SUMMARY REPORT ON FACTORIAL TRIALS IN MADAGASCAR EVALUATING THE SEPARATE AND COMBINED EFFECTS OF SYSTEM OF RICE INTENSIFICATION (SRI) PRACTICES

In 2000 and 2001, Jean de Dieu Rajaonarison and Andry Andriankaja, top students in the Faculty of Agriculture (ESSA) at the University of Antananarivo in Madagascar, conducted complex sets of trials evaluating six different factors affecting rice production. Their research was supervised by Prof. Robert Randriamiharisoa, director of research for ESSA, with support from CIIFAD and a grant from the Rockefeller Foundation.

It was anticipated that carefully controlled trials might show that one or more of the SRI practices would not contribute much higher yield that the set of SRI practices could be simplified, to make them more readily adoptable. In fact, the trials showed a high degree of *synergy* among practices. So although "young seedlings" were seen to be the most important practice in both sets of practices, none could be discarded without some loss of yield.

The two locations were the Centre de Baobab near Morondava on the west coast of Madagascar, and farmers' fields in the village of Anjomakely, 18 km south of the capital Antananarivo on the high plateau. At Morondava, one of the factors evaluated was **rice variety**, comparing results from SRI vs. conventional practices using a high-yielding variety (2798) and a local variety, *riz rouge*, both planted on poor sandy soil near sea level in a very warm climate. At Anjomakely, **soil quality** was varied, with *riz rouge* planted on both better clay soil plots and on poorer loam plots, with an elevation around 1200 m and a temperate climate.

The four main practices evaluated were:

- **Young seedlings**, transplanted at 8 days of age, compared to 16 or 20 days (at Anjomakely with higher elevation and colder temperatures, 20 days was equivalent to 16 days at Morondava with its higher more tropical climate).
- **Water management**, comparing practices that maintained soil moisture but avoided saturation, with continuous flooding.
- **Plant density**, with one seedling per hill vs. 3 seedlings per hill; and
- **Fertilization**, using compost (made from plant biomass) vs. NPK (16-11-22) in the recommended dosage vs. no fertilization as a control.

The variable of **spacing** was not tested effectively because both spacings used was 25x25 cm vs. 30x30 cm, both within the SRI range. There was no average yield difference between the two sets of plots differentiated by spacing at Morondava (each N=144), and only 0.08 t/ha difference at Anjomakely (each N=120), with each set containing half SRI and half non-SRI practices with regard to seedling age, water management, density, etc. As there was no real difference observed for this (narrow) range of spacings, the spacing trials were combined, so that instead of having three replications of each of 96 or 80 combinations, all the averages reported below are based on *at least six replications*.

All trial plots were 2.5x2.5m, laid out according to a modified Fisher bloc design. The main bloc at Morondava was divided by **water management** (SRI vs. non-SRI practice) because plot with these treatments could not be randomly irrigated (or not), since water applied to any individual plot diffuses into adjoining plots. These main sub-blocks were divided into two sub-blocs for **fertilization practice**, which minimized any effects of sub-surface movement of nutrients. While this is not as serious a problem as sub-surface movement of water, it should be avoided as much as possible. Within these sub-sub-blocs, plots were randomized for different combinations of **plant age, plants per hill, spacing,** and **variety**.

For the Anjomakely trials, two nearby locations on farmers' fields were identified having **better or poorer soil**. These were close enough that there were no climatic differences. Within these two main blocs, there were sub-blocs for **water management** and within these, sub-sub-blocs for **fertilization**. Within these, randomized combinations of **plant age, plants per hill,** and **spacing** were established, all with the same variety (*riz rouge*).

More detailed information on soil characteristics and the design and trials themselves is available in the theses (*memoires de fin d'etudes*) of Rajaonarison and Andriankaja, including tests of statistical significance. These theses, in French, are available in electronic form from CIIFAD. The summary presentation below is concerned with any *patterns of difference in yield* according to the different combinations of practices, SRI or non-SRI, and the different degrees of SRI practice use (zero, 25%, 50%, 75%, 100%).

For both sets of trials, data were gathered also on the number of tillers, number of panicles, panicle length, root length, and root density (the latter measured by a pull test of root system resistance to uprooting). The patterns for these measurements of yield components and plant characteristics mirrored those reported below for yield. Statistical analysis shown in Tables 2 and 3 shows the differences to be quite significant. The differences in Tables 5 and 6 are even larger, but significance tests have not been calculated for those yet.

