Scaling-up the System of Rice Intensification (SRI) in Goundam and Dire, Timbuktu 2009/2010

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List of Acronyms and Abbreviations

CAFON	*Coopérative Artisanale des Forgerons de l'Office du Niger*
CFA	West African CFA Franc: 1 US$ = 480 CFA
DAP	Di-Ammonium Phosphate (Inorganic Phosphorus Fertilizer)
DRA	*Direction Régionale d'Agriculture*, Government Regional Agriculture Service
IER	*Institut d'Economie Rurale du Mali*, National Agriculture Research Institution
n	Sample size
PIV	*Périmètre Irrigué Villagoise*, irrigated village perimeters
SAC	*Secteur de l'Agriculture du Cercle,* Government Agricultural Service of the Circle
SE	Standard error

Acknowledgments

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Executive Summary

The System of Rice Intensification (SRI), introduced to Mali and the Timbuktu region by Africare in 2007, has shown remarkable results: increasing rice production by 66-87% and doubling the revenue (per cultivated surface area) with 60 farmers in the Goundam and Dire Circles in 2008. Given these results, farmers in the region requested that Africare provide further technical support. 2009/2010 season activities were therefore designed to: i) scale up SRI within the area already practicing SRI, ii) introduce SRI into three new zones in the Timbuktu region; and iii) develop innovations associated with SRI practices. Africare collaborated with the Government Agriculture Technical Service at the local and regional level, and with the private firm CAFON.

Participation of volunteer farmers more than quadrupled from 60 farmers last year to 270 farmers this season, and extended from 12 villages to 28 villages. Village communities developed a farmer-to-farmer approach to assist the new farmers in correctly implementing the various SRI practices. Due to the delay of the cropping season by over one month, many farmers who had initially signed up were not able to participate. Also surface extension per farmer did not happen as farmers initially planned, but farmers opted to participate with a small plot (on average 200 m^2) than not-at-all. This year was therefore a year where knowledge of SRI was consolidated within the farming community and passed on to other farmers. The basis seems solid, as the applications of SRI practices were very well done in all 28 villages.

Average SRI paddy yield for 130 randomly selected farmers (out of the 270 farmers) was 7.71 t/ha compared to 4.48 t/ha in farmers' usual practice fields, which represents a 72% yield increase. Congruent with last year's results, all measured yield parameters were superior in SRI plots compared to farmers' fields. As yield levels decline with advancing cropping season, SRI plots produce similar yields of 6-8t/ha in locations with a 2-month cropping season delay compared to the conventional plots that were seeded under ideal conditions and in time. Thus under sub-optimal conditions SRI farmers can still produce acceptably high yields, being less vulnerable to climate variability.

A test with 15 varieties confirmed high yield potential for the locally used improved varieties Wassa, Nerica L2 and BG20-2 with 12.1 t/ha, 13.4 t/ha and 13.6 t/ha respectively. Two short cycle varieties newly developed by IER, DKA-11 and DKA-1 obtained high yields of 9.5 t/ha and 10.3 t/ha, respectively. Farmers showed much interest to test these two varieties next year and compare them to their short cycle varieties. Seven indigenous *O. glaberrima* varieties produced an average SRI yield of 4.3 t/ha, compared to 2.6 t/ha when planted with traditional practices. Farmers maintain these varieties, as they are highly important for food security, have a preferred taste, and are hardy under adverse environmental conditions. The biodiversity value of these varieties should not be underestimated, as the African rice was domesticated in this area some 3500 years ago.

An irrigation test showed that under SRI practices, water savings can be expected to be at least 32%.

Africare introduced the first hand tractor into the Timbuktu region. A number of field demonstrations and tests indicate that it is less costly to prepare the soil using a hand tractor than the big field tractors or manual land preparation.

Africare assisted 29 farmers from 11 villages to install compost pits next to their rice paddies. On average, farmers installed $3m^3$ of composts, which is sufficient to fertilize 0.12 to 0.18 hectares, or about half of their rice production surfaces, at a dose of 10 or 15t/ha, respectively. Rice straw represents the bulk of the composting material with small additions of animal manure to facilitate decomposition. The compost will be ready within 3 to 4 months, and can be applied at the beginning of the next rice-cropping season. It is recommended to associate composting techniques with SRI introduction and extension.

Based on last year's first promising but inconclusive test of the System of Wheat Intensification (SWI), this year's test, in three locations, was set up to evaluate different plant spacing in order to optimize yields. In addition, a prototype-seeding machine that seeds in lines was tested, developed by the private firm CAFON. A seeding machine that can seed in pockets, as required for SWI, is under development, and ready to be tested in the next season. Harvest results will be available by late March, and a results' report of this season's SWI findings will follow.

Introduction

Following the successful first test of the System of Rice Intensification, or SRI, in the village of Douegoussou in Goundam in 2007, Africare, in collaboration with the *Secteur d'Agriculture du Cercle* (SAC) of Goundam Circle, led an SRI evaluation with 60 farmers in 12 villages in the Goundam and Diré Circles during the 2008 cropping season. The results largely surpassed expectations: average yield for all farmers using SRI was 9.1t/ha, ranging from 5.4 t/ha for lowest yield to 12.4t/ha for the highest. On average SRI yields were 66% higher than the yields of 5.49t/ha in the control plots, and 87% higher than yields of 4.86t/ha in the surrounding rice fields. Production cost per unit of rice harvested was 30% less under SRI due to both increased yields and reduced inputs. These include using 1) 85-90% less seed (six kg of seeds per hectare compared to 40-60 kg under farmers' usual practice), 2) 30% less chemical fertilizer (due to application of organic matter), and 3) 10% less water for irrigation. Note that as reductions of 25-50% in water use have been achieved elsewhere in the world, this is not yet an optimal result. Given these results, farmers in Timbuktu region expressed great interest in adopting SRI, and requested that Africare provide further technical support.

Based on the experiences gained in 2007 and 2008, and with the availability of improved technical guidelines for local agro-ecological conditions (Africare and SAC, 2009), this season's activities were designed with the following objectives:

i. Scaling up SRI within the area already practicing SRI
ii. Introducing SRI into three new zones in the Timbuktu region
iii. Developing innovations associated with SRI practices.

Methodology

<u>Site description for scaling up:</u> The approach adopted this year aimed to obtain better geographic coverage of the four communes where SRI was introduced in 2008, and to make SRI techniques available to interested farmers in these communes. The four communes are Douekire (Goundam Circle), Arham, Bourem and Kondi (all three in Dire Circle), which have a total of 32 rice-growing villages working in 126 PIVs with a total surface of over 3300 hectares. Scaling up efforts included the 12 SRI villages from last season, along with 8 neighboring villages, thus a total of 20 villages. For the 12 remaining rice growing villages of the commune, intensive two-day farmer exchange visits were organized, so that by the end of 2009, all rice-growing villages in the four communes were able to either practice SRI or to learn about SRI practices (Table 1).

