# SRI EXPERIMENTATION IN THE FIANARANTSOA REGION OF MADAGASCAR, 2000-2001

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**Abstract**
*On-farm experiments were conducted in the high plateau of Madagascar to evaluate the critical variables of SRI. Results showed that a minimum grain yield can be about 8 t/ha if the main factors are used under the optimal conditions which have been identified through the experiment. Therefore, new technical recommendations are available for intensive rice cropping, mainly with regard to water management, weeding, seedling number for transplanting, and fertilizer application.*

## INTRODUCTION

The system of rice intensification (SRI) has reached a yield as high as 21 t/ha on the fields of Ralalason in Soatanana in 1999. Recognizing the opportunities that this system could provide to farmers, it was decided in February 200 to form a consortium with the support of CIIFAD, to bring together three organizations, ESSA, ATS and FOFIFA, for the purpose of evaluating and promoting this system in Madagascar. The particular role for FOFIFA has been to conduct precise experimentations working with farmers on their fields to have realistic conditions.

This report shares the results of experiments in the Fianarantsoa region between August 2000 and March 2001, examining the question of what are the critical variables in SRI. There were four trials done to verify aspects of the SRI methodology, working with the effective participation of farmers. This is the sort of participatory research strategy that we need to be applying directly in the rural environment.

The establishment of this series of trails had necessarily to follow the cultural calendar and the system of cultivation common in the high plateau region in the south of Madagascar. During the season between rice crops (contre-saison), potatoes are grown, followed by beans, and toward the end of the season, there is rain which suffices for irrigated rice cultivation. The period of application of compost is this between-season, not directly preceding planting of rice.

The trials had two objectives: to test the potential of SRI as a technique for maximizing production, thereby being an ideal solution for the fight against poverty and for advancing the country on the path of development; and to evaluate the principal factors involved in SRI to establish scientific explanations for their roles and contributions to this system of cultivation.

## MATERIAL AND METHODS

We conducted four trials with plots completely randomized within blocks, and with three replications, except for the first trial [where randomization was not possible given the nature of the water control variable -- adjacent plots need to have the same water status]. Non-experimental factors were maintained at an optimal level.

**Trial 1: Water Control**

Treatment 1 = Periodic irrigation with a superficial water level during the growth phase -- applying water first two days after transplanting and then maintaining a cover of water about 5 cm deep during one week. Thereafter drying the soil to the point where its surface cracks, and putting back water every two weeks. Once the reproduction phase begins (panicle initiation), maintaining a depth of 5 cm of water in the paddy field. Drain the field one week before harvesting.

Treatment 2 = Periodic irrigation applying water and draining it as described in T1; maintain a depth of 10 cm once reproduction begins, and drain the field one week before harvesting.

Treatment 3 = Continuous irrigation with a constant water level of 10 cm.

Treatment 4 = Continuous irrigation with a deeper water level, at least 10 cm and usually 20 cm constantly.

**Trial 2 : Number of Plants per Hill** (*brins par touffe*)

The young plants were transplanted with a square spacing of 30 x 30 cm, and with the number of plants per hill varied as follow:

Treatment 1 = 1 plant per hill
Treatment 2 = 2 plants per hill
Treatment 3 = 3 plants per hill

**Trial 3: Weeding**

Treatment 1 = Four weedings, beginning 10 days after transplanting, and weeding every 15 days.

Treatment 2 = One weeding plus use of herbicide, with the first weeding 10 days after transplanting, then the application of herbicide.

Treatment 3 = Herbicide application to weeds post-emergence.

**Trial 4 : Fertilization**

Treatment 1 = Control -- no fertilization

Treatment 2 = Compost -- 10 t/ha

Treatment 3 = NPK -- 90-45-30 kg/ha (200 kg/ha NPK 11-22-16 + 50 kg/ ha of urea after transplanting, and urea 100 kg/ha after panicle initiation)

## RESULTS AND INTERPRETATION

### Trial 1: WATER CONTROL

*The effect of different water application regimes on components of yield and on yield with japonica rice variety 2067.*

| | COMPONENTS OF YIELD | | | | YIELD (T/ha) |
|---|---|---|---|---|---|
| | Number of grains per panicle | Number of panicles per hill | Number of hills per $m^2$ | Weight per 1000 grains | |
| T1: Periodic water supply, 5 cm during reproduction | ***133*** | ***19*** | 11 | 23 | 6.5 ***bc*** |
| T2: Periodic water supply, 10 cm during reproduction | ***152*** | ***28*** | 11 | 23 | 10.7 ***a*** |
| T3: Continuous water, 10 cm | 136 | 21 | 11 | 23 | 7.2 ***abc*** |
| T4: Continuous water, 10-20 cm | 120 | 10 | 11 | 23 | 4.4 ***c*** |

p.p.d.s (0.01) = 4.1 t/ha

A yield over 9.5 t/ha is obtained with an irrigation regime of periodic water application, starting with a superficial water level after transplanting and gradually increasing it to 10 cm during the period of reproduction. The results of treatment T2 appear to provide the optimum conditions with neither insufficiency nor excess of water during the growing of rice. A superficial layer of water apparently does not suffice to meet the plant's hydraulic needs, and as a consequence the number of panicles and the number of grains formed is limited.

