (see section 4.2.). This observation may have been accentuated during the current season, because of the unusually high rainfall and the resulting extensive, early and prolonged flooding of many, particularly lowland, fields.

A major first task for research would be to sort out the relative importance of the many variables involved (see section 5.1.) and the major interactions between these. As a result the basic conditions, essential to successfully employ SRI-type approaches, could be determined. Second, it is important to determine what adaptations may be required in response to major different soil types (e.g., the fertile, smectite clays versus poor sandy clay loams) and to local climatic conditions that determine the duration of the growing season.

This means that the "SRI agronomy" still needs to be worked out from scratch (**conclusion 3**). For instance, is the crucial tillering feature brought about by the low plant population and wide spacing, or are the water regime and soil nutrient supply during the vegetative phase the critical factors? Or how effectively are major categories of rice varieties (e.g., early, intermediate or late maturing) able to exploit a SRI type approach? Exploratory research conducted at WARDA, strongly suggests that the full season materials have the greatest potential to exploit the SRI conditions, followed by some of the intermediate ones, while the short cycle varieties (100 to 120 days) were by far the least responsive (Stoop, in preparation). In principle, such issues need to be well clarified before starting on more fundamental studies like the possible roles of soil micro-organisms in meeting the supposedly considerable plant nutrient requirements for SRI. This would also apply to the on-going studies at the University of Antananarivo about the innoculation of rice seeds and/or of the compost used in the nursery with Azospirillum/mycorrhyzae, obtained from the root systems of abundantly tillering SRI plants.

Another important feature that was recorded in the WARDA research and that also seems to occur in farmer fields is an extension in the duration of the vegetative growth period under SRI. In the two pictures (2 and 3) of successful SRI fields, the neighbouring field had been planted at about the same date, but by using transplants that were 10 to 20 days older. Yet both fields reached maturity on about the same date, showing distinctly larger and heavier panicles for the SRI field. The thesis advanced by the WARDA research is that the latter effect has been brought about by a prolonged vegetative development made possible by a root system that continues to function actively for a longer period of time under the aerated conditions in a non-flooded soil.

To verify this thesis in farmer fields is rather complicated because of the confounding between the "seedling age at transplanting" and the "soil water regime" variables in the farming situation, and therefore the difficulty to determine their respective impacts on vegetative growth and grain yield. This is a feature that needs to be clarified further through well-controlled field experiments in which the "non-experimental variables" are fixed at realistic levels and are handled carefully. Such experiments are ideally conducted on a research farm, though it should be recognised that the soils of many of the older stations might be completely non-representative from those under farmer conditions because of their prolonged intensive cultivation, their monocropping, and frequent use of agricultural chemicals.

Since SRI employs a fundamentally different water regime from the conventional irrigated practices, research may well expose important alternatives also for the present practises of growing lowland rice. Likewise it might affect current thinking with respect to crop growth models, theoretical yield ceilings and the so-called *ideal* plant type. But also issues like natural resource use-efficiency for land and water, as well as environmental pollution from the release of methane gas from irrigated rice systems would be touched upon by such research. The importance of this research therefore goes far beyond just SRI; it could prove highly relevant to other crops and a wide array of agricultural systems by addressing key aspects of crop development in response to different water and soil fertility management regimes.

5.3.The scope for widespread adoption and the major constraints involved

The development of SRI over the past two decades and the types of responses it has generated among both *farmers* and *scientists* is a fascinating subject. The successful farmers (Eugène and Théodore RAMAROLAHY) near Fianarantsoa, who have practised SRI since 1992, confirmed that initially many neighbours showed great interest and visited their field at harvest, everyone being very impressed and ready to adopt. Next several farmers tried it, but subsequently returned to their former practices. Today he is one of the few still practising SRI in the valley, yet as the picture (photo 2) shows with considerable success. So the potential of SRI by itself is for farmers not necessarily the decisive argument to adopt (**conclusion 4**). Many other aspects ranging from technical, cultural, psychological and even political seem to enter into the equation, as the arguments elaborated in section 4 make clear.

In an early contribution, Father de Laulanié (1989) elaborated on his views about agricultural development for Third World, non-industrialised countries, Madagascar in particular. In it, he expressed several views that remain highly relevant. First, the progressive transition from a traditional (i.e., a closed, internally focused) society towards more modern, open, and therefore externally oriented (in terms of knowledge and trade) communities involves a slow and long-term development process. The failure by major bi- and multilateral aid agencies to appreciate this constraint adequately can be considered responsible for the failure of so many relatively short-term development projects.