Table 1: Characteristics of the rice-growing villages in the four communes Arham, Kondi, Bourem and Douekire

	Village	Commune	Cercle	PIV surface in ha	Number of PIVs
Old SRI Villages 2008					
1	Morikoira	Arham	Dire	90	4
2	Hara Hara I	Bourem	Dire	124	5
3	Horogoungou	Bourem	Dire	161	4
4	Bourem SA	Bourem	Dire	496	16
5	Findoukaina	Kondi	Dire	20	2
6	Dougeoussou	Douekire	Goundam	60	2
7	Kessou Koreye	Douekire	Goundam	248	7
8	Katoua	Douekire	Goundam	130	4
9	Bagadadji	Douekire	Goundam	34	1
10	Adina Koira	Douekire	Goundam	30	1
11	Niambourgou	Douekire	Goundam	165	8
12	Donghoi	Douekire	Goundam	67	3
	Total			***1625***	***57***
New SRI villages 2009					
13	Arham	Arham	Dire	75	2
14	Kondi	Kondi	Dire	94	3
15	Kondi-Keina	Kondi	Dire	?	1
16	Kobe	Bourem	Goundam	12	1
17	Goumel	Douekire	Goundam	194	8
18	Saobono	Douekire	Goundam	?	1
19	Douekire	Douekire	Goundam	90	4
20	Djinde Houndou	Douekire	Goundam	55	2
	Total			***520***	***22***
Villages included in training and farmer exchange-visits					
21	Hara Hara II	Bourem	Dire	151	6
22	Ko¥gourou	Bourem	Dire	117	5
23	Sadjilambou	Bourem	Dire	113	4
24	Gari	Bourem	Dire	60	2
25	Douta	Bourem	Dire	37	1
26	Diawatou	Bourem	Dire	55	3
27	Tangassane	Doukire	Goundam	105	4
28	Garthir_	Doukire	Goundam	125	5
29	Takakoyt	Doukire	Goundam	?	1 +
30	Gallaga	Doukire	Goundam	?	1 +
31	Babaga,	Doukire	Goundam	?	1 +
32	Kessou Bibi	Doukire	Goundam	399	14
	Total			***1162***	***47***
	All villages			**3307**	**126**

<u>SRI introduction:</u> In addition to the four communes, SRI was introduced to Arabebe, Tomba and Doya, villages in the Niafunke circle, and to the villages of Tintelout, Bangara, Timbarajan, Hondobongo, and Hamakoira, located in the Timbuktu circle. SRI can spread from these new villages to other neighboring villages, which are not yet familiar with SRI.

<u>Innovation development:</u> Based on the conclusions and recommendations aimed at increasing productivity or reducing costs from last year's evaluation (Styger, 2009) and to further innovate with the SRI principals, five innovations were carried out this year:

- ***Variety test with SRI practices***: This responds to the demand by farmers and technical staff of Africare and DRA to clarify the production potential of different varieties under SRI cultivation practices.
- ***Irrigation test***: SRI practices allow significantly reduced need for irrigation water. In the 2008 tests, SRI plots were scattered among the conventional plots and thus were irrigated according to a predetermined irrigation schedules within the irrigation perimeters, making it difficult to control water levels according to recommended SRI practice. This year, a test was set up where irrigation water was properly controlled, thus providing an indication of actual water savings using SRI methods in the Timbuktu environment.
- ***Introduction of a hand tractor:*** This responds to the necessity for improved soil preparation under SRI, which if done by hand only – the current practice - requires a much labor.
- ***Composting:*** one of the constraints identified last year was the potential shortage of organic matter to fertilize the SRI fields in the future. In response, the technique of composting was introduced, which was specifically adapted to the irrigated rice production system.
- ***System of Wheat Intensification (SWI):*** Based on last year's work to test the SRI principals with the wheat crop in three villages, and based on the results (Styger and Ibrahim, 2009), a test was carried out in three locations studying the main factors that influenced wheat productivity under SWI last year: planting density and seeding techniques.

Collaboration: Different types of collaboration were established this season:
- As in previous years, Africare established a collaboration agreement with the Government agriculture technical service-- the *Secteur de l'Agriculture du Cercle* (SAC) of Dire and Goundam with support from the *Direction Régionale d'Agriculture* (DRA) in Timbuktu-- to implement the field activities.
- Africare collaborated with the IER rice-breeding program of Sikasso. The IER rice-breeding specialist Dr. Fousseini Cisse provided new rice varieties developed in Mali, which are in the process of being tested and released across Mali. Africare designed the test protocol together with the specialist.
- Collaboration with private firm *Coopérative Artisanale des Forgerons de l'Office du Niger* (CAFON) to acquire a hand tractor and training in its maintenance and use for farmers and Africare staff by CAFON mechanics and technicians.

Staffing: Five Africare field agents and four SAC field agents carried out the fieldwork together. The SRI project was coordinated through the Africare TFSI office in Goundam and was supported by a technical consultant, who provided technical supervision.

Timeline: The activities were implemented over the period of nine months, from June 2009 to February 2010. The seeding of rice nurseries extended from June 7 to September 28, and harvest period from November 21 to January 25, 2010. The cool season, unfavorable for rice productivity, started around mid-November. SWI plots were installed between

November 15 to November 23, 2009. The harvests began at the end of February and will extend until the end of March 2010.

Control plots: This year, the control plots for the SRI plots were selected from among farmers' conventional practice rice plots. The main criterion applied was that the same seed be used in the control plot and in the SRI plot.

Data collection: For all participating SRI farmers, data was collected on SRI plot size, field preparation, organic manure application, planting (varieties used, spacing, age of transplanted seedlings), crop management (weeding, irrigation), and some data on labor and input costs.

Harvest procedure: Harvest was done with 130 farmers in their SRI plots and adjacent rice fields. In each plot, five $1m^2$ squares were placed at random in the plot. Grain was harvested separately for each of the five sub-plots, threshed and weighed with a precision PESOLA™ scale. At the same time, the moisture content of grain was measured using a FARMEX MT-PRO™ moisture meter. Number of hills per square meter was counted to determine planting density. 10 plants were randomly selected to count number of tillers and panicles, to measure height of the plants and length of the roots. Also, 5 panicles were selected randomly in each plot. Their panicle length was measured, and number of filled and empty grains was counted per panicle.

Results

A) SCALING UP SRI IN 28 VILLAGES

1. Number of farmers' participating in SRI extension

The flooding of the arms of the Niger River provides water for the rice crop planted in irrigated village perimeters (PIVs). This year, the floods arrived more than one month later than last year. Any delay in the rice-cropping season will result in yield declines. Thus, when water finally became available, farmers had little time left to stay within the agricultural calendar, and planted their rice fields 'in panic'. For some villages (among them Adina-Koira, a SRI village from last year), the water arrived too late, so farmers were not able to plant their PIVs at all. They tried to borrow some plots for the season from other villages with earlier water access. This meant splitting up plots and sharing the already small plots among more people.

This delay was not favorable to this year's SRI extension work. Africare's approach was to leave the decision-making about SRI to the farmers. The number of farmers and size of the SRI fields, as well as the location of the fields within the PIV was left to village communities to decide. With this approach, there was no outside influence on the extent of participation. Only willing farmers would participate, giving an unbiased indication of how much SRI as an innovation is valued by the rice growers of Timbuktu.

Africare field agents and the SAC field agents were present during all the important technical steps to guide farmers, emphasizing that the new farmers understand the technical requirements, and that the implementation be well done. For the eight additional villages in the four communes and the three villages in the Niafunke and Timbuktu circles, the approach was similar to last year's approach, where village communities each selected 5 volunteer farmers who participated in implementing the SRI practices on small plots with technical guidance from Africare and SAC field agents. Farmers in Arabebe village insisted testing with 11 farmers rather than five. Among the 11 farmers, two had their own small PIVs and put half of their land under SRI practices.

Due to the delayed start of the cropping season, many volunteers who signed up for SRI withdrew at the last minute, as they did not have the time to do all the preparatory fieldwork within the little time available. In some of the villages, SRI plots had already been delimited, but were abandoned because of lack of time to plant them. Farmers did tell us that the total amount of land planted under SRI was much smaller than what they had planned. An overview is given in Table 2.

The 60 farmers from the 12 villages in 2008 increased to 200 farmers this year, 40 farmers participated in the eight surrounding villages, and 30 in eight new villages in the Niafunke and Timbuktu circles, which amounts to a total of 270 farmers. All 60 farmers from last year participated in this year's SRI extension, with the exception of a few who emigrated to Bamako or elsewhere for the season. The total area under SRI was 6.05 hectares, and the average plot size was 196 m^2 per farmer. For the new farmers, the plots were usually around $100m^2$. Many of previous SRI farmers doubled their surfaces compared to last year, if they were able to plant early in the season. The ones who had to plant late, preferred to at least do a small plot, rather than none at all.