On the other hand, the plant gets asphyxiated under conditions of permanent submersion (DOBELMAN 1970). The activities of microorganisms in the process of biological transformation of organic matter are reduced under anaerobic conditions. The alternating draining and irrigation improves the soil conditions for microorganisms and as a consequence this appears to contribute to the mineral nutrition of the plant within the rhizosphere (TAKAI 1969).

**Analysis of Variance in Yield**

| *Source of Variation* | *df* | *SS* | *MS* | *Computed F* | *Tabular* | |
|---|---|---|---|---|---|---|
| | | | | | *F5%* | *F1%* |
| Replication | 2 | 16.11 | 8.1 | | | |
| Treatment | 3 | 62.44 | 20.8 | 10.8** | 4.76 | 9.78 |
| Error | 6 | 11.51 | 1.9 | | | |
| Total | 11 | 90.07 | | | | |

C.V = 19 % ** = *highly significant at 1% level*

There is a very significant difference, 6.3 tons per hectare, between the yield from keeping rice continuously flooded under 20 cm of water, and the optimal conditions. In conclusion, this trial confirms the importance of the SRI method of periodic irrigation, and a superficial level of water during the growth phase, increasing gradually to a greater depth during the reproductive phase.

**Trial 2: NUMBER OF SEEDLINGS**

*The effect of the number of seedlings transplanted per hill on components of yield and on yield with japonica rice variety 2067.*

| | COMPONENTS OF YIELD | | | | YIELD (t/ha) |
|---|---|---|---|---|---|
| | Number of grains per panicle | Number of panicles per hill | Number of hills per $m^2$ | Weight of 1000 grains | |
| T1 : 1 plant | 113 | 26 | 11 | 23 | 7.5 ***b*** |
| T2 : 2 plants | 118 | 30 | 11 | 23 | **8.9** ***a*** |
| T3 :3 plants | 110 | 27 | 11 | 23 | 7.5 ***b*** |

p.p.d.s (0.05) = 0.87 t/ha

**Analysis of Variance in Yield**

| *Source of Variation* | *df* | *SS* | *MS* | *Computed F* | *Tabular* | |
|---|---|---|---|---|---|---|
| | | | | | *F5%* | *F1%* |
| Replication | 2 | 0.74 | 0.37 | | | |
| Treatment | 2 | 4.2 | 2.1 | 14* | 6.25 | 18 |
| Error | 4 | 0.61 | 0.15 | | | |
| Total | 8 | 5.56 | | | | |

C.V = 4.8% * = *significant at 5% level*

Under the soil and other conditions of this trial, increasing the number of plants per hill improves yield but only up to two plants per hill, not more. In this case, there was a yield increase of 1.4 t/ha between transplanting 1 vs. 2 seedlings per hill. Under conditions of average soil fertility, transplanting 3 plants per hill appears to be too dense. There is competition for nutrients between plants and for light for photosynthesis, leading to insufficient formation of tillers and grains. Between T2 and T3, the number of grains formed per panicle diminished from 118 to 110, and the number of panicles per hill from 30 to 27.

The conclusion from this SRI trial is the following. Although there could be more risk when transplanting just a single plant per hill, this was not evident. The nutrient reserves in the endosperm of the grain are largely sufficient for the plant, at least for four days and maybe up to five (DE DATTA 1981; VERGARA 1984). The application of water to a depth of 5 cm two days after transplanting comes when the roots have begun to extend themselves in the soil. One can improve results by transplanting 2 plants per hill, instead of 1, if the soil is fertile. The result, of course, depends on the degree of fertility of soil, and results from such an experiment are likely to vary depending on soil and other factors affecting growth. [Note: Other SRI evaluations have pointed to 1 plant per hill as the most productive practice. The results here indicate a need for further evaluation of this factor. Single plants are definitely better than 3 plants per hill, but possibly 2 plants per hill, depending on soil conditions, may be more productive. There could also be variances in varietal responses to this factor of plants per hill.]

**Trial 3 : WEEDING**

*The effect of two different treatments (weeding vs. herbicide) on the components of yield and on yield with the japonica rice variety 2067.*

| | COMPONENTS OF YIELD | | | | YIELD (t/ha) |
|---|---|---|---|---|---|
| | Number of grains per panicle | Number of panicles per hill | Number of hills per $m^2$ | Weight per 1000 grains | |
| T1 : 4 weedings | 125 | 28 | 11 | 23 | 7.9 |
| T2 : 1 weeding + herbicide | 135 | 26 | 11 | 23 | **9.5** |
| T3 : Herbicide | 131 | 26 | 11 | 23 | 8.5 |

**Analysis of Variance in Yield**

| *Source of Variation* | *df* | *SS* | *MS* | *Computed F* | *Tabular* | |
|---|---|---|---|---|---|---|
| | | | | | *F5%* | *F1%* |
| Replication | 2 | 2.64 | 10.32 | | | |
| Treatment | 2 | 4.24 | 2.12 | 1.09 *ns* | 6.94 | 18 |
| Error | 4 | 7.76 | 1.94 | | | |
| Total | 8 | 32.64 | | | | |

C.V = 16 %  ns = *no significant at 5% level*

The statistical analysis of yields did not show a significant difference between weeding and herbicide use. But it did show a weak degree of significance (at the 20% level), with the better treatment being one weeding followed by the application of herbicide. The herbicide used, *Rifit extra*, in our experience has an effect not only on the elimination of weeds but also an effect of fertilizing the soil. The leaves in contact with the herbicide at first have a momentary drying out, but they become very green some time after the treatment.