Second, sustainable development would require a major emphasis on "education" in a broad sense, i.e., an exposure to the principles of biology (crops and animals), of the environment (climate, water and soils), and of child and health care to counter traditional beliefs and superstition. De Laulanié stated that in the absence of this broader education, the introduction of new/improved technologies tends not to "stick" with the people. Again this feature was generally bypassed during the past decades by the predominantly short-term project approaches that were aimed at introducing "rapid change".

Third, he underscored the diversity in people's aptitudes towards for instance agriculture. His estimate is that 80% of the rural population conducts agriculture on a traditional, routine basis for survival and/or as a secondary activity. Only for a minority of some 10% is agriculture a full-time "profession". Initially it will be only this small group that will be inclined to experiment, to observe the crop closely, and finally to adopt new practices. Obviously, this feature applies more widely and will not be limited to agriculture or for that matter SRI and rice farming.

In general, *agricultural development* will involve a switch from routine traditional and extensive practices towards increased intensification by investing in additional internal (labour/time) and/or external (commercial inputs) resources. Maximising the profitability of either internal or external inputs requires, however, a considerable degree of professionalism, individualism and personal motivation, which are attitudes that are not particularly valued in closed, collective and traditional communities. It follows that the introduction of agricultural practices that are drastically different from the centuries-old, traditional ones (e.g., for rice the drainage of water during the vegetative phase as opposed to flooding) encounter disbelief and resistance in spite of the field evidence to the contrary. Interestingly enough, highly educated scientists have shown similar reactions when for instance their scientific paradigms were being challenged, as in the case of SRI - - - -.

But it is not only the introduction of new/different practices, it is also the precise timing of their implementation that tends to be even more crucial in maximising the returns and in minimising the risks. As such, the agricultural intensification process and the transformation from a low input, traditional agriculture into intensified forms of production involves profound technical changes as well as mentality changes for farmers. Agricultural research and development have given inadequate attention to the interactions between the calendar of operations (i.e., the need for timely implementation) and the various investments to ensure that their respective benefits are optimised as required for a "knowledge-intensive" agriculture (**conclusion 5**). This conclusion is supported by the various field observations (see sections 4.2. and 4.3.). So there are many technical, as well as cultural and psychological reasons, why the dissemination of SRI in Madagascar has been slow. Obviously very similar reasons are most likely to apply to other (African) countries and to other major cropping systems (for instance, the Sahelian millet system: Amir Kassam, pers. comm.).

6 Concluding remarks

Madagascar has been blessed by the presence of a huge bio-diversity in local rice varieties, having evolved for centuries in their respective adaptations to the wide range of location-specific conditions associated with mountainous eco-systems. Therefore, one could question the wisdom of national agricultural policies (largely inspired by the views of international research, development and donor agencies) to earmark *local varieties* as one of the major obstacles to rice production and future national food security. The planned, complete replacement of local by improved varieties and of the traditional rice production systems by SRI in the Fianarantsoa region by 2006 (UPDR, 2002), therefore may be characterised as unrealistic and ill-advised.

The major significance of SRI practises is probably that it points to important, so-far unexploited, potentials in crop production that go way beyond what has been believed to be yield ceilings based on theoretic crop modelling efforts. Moreover, these yields were realised by using traditional, full-season, local varieties that have always been characterised by the research establishment as notoriously inefficient and unable to respond effectively to intensification practices. Instead it might be concluded that "conventional" agronomic research has so far been unable to define an appropriate agronomic package that would permit these varieties to fully express their potentials. The fact that mostly small farmers could develop an empirical package of practices for rice that in many ways goes entirely against conventional wisdom (single plants, wide spacing, very young transplants, and drainage rather than irrigation) is quite revealing for the limitations of (international) agricultural research.

A most exciting aspect of the present study and the results obtained in earlier exploratory WARDA experiments, is that it may open up many fields for renewed research with opportunities for fundamental changes in agricultural practices leading to beneficial effects for farmers as well as for the environment. So rather than consider SRI as a "myth", it should be considered – until proven otherwise – as a "missed opportunity" in terms of research.

To seize this opportunity, researchers will need to match the agricultural professionalism shown by some Madagascar farmers. Agricultural scientists locked away in their offices and glued behind their computer screens are unlikely to achieve this. In that respect also research management has a fundamental task in stimulating scientific curiosity and flexibility among scientists. The SRI experience shows that nature still has numerous undisclosed secrets, even in the unpretentious discipline of agronomy, and that unlocking some of these secrets is not necessarily a matter of sophisticated and costly techniques.