One unexpected development was that in several villages, not every farmer who wanted to practice SRI was allowed to do so. It was up to the villagers to screen volunteer participants, to decide which were the 'serious' farmers, as the villagers themselves wanted to assure the full success of SRI. In many of the villages, SRI fields were regrouped in one location, so that farmers could help each other during land preparation, nursery management, transplanting, and weeding. This also facilitated irrigation management, because good SRI practice calls for a wetting and drying irrigation cycle different from conventional irrigation (continuous flooding). This allowed farmers to reduce their irrigation applications by more than they could in 2008.

'New' SRI farmers began by helping the 'old' SRI farmers in their fields, thus learning directly how to carry out correctly the various SRI management techniques before they began SRI in their own fields. Both Africare and DRA field agents were present at the beginning of each new activity to guide farmers. Interested villagers who were not among the SRI farmers selected for this year helped out in the various field operations, thus acquiring skills that will allow them to join 'the SRI group' next year.

Table 2: Number of SRI farmers and SRI surface area for 28 villages (2009/2010)

	Villages	Number of SRI farmers	Area under SRI (m2)	Average area per farmer (m2)
12 villages from 2008 in Goundam and Dire Circle				
	Bourem	19	2603	137
	Harahara	25	8061	322
	Horogoungou	20	11600	580
	Fendoukaina	18	4516	251
	Morikoira	16	1336	84
	Niambourgou	6	2969	495
	Donghoi	26	2886	111
	Adina koira	16	309	19
	Bagadadji	15	2500	167
	Douegousou	11	6443	586
	Katoua	16	5080	318
	Kessou Koreye	12	3237	270
		200	**51540**	**278**
8 new villages neighboring the old 12 villages				
	Kobe	5	513	103
	kondi	5	312	62
	Arham	5	290	58
	Kondi kaina	6	247	41
	Djinde Hondou	5	393	79
	Douekire	5	502	100
	Goumel	4	622	156
	Saobomo	5	520	104
		40	**3399**	**88**
8 new villages in Niafunke and Timbuktu Circle				
	Tintelout	2	200	100
	Bangara	4	400	100
	Arabebe	11	2652	241
	Timbarajen	4	400	100
	Doya	2	200	100
	Tomba	5	1156	231
	Hondobongo	1	248	248
	Hamkoira	1	316	316
		30	**5572**	**180**
	28 villages	**270**	**60511**	**196**

The management-intensive approach to working with field agents and the pioneer farmers in 2008 aimed to establish high-quality foundation of SRI knowledge. This meant working closely with a small group of farmers. In 2009, the knowledge acquired by farmers and field agents spread easily and fast as it was built on a solid foundation.

Especially in the old villages, where SRI plots were regrouped into one location, SRI crop management was most often impeccable and done according to recommended guidelines.

SRI farmers of Bagadadji village position themselves in their SRI plots, totaling to 0.25 ha. Notice that no weeds are growing, the plots are in the 'drying stage' of the irrigation cycle, and the cono-weeder was applied in both directions: all indicating that farmers follow the technical guidelines correctly.

SRI plot showing a visible pattern that the plot was cross-weeded, using the cono-weeder correctly in both directions. The plot is not inundated, as recommended during the tillering phase of the rice.

13 of the 15 SRI farmers of Bagadadji (standing) and Africare and SAC field agents (front row) during a SRI field visit.

2. Rice grain yield

Average paddy yield for 130 SRI farmers was 7.71 t/ha compared to their conventionally grown fields with 4.48 t/h (adjusted to 14% grain moisture content) (Table 3). This represents a 72% yield increase of SRI over farmer's practice.

Table 3: SRI and farmer practice yield in Goundam and Dire Circles, 2009/2010

	t/ha	SE	n
SRI	**7.71**	0.26	130
Farmer Practice	**4.48**	0.16	130

* SE: Standard Error, n: sample size

The range of yields was large. For SRI it extended from 2.7 t/ha being the lowest yield to 13.4 t/ha being the highest. For the control the lowest yield was 0.3 t/ha and the highest 9.75 t/ha. Five out of the 20 villages, namely Morikoira, Adina, Djinde Houndou, Kondikeina and Douekire had to forego their harvests, as they were too late in planting. The yield range can be explained in part by the extended period of when farmers were able to start their cropping season (Table 4).

Table 4: Planting parameters for SRI and control plots

	SRI (n=120)	Control (n=120)
Date for Nursery establishment	July 6 - Sept 28	June 7 - Sept 2
Date for Transplanting	July 22 - Oct 10	July 22 - Oct 1
Age of transplanting, range (days)	8 - 17	15 - 45
Age of transplanting, average (days)	11.7	27.7
Number of cropping season days (average, n=120)	127	139

The age of transplanted seedlings greatly varied in the control plots, between 15 and 45 days (Table 4). In the first villages to plant, nurseries for SRI and farmers' fields were not started at the same time. The latter were installed too much in advance of the actual flooding. Nursery planting dates were based on guesswork in order to be ready with the seedlings when water became available. With the delay of the floods, the age of the plants in the nursery increased to as much as 45 days in some villages. SRI nurseries were only established once the floodwater arrived in order not to exceed the 2-leaf stage for transplanting. In other villages, where farmers waited for the floods to arrive to install their SRI and village nurseries, transplanting happened much earlier than under the usual practice of 25 to 30 days. For instance, in the village of Bagadadji, the 100 farmers planting the 30-hectare PIV, transplanted their rice plants at the age of 17 days. Farmers were inspired by SRI practices of planting young seedlings, and thus were able to gain time over an advancing season.

In order to better understand the relationship between yields and the time when rice-growing season was started in the different villages, the data were plotted out on a graph (Figure 1). The figure shows clearly that yields decline when planting takes place later in the season, both for SRI and control plots. The regression lines show the change of yields along the season. Average yield for SRI reaches almost 12t/ha when season starts in June and decreases steadily to about 5 t/ha when started in mid-September. For the control plots, highest yields are about 7.5 t/ha when rice is seeded in June, falling to about 3 t/ha when seeded in September.

The graph shows also an important advantage of using SRI methods for farmers who are in non-optimal conditions, as also seen in last year's result (Styger, 2009). For instance, villages, which were able to begin the season only in August, reached yields of 6 to 8 t/ha when applying SRI practices. The same yields were achieved under conventional practices in villages that started in June. Even with a 2-month delay and working in sub-optimal conditions, farmers are still able to secure production, important for improving food security of the region in the face of climate variability.