With growing conditions controlled, using all SRI practices -- young seedlings, one per hill, aerated soil, with compost added -- gave *yield increases of 140% to 245%,* compared to plots using only non-SRI practices -- more mature seedlings, three per hill, saturated soil, with NPK fertilizer applied. In both sets of trials, the increments to average yield generally increased as a larger *proportion* of SRI practices was used. The largest increase in both sets of trials came when from going from 75% SRI to 100% SRI. This added almost 2 t/ha to yield in these trials. (The factor of weeding, which could add more to yield, was not tested.)

Absolute and relative yields will vary, possibly widely, across sets of factorial trials as differences in soil, climate and variety affect the outcomes from particular sets of practices. However, that these two sets of trials, under very different soil and climatic conditions, showed such a consistent **pattern** of results, having averages for 6 rather than just 3 plots, suggests that the relationships reported here are reasonably robust.

This analysis should be seen, however, not so much as a ***conclusion*** as an ***invitation*** for others to undertake similar sets of factorial trials to assess the effects of SRI practices both *separately*, other things being equal, and *collectively*, in different combinations.

Table 1: FACTORIAL TRIAL RESULTS, COMPARING HIGH-YIELDING AND TRADITIONAL VARIETY RESPONSES TO SRI METHODS VS. NON-SRI METHODS, MORONDAVA, 2000

Yield figures below in tons/ha are all averages from 6 replicated trial plots.
Conventional results are *italicized and underlined*; SRI results are **bold faced**.
Two different varieties were used in the trials, with soil type all *sable roux* (rough sand).

(a) *MODERN VARIETY (2798 -- RIZ BLANC)*

	CONTINUOUS FLOODING				SRI WATER MANAGEMENT			
	16-DAY PLANTS		8-DAY PLANTS		16-DAY PLANTS		8-DAY PLANTS	
	3 per hill	1 per hill	3 per hill	1 per hill	3 per hill	1 per hill	3 per hill	1 per hill
No Fertilizer	1.68	1.90	2.28	2.31	1.69	1.92	2.61	3.47
NPK	*2.84*	2.79	4.08	4.50	4.04	4.10	5.75	6.62
Compost	2.69	2.73	3.35	3.85	4.18	3.82	4.42	**6.83**

(b) *TRADITIONAL VARIETY -- RIZ ROUGE*

No Fertilizer	1.49	1.77	2.01	2.46	1.91	1.95	2.46	3.14
NPK	*2.11*	2.28	3.09	3.65	2.64	2.89	3.34	4.29
Compost	2.67	2.47	4.50	5.18	3.10	2.88	4.78	**5.96**

Table 2: FACTORIAL TRIAL RESULTS, YIELD IN TONS/HA, EVALUATING EFFECTS OF USING GREATER NUMBERS OF SRI METHODS, MORONDAVA, 2000

N of trials in parentheses; SRI practices shown in **bold face**

	Variety		
Conventional	**HYV**	**Tradl.**	**Ave.**
SS/16/3/NPK	2.84 (6)	2.11 (6)	2.48 (12)
1 SRI Practice			
SS/ 16 / 3 / **C**	2.69 (6)	2.67 (6)	
SS/16/**1**/NPK	2.74 (6)	2.28 (6)	
SS/ **8** /3/NPK	4.08 (6)	3.09 (6)	
AS/16/3/NPK	4.04 (6)	2.64 (6)	
	3.34 (24)	2.67 (24)	3.01 (48)
	+0.50 t	*+0.56t*	*+ 0.53 t*
	(p=.021)	(p=.007)	
2 SRI Practices			
SS/16/ **1** / **C**	2.73 (6)	2.47 (6)	
SS / **8** / 3 / **C**	3.35 (6)	4.33 (6)	
AS/16/**1**/NPK	4.10 (6)	2.89 (6)	
AS/16/ 3 / **C**	4.18 (6)	3.10 (6)	
SS/ **8** /**1**/NPK	5.00 (6)	3.65 (6)	
AS/ **8** /3/NPK	5.75 (6)	3.34 (6)	
	4.28 (36)	3.24 (36)	3.78 (72)
	+0.94 t	*+0.62 t*	*+0.78 t*
	(p=.000)	(p=.000)	
3 SRI Practices			
SS/ **8** / **1** / **C**	3.85 (6)	5.18 (6)	
AS/16/ **1** / **C**	3.82 (6)	2.87 (6)	
AS/ **8** / 3 / **C**	4.49 (6)	4.78 (6)	
AS/ **8** /**1**/NPK	6.62 (6)	4.29 (6)	
	4.69 (24)	4.28 (24)	4.48 (48)
	+0.41 t	*+ 0.99 t*	*+0.70 t*
	(p=.000)	(p=.000)	
All SRI Practices			
AS / 8 / 1 / C	6.83 (6)	5.96 (6)	6.40 (12)
	+2.14 t	*+1.68 t*	*+1.92 t*
	p=.000)	(p=.000)	