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Appendix A: Itinerary

3/3	Travel Amsterdam to Antananarivo
4/3	Meeting with Prof. Robert RANDRIAMIHARISOA, Chairman of the École Superieur des Sciences Agronomiques (ESSA) of the University of Antananarivo and Sebastien RAFARALAHY and Justin RABENANDRASANA of the Association Tefy Saina
5/3	Travel from Antananarivo to Antsirabe with Sebastien and Prof. Benjamin RAKOTO, Prof. Jean Chrysostome and 5 students; visits to the farms of: Samuel RANAIVO; Mme Marie Julienne RAZANADRAFABA (in Ambano) and Mme Josephine RAZAFIMALALA. This visit was led by Dieudonné RAKOTOARIMANANA, trainer of Tefy Saina].
6/3	Travel from Antsirabe to Fianarantsoa
7/3	Field visit around Fianarantsoa with Edmond RATAMINJANAHARY, farmers Eugene and Theodore RAMAROLAHY; visit to Estate of Société MARC et Frères, University students experiments.
8/3	Field visit to Ambatotokana: 2 farmers
9/3	Field visit to Ambatovaky village: Jean Honoré RALAINANDRASANA (several fields)
10/3	Return Fianarantsoa to Antsirabe; stops at Ivato Centre (school) 2 fields; Monastère des Soeurs Bénédictines, several harvested fields; Ilaka Centre: farmer Roger Martin RANDRIANJATOVO with guidance from the Soeurs du Bon Sauveur
11/3	Travel from Antsirabe to Antananarivo; Discussions at Tefy Saina
12/3	Discussions at ESSA/University: Prof. Robert RANDRIAMIHARISOA and Patrick RAJAOMILISON, field visit of University Farm plots; Field visit to farm plots in Anjomakely: Laurent RAMALANJAONA and another farmer with Fetra ANDRIANAVALONA, trainer of Tefy Saina and two students from ESSA.
13/3	Visit and lecture at "Laulanié Green University"; Discussion with Hamon RANDRIAMIHARY (founder and owner) and Mme Yolande Discussions at FOFIFA with Dr. Francois RASOLO (DG), Mme Yvonne RABENANTOANDRO (Directeur scientifique) and Mme Jacqueline RAKOTOARISOA (Chef Département de Recherches Rizicoles) Meeting/dinner with Glenn Lines
14/3	Debriefing with Prof. Robert RANDRIAMIHARISOA (University), Sébastien RAFARALAHY and Justin RABENANDRASANA (Association Tefy Saina)
15/3	Departure for Amsterdam

Appendix B: Survey / informal interviews about SRI in Madagascar

Major issues to be covered:

What are according to the farmers the *most critical factors and issues* in successfully using the SRI method?

- **knowledge, experience**, role of informal experimentation

- **strict planning of field operations** in relation to labour requirements / bottlenecks (transplanting, early weeding, compost preparation and application, etc.

- **nursery management**: seed rates; timing of seeding; seed preparation/priming

- **land / field preparation :** leveling

- **transplanting and early development phase**:
  - timing / seedling age in relation to weather /rainfall conditions
  - importance of very young seedlings

- **water management**:
  - *full control*: timing, frequency and rate of irrigation; irrigation regime adjustments in response to crop development phase,
  - *partial or no control*: what adjustments in other SRI components,

- **appropriate rice varieties**:
  - how many varieties used per farm;
  - plant characteristics (maturity, tillering; height, others) of varieties particularly suitable to SRI,

- **soil fertility management**: sustainability issue; crop rotation / land use
  - *compost* preparation (quality; specific organic components/composition) and use
  - timing of application and rates used for compost
  - *mineral fertilizers* : what types and quantities; suitability

SRI interview guide

Household background

Farmer name						
Household size (Total Nb of persons)						
Nb. of actifs on-farm outside						
Total surface area of farm (ha)						
Presence of different land types						
Presence of livestock Cattle Small ruminant Others						
Sources of revenu Farm products Rice Labour Remittances						
Other observations						

SRI experience

Nb of years SRI experience						
Total area cultivated (ha) SRI rice Conventional rice Major other crops						
Land type SRI field						
Soil type SRI field						
Nb of years SRI on same plot						
Preceding crop to SRI Rotations						
Number of rice varieties for SRI						
Plant spacing						
Weeding/cultivation operations						
Water regime						