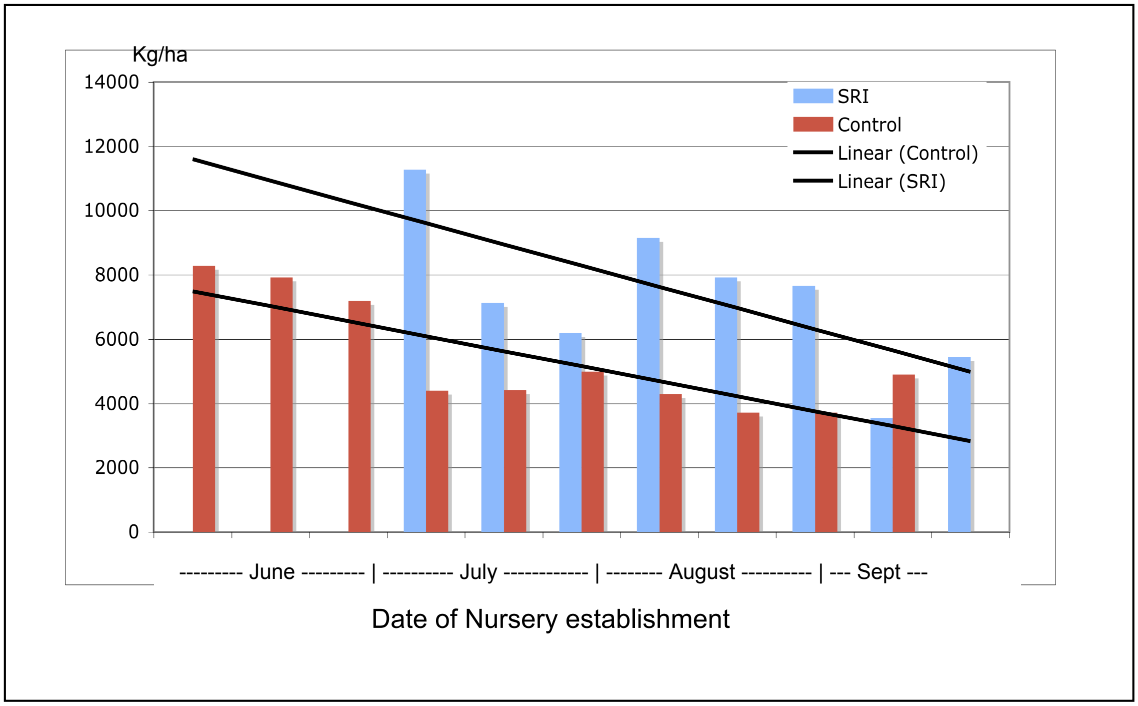

Figure 1: Rice grain yield (kg/ha) in relation to the time of nursery establishment for SRI plots and for control plots (n=130)

Another important result within this context is that SRI plots matured and were harvested 12 days earlier than under conventional practice. Average SRI crop cycle for all 130 farmers was 127 days compared to 139 days in the farmers' conventional practice fields (Table 4).

3. Rice variety performance

Six varieties were used in the SRI villages (Table 5). Best performing varieties were BG90-2 and RPKN2 with an average of more then 10 t/ha. Nerica L2 and Andy 11 produced between 7 and 8 t/ha. Least productive were D-52 and Watt, both varieties that were used in late planting villages, with yields of 5.2 and 4.4 t/ha respectively. D-52 was planted in two late villages where PIVs were flooded, which reduced yields in SRI plots. As for RPKN2 and Adny11, they replaced the preferred and longer cycle BG90-2 in many villages. Productivity for both varieties was high when planted early.

There is much to learn about yield performance of the different varieties under SRI. It is not a static parameter, but depends strongly on the starting of the cropping season in the context of Goundam and Dire. Monitoring SRI yields over a number of years will help deepen understanding of yield performance according to changing environmental and climate conditions.

Table 5: Rice grain yield (kg/ha) for six varieties used in SRI plots and farmers' fields

Variety	SRI kg/ha	SE	n	Farmer's field kg/ha	SE	n	SRI % increase
BG90-2	10768	334	20	5525	415	26	+ 95
RPKN2	10122	427	16	4104	260	16	+ 157
Nerica L2	7921	452	20	4434	302	12	+ 79
Adny 11	7380	560	34	4899	321	34	+ 51
D-52	5185	232	14	5005	199	19	+ 04
WATT	4353	335	13	1819	298	13	+ 139

4. Yield parameters

Yield parameters and other crop characteristics are presented in Table 6.

Table 6: Yield parameters for SRI and farmer field plots

	Tillers/hil Number	SE	Panicle/hil Number	SE	Fertile tillers %	Tillers/m2	Panicles/m2
SRI	29.1	0.74	27.9	0.75	95.9	387	372
Farmer field	19.0	0.41	17.8	0.43	93.9	366	344

	Plant height cm	SE	Root length cm	SE	Panicle length cm	SE	Grains/panicle Number	SE	Empty grains %	SE
SRI	82.1	1.54	20.5	0.39	21.8	0.22	128.6	3.17	17.7	1.15
Farmer field	78.9	1.76	17.2	0.40	20.1	0.21	98.4	2.21	21.3	0.96

As with the 2008/2009 results (Styger, 2009), all measured yield parameters were superior in the SRI plots compared to farmers' fields. In the SRI plots the plants had 29 tillers compared to 19 tillers per hill in the farmers' field, the number of panicles per hill were 27.9 and 17.8 respectively. The number of SRI tillers and panicles per square meter were also superior compared to farmer's field with a total of 372 panicels/m^2 compared to 344 panicles/ m^2. SRI panicles were about 2 cm longer, had 30 more grains and had a lower percentage of empty grains with 17.7% compared to 21.3% empty grains in farmers' fields. SRI plants are slightly taller than when planted conventionally and their roots are longer and bulkier, certainly a result from improved soil aeration.

5. Crop management

A summary of various crop management interventions is presented in Table 7. All SRI farmers tilled the soil, but this year more farmers preferred manual tilling over tractor tilling. Tractor work in the region creates often badly leveled fields, not suitable for SRI plots. More then half of the farmers did not till their conventionally grown rice fields. About 70% of farmers leveled the fields with wooden boards they pushed over the mud surface. This method proved to be much less labor intensive than pulling wooden beams across the mud, as done last year. 1 % of the farmers used the hand tractor Africare bought for demonstrative purposes.

Table 7: Percentage of farmers executing different crop management tasks for SRI plots and farmer fields.

	SRI	Farmer Field		SRI	Farmer Field
Soil preparation			***Weeding***		
Manual	87%	37%	Cono-W0	0	
Tractor	13%	6%	Cono-W 1	4%	
None	0%	57%	Cono-W 2	29%	
			Cono-W 3	54%	
	100%	100%	Cono-W 4	13%	
Field Leveling				100%	0%
With board	69%	0			
Manual (daba)	30%	0	Manual 0	22%	26%
Hand tractor	1%	0	Manual 1	37%	18%
			Manual 2	41%	43%
	100%	0%	Manual 3	0%	13%
				100%	100%

All SRI farmers used the cono-weeder at least once. Two-thirds used it three or four times. This differed from last year, when the majority of farmers used them only twice (see Table 8). This increase in cono-weeder use shows that farmers understood the importance of the weeder for crop development. Often it takes a year of observation in order to evaluate the beneficial impact of a tool. This seems to be the case with the weeder.

Table 8: Percentage of farmers using cono-weeders from one to four times in the 2008 and 2009 cropping season

	2008	2009
Cono-W1	10	4
Cono-W2	50	30
Cono-W3	30	54
Cono-W4	10	13

Regarding time needed for weeding, the data confirms last year's result that even using the cono-weeder four times requires less time than when farmers do all the weeding by hand, between one and two times, as done under conventional practice (see Table 9).

Table 9: Time needed for weeding SRI plots and conventional plots (in person day/ha)

	Conoweeding Number	person day/ha	Hand weeding person day/ha	Total weeding person day/ha
SRI plots	1	3.4	9	12.4
	2	6.4	9	15.4
	3	9.4	9	18.4
	4	12.9	9	21.9
Farmer field	0	0	32.5	32.5

Labor demand patterns as described last year was confirmed for most interventions. Time for transplanting decreased by about half from last year (from 77 person day/ha to about 38 person day), when it was about three times higher then conventional methods (24 person day), thus it still takes longer than the conventional transplanting. Farmers in the area are able to use the strings for transplanting in line more efficiently compared to the field agents' method, which consists of correctly placing 3 strings in right angles within the plot and proceed with correctly measured angles when transplanting.

Many of farmers are able to plant in line based on their visual abilities and use the string only as a guide. Also, manipulating small plants becomes easier with habit. Nevertheless, labor demand needs to be confirmed. Field agents encountered difficulties in obtaining good data when monitoring the many farmers and their activities in their SRI plots and farmer fields, which all have different dimensions and are not located side by side.