Table 3: FACTORIAL TRIAL RESULTS, YIELD IN TONS/HA, EVALUATING EFFECTS OF SRI METHODS USED WITHOUT ANY FERTILIZATION, MORONDAVA, 2000

N of trials in parentheses; SRI practices shown in **bold face**

	Variety		
Conventional	**HYV**	**Tradl.**	**Ave.**
SS / 16 / 3	1.51 (6)	1.49 (6)	1.50 (12)
1 SRI Practice			
SS / 16 / **1**	1.90 (6)	1.77 (6)	
SS / **8** / 3	2.36 (6)	2.01 (6)	
AS / 16 / 3	1.69 (6)	1.91 (6)	
	1.93 (18)	1.89 (18)	1.91 (36)
	+0.42 t	*+0.40 t*	*+ 0.41 t*
	(p=.0036)	(p=.007)	
2 SRI Practices			
SS / **8** / **1**	2.31 (6)	2.46 (6)	
AS /16/ **1**	1.92 (6)	1.95 (6)	
AS / **8** / 3	2.61 (6)	2.46 (6)	
	2.28 (18)	2.28 (18)	2.28 (36)
	+0.35 t	*+ 0.39 t*	*+0.37 t*
	(p=.0003)	(p=.0003)	
All SRI Practices			
AS / 8 / 1	3.47 (6)	3.14 (6)	3.30 (12)
	+1.19 t	*+0.86 t*	*+1.02 t*
	(p=.000)	(p=.000)	

Table 4: FACTORIAL TRIAL RESULTS, COMPARING YIELD RESPONSES ON CLAY AND LOAMY SOILS, ANJOMAKELY, 2001

Yield figures below in tons/ha are averages from 6 replicated trial plots
Conventional results are *italicized*; SRI results are **bold faced**
Traditional variety (riz rouge) was used for all trials, with soil type as a variable.

CLAY (BETTER) SOIL

	CONTINUOUS FLOODING				SRI WATER MANAGEMENT			
	20-DAY PLANTS		8-DAY PLANTS		20-DAY PLANTS		8-DAY PLANTS	
	3 per hill	1 per hill	3 per hill	1 per hill	3 per hill	1 per hill	3 per hill	1 per hill
No Fertilizer	2.26	2.78	3.09	3.75	4.82	5.42	5.65	6.25
NPK	*3.00*	5.04	5.08	6.07	7.16	8.13	8.15	8.77
Compost	3.71	4.50	6.72	7.45	6.86	7.70	9.32	**10.35**

LOAM (POORER) SOIL

NPK	*2.04*	2.78	2.60	3.15	3.89	4.36	4.44	5.00
Compost	2.03	2.44	3.41	4.10	3.61	4.07	5.17	**6.39**

TABLE 5: ANALYSIS OF FACTORIAL TRIAL RESULTS, WITH SOIL DIFFERENCES, ANJOMAKELY, 2001

N of trials in parentheses; SRI practices shown in **bold face**

Conventional	**Clay**	**Loam**	**Ave.**
SS/20/3/NPK	**3.00** (6)	**2.04** (6)	**2.52** (12)
1 SRI Practice			
SS/ 20 / 3 / **C**	3.71 (6)	2.03 (6)	
SS/20/**1**/NPK	5.04 (6)	2.78 (6)	
SS/ **8** /3/NPK	7.16 (6)	3.89 (6)	
AS/20/3/NPK	5.08 (6)	2.60 (6)	
	4.25 (24)	**2.83** (24)	**3.54** (48)
	[+1.25 t]	[+0.79t]	[+1.02 t]
			+40.5%
2 SRI Practices			
SS/20/ **1** / **C**	4.50 (6)	2.44 (6)	
SS / **8** / 3 / **C**	6.86 (6)	3.61 (6)	
AS/20/**1**/NPK	6.07 (6)	3.15 (6)	
AS/20/ 3 / **C**	6.72 (6)	3.41 (6)	
SS/ **8** /**1**/NPK	8.13 (6)	4.36 (6)	
AS/ **8** /3/NPK	8.15 (6)	4.44 (6)	
	6.74 (36)	**3.57** (36)	**5.16** (72)
	[+2.49 t]	[+0.74 t]	[+1.62 t]
	+58.6%	*+26.1%*	*+45.8%*
3 SRI Practices			
SS/ **8** / **1** / **C**	7.70 (6)	4.07 (6)	
AS/20/ **1** / **C**	7.45 (6)	4.10 (6)	
AS/ **8** / 3 / **C**	9.32 (6)	5.17 (6)	
AS/ **8** /**1**/NPK	8.77 (6)	5.00 (6)	
	8.31 (24)	**4.59** (24)	**6.45** (48)
	[+1.57 t]	[+1.02 t]	[+1.29 t]
	+23.3%	*+28.6%*	*+25.0%*
All SRI Practices			
AS / 8 / 1 / C	**10.35** (6)	**6.39** (6)	**8.37** (12)
	[+2.04 t]	[+1.80 t]	[+1.92 t]
	+24.5%	+39.2%	*+30.0%*