[Note: These results are quite different from those usually obtained with SRI methods, where the number of weedings increases yield, presumably because of a *soil aeration* effect, stimulating greater microbiological activity in the rhizosphere. The finding here calls for further research to evaluate the effects of weeding (with a mechanical hand weeder) compared to the use of herbicides, as this is an important factor to be assessed. The amount of labor required for weeding with the hand weeder is for some farmers a deterrent to using SRI. If herbicides give as good or better results, or if just one weeding supplemented with herbicide application gives the best results, this should be known. This result could be affected by soil conditions, so a number of trials should be undertaken.]

**Trial 4 : FERTILIZATION**

*The effect of two types of fertilization (NPK and compost) on the components of yield and on yield with the japonica variety 2067.*

| | COMPONENTS OF YIELD | | | | YIELD (t/ha) |
|---|---|---|---|---|---|
| | Number of grains per panicle | Number of panicles per hill | Number of hills per $m^2$ | Weight per 1000 grains | |
| T1 : Without fertilization | 111 | 11 | 11 | 23 | 3.1 ***b*** |
| T2 : NPK | 123 | 19 | 11 | 23 | 6.1 ***ab*** |
| T3 :Compost | 128 | 25 | 11 | 23 | **8.0** ***a*** |

p.p.d.s (0.01) = 3.78 t/ha

**Analysis of Variance in Yield**

| *Source of Variation* | *df* | *SS* | *MS* | *Computed F* | *Tabular* | |
|---|---|---|---|---|---|---|
| | | | | | *F5%* | *F1%* |
| Replication | 2 | 0.04 | 0.02 | | | |
| Treatment | 2 | 36.48 | 18.24 | 18.29** | 6.94 | 18 |
| Error | 4 | 3.98 | 0.99 | | | |
| Total | 8 | 40.51 | | | | |

C.V = 17.5 %

** = *highly significant at 1% level*

The best treatment in this trial is clearly with compost, which permits a yield of 8 t/ha, compared to 3.1 t/ha in the control without fertilization. One can say that this is the residual effect of organic matter still in the soil of the rice paddy where there was previous cultivation of potatoes. There can also be minerals available from biological fertilization. A further advantage for improving fertility can be the better soil structure and capacity for retention of water in the soil (W. E. LARSON and C. E. CLAPP, 1984)

The results of this trial confirm also the effect of using chemical fertilizer, which gave a yield of 6.1 t/ha, typical for the soils in Madagascar in general (ANDRIANAIVO, 1991). However, with regard to use of organic fertilizer, it is well known that the best results do not come in the first year of use, but rather beginning in the second year. One should think in terms of the cumulative effect of compost as it is periodically applied in the dry season and the contra-saison (D. S. JENKINSON and A. E. JOHNSON, 1977). The following table recapitulates the yields of rice obtained in the four sets of trials for SRI in the Fianarantsoa region.

| | **Water Control (t/ha)** | **Number of plants/hill (t/ha)** | **Weeding (t/ha)** | **Fertilization (t/ha)** |
|---|---|---|---|---|
| T1 | 6.5 | 7.5 | 7.9 | 3.1 |
| T2 | **10.7** | **8.9** | **9.5** | 6.1 |
| T3 | 7.2 | 7.5 | 8.5 | **8.0** |
| T4 | 4.4 | | | |

**CONCLUSIONS**

We can see that SRI techniques for rice culture can guarantee a yield of 8 t/ha at a minimum. Knowledge of the principal factors of SRI contributes to better and better results. The factors which must not be neglected if one is to achieve the benefits of this method are the critical factors. Actually these are identified and determined with much precision according to the results of experimentation. The optimal utilization of these factors mentioned above is:

1. **Water control:** Periodic irrigation starting during the growth phase with a superficial application of water, increasing gradually to a constant depth of 10 cm during the reproductive phase.
2. **Fertilization:** The best results are with a rotation in crops, using compost on the rice paddy for the preceding season (contra-saison).
3. **Number of plants to transplant:** Two plants are best in the case of soil of moderate fertility.
4. **Means of controlling weeds:** Of the two possibilities, using a hand weeders or herbicides, neither four weedings nor herbicide by itself gave the best results. The best was a combination of weeding and then the use of a post-emergence herbicide.

Note that the factor of transplanting **young plants** was not examined, being taken as the foundation for the SRI methodology. Having gotten these results with separate trials, we envision in the next year a testing of their synthesis to verify synergy among these four factors.

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