Farmers fertilized their fields with 82kg/ha of DAP in addition to 116kg/ha of urea, thus applying a total of 198 kg/ha chemical fertilizer (Table 10). The SRI plots were amended with 11t/ha of organic manure, 30 kg/ha of DAP and 118 kg/ha of urea. Chemical fertilizer used under SRI totaled 148kg/ha, a 25% reduction compared to the conventional practice. In their main fields, farmers did not apply any organic manure, but used DAP instead. Inorganic fertilizer applications were well below of the recommended dose of 100 kg/ha of DAP and 200 kg/ha of urea for both treatments.

Table 10: Fertilization of SRI plots and farmer fields

	SRI	Farmer Field
Fertilization		
Organic Matter	11t/ha	0
DAP	30kg/ha	82kg/ha
Urea	118 kg/ha	116 kg/ha

B) INNOVATIONS

6. Rice variety test using SRI methods

A variety test was installed in the village of Horogoungou, Dire circle. The village chief provided land next to an independent irrigation canal to allow proper SRI irrigation (alternate wetting and drying) of the plots. The experiment was designed in collaboration with the rice-breeding specialist of the IER rice-breeding program in Sikasso.

The objective was to evaluate the performance and productivity of 15 varieties under SRI practices. Among the 15 varieties, eight were improved varieties (five new varieties from IER, and three varieties found in the region), and seven were locally found *O. glaberrima* varieties. Among the improved varieties two were rainfed, five irrigated and one deep-water rice variety. Among the *O. glaberrima* varieties, four normally grow in landscape depressions, and three under deep-water conditions. Additionally, 6 out of the 8 improved varieties were crosses between *O. sativa* x *O. glaberrima*. See the details of the varieties in the following table.

Table 11: Name and characteristics of 15 varieties included in SRI performance test

No	Name of Varieties	Characteristics	Origin	Type
1	DKA-P1	Rainfed	IER Sikasso	O. sativa x O. glaberrima
2	Nerica 4	Rainfed	IER Sikasso	O. sativa x O. glaberrima
3	DKA-1	Irrigated	IER Sikasso	O. sativa x O. glaberrima
4	DKA-11	Irrigated	IER Sikasso	O. sativa x O. glaberrima
5	DKA-14	Deep-water	IER Sikasso	O. sativa x O. glaberrima
6	Nerica 2	Irrigated	Office Faguibine	O. sativa x O. glaberrima
7	Wassa	Irrigated	Farmers	O. sativa
8	BG90-2	Irrigated	Farmers	O. sativa
9	Bawo	Depression	village Galaga	O. glaberrima
10	Dembo	Deep-water	village Galaga	O. glaberrima
11	Gnamagnou	Deep-water	village Galaga	O. glaberrima
12	Dambou	Depression	village Galaga	O. glaberrima
13	Boulou	Deep-water	village Galaga	O. glaberrima
14	Tretre	Depression	village Galaga	O. glaberrima
15	Kobe Ber	Depression	village Galaga	O. glaberrima

The test applied a randomized bloc design with 3 repetitions, with plot sizes of 1.5 m x 5 m. The harvested plot was 1.2m x 4.5m. Plants were transplanted at the two-leaf stage (9 days old), one plant/hill with a spacing of 30 cm x 30 cm between the plants. Fertilization was based on organic matter application of 20t/ha at the beginning of the season, with slight correction of Nitrogen deficiency for the irrigated varieties with 75kg/ha of urea during the season.

The two rainfed varieties as well as all local varieties did not receive any chemical fertilizer, because their leaves stayed dark green during the entire cropping season. A cono-weeder was used four times during the cropping season, incorporating weeds and aerating the soil, which favors root growth and tillering. Yield and yield parameters are presented in the following table.

Table 12: Yield and yield parameters of 15 varieties under SRI cultivation methods

Variety	Yield t/ha	Tillers/ plant Number	Panicles/ plant Number	Plant height cm
Improved varieties				
Dka P1	**3.51**	24.9	24.5	77
Nerica 4	**3.44**	15.9	15.6	87
DKA 1	**10.30**	33.7	32.4	81
DKA 11	**9.47**	28.6	27.4	81
DKA 14	**7.48**	29.9	24.2	115
Nerica L2	**13.58**	31.3	30.1	91
Wassa	**12.08**	34.1	31.2	81
BG90-2	**13.36**	34.5	30.4	83
Local varieties				
Bawo	**4.92**	53.3	52.1	104
Dembo	**3.85**	29.8	29.8	152
Gnamagnou	**3.45**	35.8	35.8	159
Dambou	**3.77**	28.5		154
Boulou	**5.44**	36.0		152
Tre	**5.01**	44.8	36.9	114
Kobe Ber	**3.93**	37.1	32.3	129

Variety	Root length cm	Panicle length cm	Filled grains/ panicle Number	Empty grains/ panicle Number
Improved varieties				
Dka P1	18.1	19.3	83	25
Nerica 4	20.4	18.2	84	28
DKA 1	25.3	23.2	205	12
DKA 11	23.5	20.1	132	21
DKA 14	22.0	26.7	175	19
Nerica L2	20.8	26.1	161	28
Wassa	20.9	26.7	143	22
BG90-2	21.5	24.8	163	16
Local varieties				
Bawo	20.6	18.9	91	12
Dembo	19.0	22.3	81	15
Gnamagnou	19.3	21.6	84	16
Dambou	24.8	21.0	92	22
Boulou	20.7	20.9	94	21
Tre	20.3	24.0	82	14
Kobe Ber	20.4	20.3	71	20

Although rainfed varieties were much less productive compared to irrigated varieties, it can be concluded that rainfed rice can grow well under SRI practices in an irrigation environment. The yields of DKA-P1 and Nerica 4, usually grown in the Sikasso region in Southern Mali, are good with about 3.5t/ha.

The new short cycle varieties DKA-1 and DKA-11 were very productive with yields of 10.3 and 9.5 t/ha, respectively. DKA-1 was most appreciated by farmers during the farmer evaluation visits. DKA-1 had the highest number of panicles per plant, the longest roots and the highest number of filled grains per panicle of all tested varieties. Farmers expressed interest in testing these short cycle varieties next year. The long-cycle varieties BG90-2, Nerica L2 and Wassa, obtained highest yields of between 12-13.5 t/ha.

DKA 1 variety at harvest using SRI methods 1 plant /hill. Notice the high tiller numbers (average of 34 /plant) and strong root development

As for the depression and deep-water rice varieties, the improved deep-water variety DKA-14 produced a very good yield with 7.4t/ha. Local varieties obtained 4.2t/ha on average for deep-water varieties and 4.4 t/ha for depression varieties. We harvested three plots in a landscape depression under farmer practice close to the Horogoungou village, with an average yield of 2.6 t/ha. SRI showed therefore an increase of 72%.

Farmers recommended increasing the spacing between the plants for the local varieties to at least 50 cm x 50 cm if not more under SRI. The *Glaberrima* varieties fell over when not harvested in time. Although these varieties tend to be neglected by research and extension services, farmers in all the villages continue growing them under traditional practices. Depending on the climate and rain conditions, success is not always guaranteed. In depressions for instance, rice production depends essentially on rainfall (which at 150-200mm is very low). Rice production is very irregular in these systems and highly vulnerable to climate variations. Nevertheless, there are important reasons farmers grow these indigenous varieties. First, they are important for food security. For instance, the *Tretre* variety has very short cropping cycle, and is harvested after only 80 days, reaching a yield of 5t/ha. During the hungry season, this variety is the first to produce and provide food. Another reason why farmers will not stop growing the *Glaberrima* varieties is their taste, which is seen as exceptionally good and not comparable to the improved irrigated varieties. Furthermore, farmers appreciate the fact that these varieties are very hardy and if fertilized according to SRI principles do not need additional inorganic chemical fertilizer. Finally, these varieties have an important biodiversity value, considering that the African rice was domesticated in this area more than 3500 years ago, and has been grown there ever since (WARDA, 2001). Farmers are interested in planting small areas of *Glaberrima* under SRI next year in order to quickly secure their staple food during the hungry season.