TABLE 6: ANALYSIS OF FACTORIAL TRIAL RESULTS, ANJOMAKELY, 2001, ON CLAY SOILS WITH NO FERTILIZER OR COMPOST APPLIED

N of trials in parentheses; SRI practices shown in **bold face**

	Clay (Better) Soil		
Conventional			
SS / 20 / 3	2.26	(6)	
1 SRI Practice			
SS / 20 / **1**	2.78	(6)	
SS / **8** / 3	4.82	(6)	
AS / 20 / 3	3.09	(6)	
	3.56	(18)	[+ 1.30 t]
			+57.5%
2 SRI Practices			
SS / **8** / **1**	5.42 (6)		
AS /20/ **1**	3.75 (6)		
AS / **8** / 3	5.65 (6)		
	4.94 (18)		[+1.38 t]
			+38.8%
All SRI Practices			
AS / 8 / 1	**6.25** (6)		[+1.31 t]
			+26.5%

TABLE 7: COMPARISONS OF FACTOR EFFECTS, ANJOMAKELY, 2000

The yield differences reported are with all other factors being equal,
i.e., with equal numbers of SRI and non-SRI practices for
each of the *other* factors when an average is calculated
[for each average, N = 120, except for fertilization, each N = 96]

Young seedling effect ***+ 2.48 t/ha***

8 days old	**6.28 t/ha**	**vs.**	**20 days old**	**3.80 t/ha**

Water management effect ***+ 1.41 t/ha***

Water control	**5.75 t/ha**	**vs.**	**Flooding**	**4.34 t/ha**

Fertilization (average for clay/loam soils) ***+ 1.01 t/ha***

Compost	**5.49 t/ha**	**NPK fert.**	**4.48 t/ha**

Average on clay soils w/o any fertilization was 4.25 t/ha
Note: results are for a traditional variety, less responsive to application of NPK

Plants per hill effect ***+ 0.78 t/ha***

1 plant/hill	**5.43 t/ha**	**vs.**	**3 plants/hill**	**4.65 t/ha**

Spacing effect (note: both are within SRI range) ***+0.08 t/ha***

30 x 30 cm	**5.08 t/ha**	**vs.**	**25 x 25 cm**	**5.00 t/ha**

Soil effect (averaged for equal number of trials with compost and NPK fertilization)
Clay (better) soil 6.75 t/ha vs. Loam (poorer) soil 3.72 t/ha

Clay (better) soil without either compost or NPK amendments 4.25 t/ha

Table 8: SUMMARY COMPARISONS OF FACTORIAL TRIAL RESULTS, MORONDAVA, 2000, AND ANJOMAKELY, 2001

	Standard Practices (t/ha)	SRI Practices (t/ha)	*Increase*
Morondava			
HYV (2798) (N=144)	2.84	6.83	*140%*
Traditional (*riz rouge*) (N=144)	2.11	5.96	*182%*
Anjomakely			
Good (clay) soils (N=120)	3.00	10.35	*245%*
Poor (loam) soils (N=120)	2.04	6.39	*213%*
	20-day seedlings 3 plants per hill standing water fertilizer (NPK)	8-day seedlings 1 plant per hill water control compost	

	Standard Practice (t/ha)	SRI Practice (t/ha)	Difference (t/ha)
Young Seedlings	20/16 days	8 days	
Morandava	2.61	3.96	1.35#
Anjomakely	3.80	6.28	2.48
Water Management	Flooding	Water control	
Morandava	2.86	3.71	0.85#
Anjomakely	4.34	5.75	1.41
Plants per Hill	3 seedlings	1 seedling	
Morandava	3.05	3.51	0.46#
Anjomakely	4.65	5.43	0.78
Fertilization	NPK	Compost	
Morandava	3.69	3.96	0.27#
Anjomakely	4.48	5.49	1.01*

#All Morondava trials done on poorer soils (*sable roux*, sandy) than those at Anjomakely

*All Anjomakely trials were done with traditional variety (*riz rouge*) whereas Morandava trials were half with traditional variety, half with improved, high-yielding variety (2798).