Varieties 117 days after nursery establishment: from right to left: DKA1 and DKA 11 ready to be harvested (where people are standing), followed by DKA14 (distinctly higher) followed by the Nerica, Wassa and BG90-2 (each variety occupies 5 planting rows)

Glaberrima variety *Tretre* is ready for harvest at 2.5 months. This variety allows ending the hunger season, at a time when the improved irrigated varieties are still in tillering stage. *Tretre* yield was 5t/ha.

7. Irrigation test

An irrigation test was installed in the village of Bagadadji, Goundam Circle with two large plots side by side: one SRI plot and one control plot, each plot 27 m x 10 m for (see photo). Soil preparation was done identically for both plots using the hand tractor, including plowing, puddling and field leveling. The same amount of organic manure was applied to both plots at the rate of 9t/ha.

A washbore pump was installed at the short side and in the middle of both plots, from where each plot was easily irrigated by the pump when needed. The time used for pumping water was measured and noted for each irrigation event (Figure 2). For the SRI plot, alternate wetting and drying irrigation was applied, for the control plot, the usual irrigation method of keeping the plot inundated was respected.

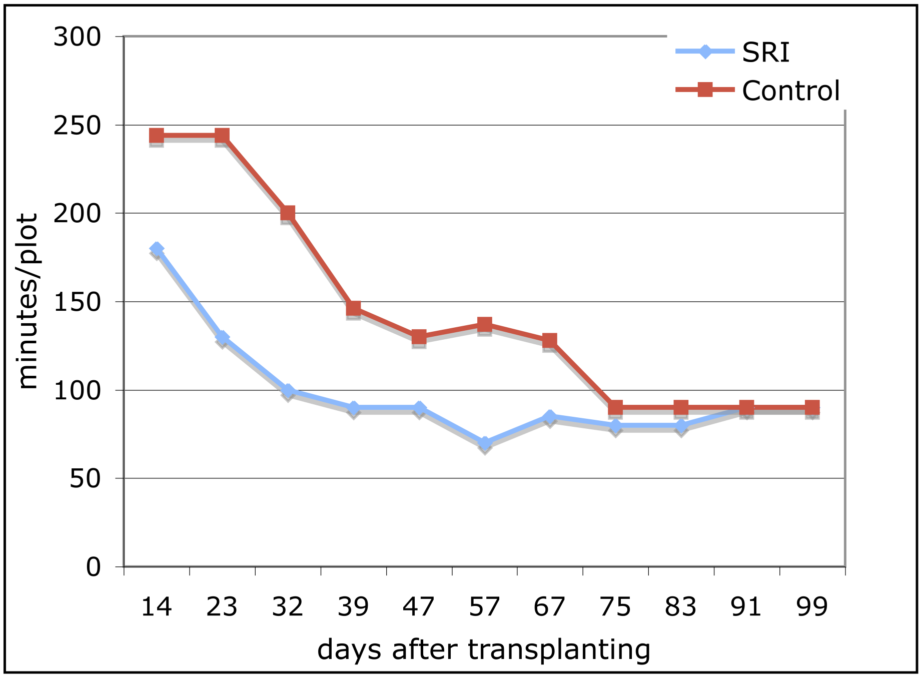

Figure 2: Irrigation time (in minutes/plot) for each irrigation event of the cropping season for the SRI and the control plot.

Total minutes needed to irrigate the SRI plot for the entire season was 1085 minutes, whereas for the control plot this was 1589 minutes. SRI irrigation used therefore 68% of the water of the control plot irrigation. In other words, SRI irrigation used 32% less water than the conventional irrigation method.

This result represents the minimum of possible water savings. It can be expected that compared to farmers' practice the water savings will be substantially higher. Because the control plot was leveled equally to the SRI plot, less water was needed to fill it, compared to an unleveled plot, as is the usual farmers' practice. Additionally, the same amount of organic manure was applied to both plots, creating similar water holding capacity of soils for both treatments. Normally farmers do not apply organic matter, which reduces the soils water holding capacity.

8. Introduction of hand tractor

The SRI system requires good soil preparation, including the incorporation of organic matter and the field leveling. These two practices are not usually included in the conventional practices in the area. Under SRI, fields are pre-irrigated, organic matter applied, soil plowed, water added and soils puddled, and finally soils leveled. In this area, nearly all farmers do all the soil preparation by hand; and a few have access to tractors to plow their land. To extend SRI to larger surfaces and allow farmers to eventually switch entirely to SRI practices, it is important to continue developing technological improvements. One of them is to find ways for farmers to use less time and labor for soil preparation. With this in mind, Africare introduced a hand tractor, previously unknown in the region, into the project area. This particular hand tractor is used in Office du Niger and is manufactured by the *Coopérative Artisanale des Forgerons de l'Office du Niger* (or CAFON) in Niono. It is used to plow, to herse, to puddle, and to level fields (See photos for field leveling). It can also serve for transportation, by attaching a 3-ton capacity trailer. The costs of acquisition and for using the hand tractor are presented in the following table.

Table 13. Costs related to the acquisition and use of the hand tractor model sold by CAFON (source of information: CAFON, 2010)

	Costs in CFA
Acquistion cost in CFA	
HT* + all equipement + trailer	2,900,000
HT + equipment without trailer	2,000,000
Handtractor without motor	1,940,000
Motor	60,000
Yearly costs of hand tractor in CFA	
Yearly amortization hand tractor over 7 years	277,000
Yearly amortization of motor over 4 years	15,000
Yearly maintenance and repair	100,000
Total costs/year	392,000

* HT: Hand tractor

Hand tractor demonstrations were organized at the beginning of the rice-growing season in the villages of Bagadadji, Findoukaina and Kondikaina. A specialist from Niono gave a 10-day training in hand tractor use, maintenance and repair to Africare field agents and some farmers.

 

Later in the season, representatives from all the SRI villages were invited to the village of Horogoungou to witness a three-day hand tractor demonstration and test on a plot of 25 m x 25 m. On the first day, the plot was delimited followed by a pre-irrigation. During the second day, the softened soil was tilled, followed by introducing a 2 cm layer of water into the plot. On the third day, soil puddling and leveling were undertaken. Time needed for the various operations was monitored for the demonstration plot of 625 m^2 and is presented in Table 14.

Table 14: Time needed for soil preparation by the hand tractor

	Africare field test		**CAFON data**
	625 m2	**1 hectare**	**1 hectare**
Parameters	minutes	hours	hours
Tilling	17	4.53	4.6
Soil puddling	5	1.33	2.7
Leveling	9	2.40	2.7
Total time needed	*31*	*8.27*	10
Gaz consumption (l)	1.5 l	24 l	10-15 l
Cost gazoline (550 CFA/l)	825 CFA	13200 CFA	5500-8250 CFA
Tractor driver tilling, puddling			6000
Tractor driver, leveling			3000

The table also includes data on hand tractor use in the Office du Niger area from CAFON (Ousmane Djire, personal communication, CAFON, February 2010). The data from our test correspond well with the CAFON data, with the exception of fuel consumption, which we overestimated in the field test. It takes a bit more than one-person-day, or 10 hours, to prepare one hectare of rice paddy including tilling, puddling and leveling. A hand tractor driver is paid 6000 CFA for tilling and puddling 1 hectare, and 3000 CFA/ha for field leveling. Including fuel (Table 14), the costs to prepare one hectare amount is about 14,500 to 17,250 CFA.

Amortization and maintenance of the hand tractor costs 392,000 CFA/year (Table 13). The profitability of the hand tractor depends on how many hectares are prepared per season, and if the hand tractor is used additionally to soil preparation also for transportation. In the Office du Niger zone, hand tractors use for transportation is apparently more important than its use for soil preparation.

For our calculations, we consider its use for soil preparation only. The amortization and maintenance costs provided in table 13 are based on about 50 hectares of soil preparation per year. Thus for 1 hectare, a cost of 7840 CFA is to be added to the other preparation costs.

In summary: the total cost to use a hand tractor for soil preparation (tilling, puddling and leveling) adds up to 22,340-25,090 CFA/ha. This cost takes into account amortization, maintenance and repair, gas consumption and operator remuneration.

Hiring a tractor to plow one hectare costs 30,000 CFA in the zone, without soil puddling and leveling included. Also, undertaking all the operations by hand amounts to about 55 person days/ha or costs 55,000 CFA (Styger, 2009). Using a hand tractor for soil preparation seems therefore to be the least expensive method in the area. At the same time, the tractor allows doing a good quality soil preparation.

Based on the demonstration and these first calculations, farmers in the region are interested in acquiring hand tractors. If needed, Africare may assist in facilitating orders from hand tractor producer, and organizing further training sessions. If at least a few hand tractors are introduced next season, more reliable economic data will become available.

9. Composting Activities

SRI fertilization relies on the application of organic matter (in the Timbuktu region mostly animal manure) at a rate of 10 to 15 tons/ha. SRI farmers in the Goundam and Dire Circle have followed this practice to date. They collected animal manure from their cattle and small ruminant enclosures that accumulated over the years. Some of the villages have access to large manure reserves, others face shortfalls. The latter were obliged to collect or buy manure from other villages. So far, availability of animal manure has been sufficient, but the surface area under SRI is still limited. Once SRI is adopted at a larger scale across the region, it is likely that the amount of available animal manure will be insufficient.

The objective of this activity was to introduce composting as a new technique into the SRI villages. This will help farmers to become less dependent on large amounts of animal manure needed to fertilize SRI fields. Composting can easily be done with organic matter produced on location, largely rice straw.

Rice straw represents the bulk of the composting material. It is supplemented by small amounts of animal manure, which catalyzes the decomposition process, and if available by ash and other organic material. In the Timbuktu region, where weather conditions are very dry and hot, compost pits are favored over the compost heaps usually installed in wetter areas. It is easier to maintain moisture in pits, and often it can be sufficient to add water only once in the beginning when the compost is put together.

Africare approached SRI farmers to participate on a volunteer basis. The idea was to install composting pits close to the rice fields on the PIV. This allows farmers to have their organic matter on location and readily accessible at the beginning of the following season, with no need to transport it from far. The most difficult part is to dig the pits. It is recommended to dig a pit one meter deep and then adjust the length and width according to needs.

A 1 m^3 pit produces 600 kg of compost. For farmers in the region, who plant on average a field size of 0.3 hectares, it is sufficient to dig out a pit of 5 to 8 m^3, which responds to a dose of 10 to 15 t/ha, respectively. The following table provides the relationship between compost pit size and the size of the fields that can be fertilized with the produced compost.

Table 15: Conversion table relating compost pit size to amount of compost produced

Compost pit size m3	Compost produced kg	Field surface (ha) Dose 10t/ha	Field surface (ha) Dose 15t/ha
1	600	0.06	0.04
2	1200	0.12	0.08
3	1800	0.18	0.12
4	2400	0.24	0.16
5	3000	0.3	0.2
6	3600	0.36	0.24
7	4200	0.42	0.28
8	4800	0.48	0.32
9	5400	0.54	0.36
10	6000	0.6	0.4
16.6	10000	1.0	
25	15000		1.0

Africare technicians talked to farmers about the advantages of composting and assisted volunteers to put the compost pits together. The number of farmers and the compost sizes installed are presented in the following table.

Table 16: Number of volunteer farmers participating in composting activity and size of compost pits produced

Villlage	Number of Farmers	Number of total pits	Number of pits at $1m^3$	Number of pits at $2m^3$	Number of pits at $3m^3$
Horogoungou	5	5		5	
Katoua	2	2			2
Dongoye	3	3	3		
Arabebe	1	1			
Tomba	1	2			2
Bourem	3	3			3
Kobe	2	2	2		
Arham	2	2			2
Harahara	2	2	2		
Bagadadji	5	5			5
Saobomo	3	3			3
Total	29	30	7	5	17
Total m^3 of compost pits/category			7	10	68
Total m^3				**85**	

In total 29 farmers from 11 villages volunteered to do a test. Most of them dug a pit of $3m^3$. In total 85 m^3 were installed, which will produce 51 tons of compost, sufficient to apply to

3.5 to 5 hectares of SRI. Not all of the SRI villages participated. Some villages will not plant their rice in the same location as this year, thus they would need to transport the compost produced this year to the location for next year. Other PIVs were flooded at the end of the cropping season, thus installing a compost pit next to the rice fields was not an option. Other villagers may not have seen a need to produce compost, as they still have large manure reserves. With the start of this activity, farmers from the village and from neighboring villages will witness the outcome of the composting activities, and develop an understanding of its advantages. Composting, like SRI, is a knowledge-based technology, which better utilizes available resources, reducing outside dependency on chemical fertilizers.

Africare plans to organize farmer exchange visits in June/July when the pits are emptied to show other farmers how easy it is to produce high quality organic matter. When emptying the compost pits, quality of the produced compost will be monitored. Where decomposition processes were not ideal, conclusions will be drawn for improving the technical guidelines.

Dug out compost pit of $1m^3$ is filled in alternating layers with rice straw and manure (from left to right). After each layer, the pit is filled with water to saturation. Once the pit is filled, it is watered again. A clay layer will close the pit to preserve moisture. Finally, a layer of branches protects the compost from the sun. Big branches had been inserted vertically in the pit before the filling started. Two to three days after the pit is closed up and when the material has started to settle, the branches are taken out, allowing the air to enter the pit, which is needed for a correct decomposition process.

10. The System of Wheat Intensification (SWI)

Based on last year's preliminary tests with farmers on the System of Wheat Intensification (SWI) http://ciifad.cornell.edu/sri/countries/mali/MaliSWIrpt071309.pdf, we set up a more comprehensive test this season. The test responds to the main factors to improve crop performance that were identified last season. These include plant spacing and seeding techniques. Initially planned for one site, farmers in surrounding villages expressed interest to participate in the testing as well. We were therefore very fortunate to run this test in three sites.

The village of Horogoungou was the main site, with seven treatments, plots of 5 m x 5 m per treatment, and repeated three times. Bagadadji and Findoukaina villages are extension sites, where seven and five of the treatments, respectively, were implemented (Table 13). The plot sizes were 5m x 10m for each of the treatments, without replication.

Table 17: Treatments of the SWI test in three villages

	Treatment	Horogoungou	Bagadadji	Findoukaina
T1	DS* 20cm x 20cm	x	x	x
T2	DS 15cm x 15cm	x	x	x
T3	DS 10cm x 10cm	x	x	x
T4	DS 15cm x 10cm	x	x	
T5	Seeding in lines (20cm apart)	x	x	x
T6	Transplanting of seedlings	x	x	
T7	Control: Broadcast seeding	x	x	x

* Direct seeding

All SWI plots were installed in November: November 18/19 in Findoukaina, between November 15 and 20 in Horogoungou, and on November 23 in Bagadadji. Harvests started at end of February 2010, and are expected to finish by late March. Harvest results can therefore not be given in this report. A separate SWI report including all the results will be written up in April, when all data are available.

SWI test at Horogoungou, showing three planting blocs with each 7 treatments, 2 days after seeding

In SWI plots, the cono-weeder was used the same way as with SRI

Uprooted SWI plant in January 2010 showing strong tiller and root development

In addition to the test in three villages, we were able to test a seeding machine, developed as a prototype by the private firm *Coopérative Artisanale des Forgerons de l'Office du Niger* (CAFON) in Niono, region of Segou. The prototype was initially developed for seeding rice, but the company lent us the machine to be tested for the first time with wheat. Two large fields were prepared, hersed and seeded with the hand tractor that Africare had introduced this year for the first time into the region. The development of the wheat plants was very satisfactory. During farmer field visits, farmers appreciated the crop performance greatly when compared to their traditional plots.

Prototype seeding machine developed by CAFON, attached to a hand tractor.

A CAFON technician executes the first field test with wheat. Above: he uses a herse to prepare an even seed bed; below: seeding in action!

Traditionally, farmers broadcast wheat seeds. This results in a very high plant density. The crowded plants have little room for tiller and root development, and produce only a few small panicles per plant (see photos below). Although the Goundam and Dire Circles are the areas with the highest wheat production in the country, little has been done to improve cropping practices.

Yields under the traditional practices are usually low, only about 2t-2.5t/ha. The first SWI test last year showed very good development of individual plants, with much longer panicles and much higher number of tillers/plant. Last year's test resulted in a yield increase of 10 percent, but the spacing of 25 cm x 25cm between the plants was obviously too high. This is why we tested this year reduced planting densities, in the hope to improve yield beyond the 10 percent of last year.

SWI plant, direct seeded at 1 plant/hill shows good tiller development

In 2009, average number of SWI tillers were 18.4 (left) compared to 3.7 under traditional practices (right).

Under SWI (left), average lenght of panicles was 10.2 cm, compared to 4.2 cm for the traditionally seeded plot (right) in 2009.

If SWI should become an acceptable alternative for farmers compared to their traditional practices, a good method for seeding in pockets needs to be developed. Seeding in pockets and in lines by hand is a difficult and time-consuming task, and thus unlikely to be adopted, when compared to the less labor-intensive broadcasting. In late November, farmers are extremely busy, as the wheat seeding coincides with the rice harvest. Between the two tasks, rice harvest has priority, therefore any wheat seeding technique needs to be labor extensive. If the wheat seeding is delayed – which happens very often – the crop will enter the hot harmattan season during its maturation period, diminishing its productivity.

Based on this analysis, we started looking for seeding machines in Mali, which could seed the wheat in pockets, as SWI requires. We quickly found that no such seeding machine is available either from the private sector or from the research institutions in Mali.

The private company *Coopérative Artisanale des Forgerons de l'Office du Niger* (CAFON), has agreed to look into developing a seeding machine that could seed wheat in pockets. This machine will be available later this year. In the meantime CAFON offered to let us try out another prototype developed to seed in line, as described above. So far, this technique seems to have caught the attention of the farmers. We will carefully evaluate plant development and crop production for all the different treatments and seeding techniques. It can already be recommended that next year both types of seeding machines be tested together.

Conclusions and recommendations

The results from this year's SRI extension in the Goundam and Dire Circles of Timbuktu – the second year of evaluation – confirmed the findings from last year: i) substantial yield increase, averaging 72% this year, ii) varieties used in the region show improved performance under SRI practices, and iii) rice productivity is more resilient when applying SRI methods under non-optimal climate and environmental conditions.

The scaling up efforts were very successful considering that number of farmers participating quadrupled compared to last year. Participation was entirely voluntary, but unlike last year, villagers had to develop a farmer-to-farmer approach of passing on the technical knowledge to new-comers, as there were not enough Africare and SAC field agents to provide the same level of intensive technical assistance to everybody. 200 farmers—up from 60 last year—worked with SRI in the 12 villages where it had already been introduced. They were joined by 40 farmers from eight surrounding villages and by 30 farmers in eight villages in the Niafunke and Timbuktu circles. Nevertheless, given the seasonal difficulties, fewer farmers were able to work with SRI than had wanted to participate at the beginning of the cropping season.

Technical quality of implementing SRI practices was very good in all the villages, confirming the approach taken last year to start small and assure high quality technical backstopping. Once this base is created, the knowledge can spread quickly to a larger number of farmers, and applications are done well.

Nevertheless, despite farmers' plans to increase the surfaces compared to last year, the extension in SRI surface area per farmer remained modest this season. Because farmers had very little time to plant their rice fields - due to delay of the rainy season and arrival of the floods by over 1 month – they opted to participate in the SRI extension with small plots rather then not participate at all. Thus, it seems that villagers opted for a consolidation of the knowledge at the village level this year, and it remains to be seen how the extension dynamics will develop next year.

It is important to continue innovation development associated with SRI practices. This will address some of the difficulties farmers face in increasing the surface area under SRI.

The variety test showed very promising results, especially for the two short-cycle varieties DKA-1 and DKA-11, which were developed by IER in Sikasso. It is recommended to distribute these two new varieties to farmers next year, who can test and compare them to other short cycle varieties used in the region. High SRI yields of up to 5 t/ha for *O. glaberrima* varieties, which are adapted and appreciated in the area, indicate that these varieties can be gain new value and respect in being productive varieties for this region.

The irrigation test has shown that with SRI practices, a minimum of 32% of irrigation water can be saved compared to conventional irrigation practices.

The first tests of the hand tractor seem to provide high quality soil preparation, and were much appreciated by farmers. It also seems to be economically competitive with the large field tractor and with manual soil preparation, which are the current practices. It would be of great interest to introduce a number of hand tractors to the region, and undertake a good economic evaluation. On the technical side, hand tractors will stimulate farmers to increase plot size. It is easier to handle this machinery on larger plots, besides the fact that it is more economical to work on a larger plot compared to the sum of small plots. As the hand tractor will create good field leveling, farmers can more easily increase plot sizes. All these changes will facilitate the extension of SRI surface area.

Composting activities started in 11 villages this year. It can be expected that once the compost is harvested and applied to the fields, the SRI farmers will be able to witness the usefulness of the technique. If produced on site with rice straw as the main composting material, farmers will become less dependent on finding and transporting large amounts of animal manure. Ideally, interest in composting will grow and be adopted in parallel with SRI practices. Composting practices should become integral part of technical guidelines and extension work on SRI.

Based on last year's promising but not very conclusive test on the System of Wheat Intensification, this year's test was set up to address the main questions of plant spacing and seeding techniques. The main difficulty farmers face is the limited time available for wheat seeding as it coincides with the time of the rice harvest. The time element is critical for farmers to switch from seed broadcasting to seeding in pockets, as recommended for SWI. Seeding by hand is hardly a workable alternative. However, a seeding machine attached to a hand tractor could save time. With the expected higher productivity, SWI could become an attractive alternative to the current extensive practices. Harvest results (available late March) will provide more insight on productivity and economic benefits in order to develop recommendations for next season. Testing of different seeding machine models and associated farmer evaluation should help to further guide the development of new techniques.

It is essential to continue the farmer-centered approach applied by Africare and SAC over the past two years, putting the farmers in the drivers' seat for adapting SRI practices to local conditions. Researchers, and field agents should work with farmers, study what is happening in the field, and support innovation development that responds to questions and needs that arise from the field. It is also recommended to support farmers in their own experimentations and to encourage their initiatives. For instance planting indigenous varieties under SRI practices should be supported if farmers choose to test them in their fields. This means that researchers and extension agents should spend much time in the field, and discuss with farmers on how to further improve agricultural practices. SRI has brought about many new insights, but has also challenged the old paradigm of agricultural improvements that depend much on outside resources. It also challenges how research and extension should be carried out. Approaches to implementation should be adapted accordingly.

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