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TECHNICAL REPORT

Application of system of rice intensification practices in the arid environment of the Timbuktu region in Mali

Erika Styger · Malick Ag Attaher · Hamidou Guindo · Harouna Ibrahim · Mahamane Diaty · Ibrahima Abba · Mohamed Traore

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Abstract Cereal production is chronically deficit in the Timbuktu region of Mali, sufficient for only 4.5 months of annual household consumption. Small-scale, village-based irrigation schemes, usually 30–35 ha in size, irrigated by a diesel motor pump, have become important to improve food security in this arid region. The NGO Africare has worked during the past 12 years with farmers in Goundam and Dire circles to establish irrigation schemes and provide them with technical assistance. In 2007, Africare undertook a first test of the System of Rice Intensification (SRI) in Goundam circle. After farmers observed a yield of 9 t ha^{-1} of paddy compared to 6.7 t ha^{-1} in the control plot there was interest in larger scale testing of the SRI system. In 2008, Africare, in collaboration with the local Government Agriculture Service and with support from the Better U Foundation, implemented a community-based evaluation of SRI with 60 farmers in 12 villages. Farmers in each village selected five volunteers, who each installed both SRI and control plots, side by side, starting the nurseries on the same day and using the same seed. For SRI plots, seedlings were transplanted one plant $hill^{-1}$ at the two-leaf stage (on average, 11.6 days old), with spacing of 25 cm × 25 cm between hills and aligned in both directions. This allowed farmers to cross-weed with a conoweeder, on average 2.4 times during the season. In the control plots, farmers planted 3 plants $hill^{-1}$ with seedlings 29.4 days old and spaced on average 23.7 cm, not planted in lines. Weeding was done by hand. 13 t ha^{-1} of organic matter was applied under SRI management, and 3 t ha^{-1} in the control plots. Fertilizer use was reduced by 30% with SRI compared to the control. Although alternate wetting and drying irrigation is recommended for SRI, this was not optimally implemented due to constraints on irrigation management within the scheme; thus water savings were only 10% compared to the control. Average SRI yield for all farmers reached 9.1 t ha^{-1}, with the lowest being 5.4 t ha^{-1} and highest being 12.4 t ha^{-1}. SRI yields were on average 66% higher than the control plots at 5.5 t ha^{-1}, and 87% higher than the yields in surrounding rice fields at 4.9 t ha^{-1}. Number of tillers and panicles $hill^{-1}$, number of tillers and panicles m^{-2}, and panicle length and number of grains $panicle^{-1}$ were clearly superior with SRI compared to control plants. Farmers tested five varieties, all of which produced better under SRI. The SRI system allowed for a seed reduction of 85–90%: from 40–60 kg ha^{-1} for the control plots to 6.1 kg ha^{-1} under SRI. Although production costs per hectare were 15% higher for SRI, revenue was 2.1 times higher than under the control. Farmers were very satisfied with these results. In 2009/2010, Africare and the Government's agriculture service worked with over 270 farmers in 28 villages to scale up SRI practices and to test innovations, including composting techniques, optimization of irrigation, and techniques to reduce labor requirements and production costs. The good crop performance along with other advantages was confirmed in this third year with SRI yields of 7.7 t ha^{-1} ($n = 130$ farmers) compared to 4.5 t ha^{-1} in farmers' fields.

E. Styger (✉)
SRI International Network and Resources Center (SRI-Rice),
Cornell University, Ithaca, NY, USA
e-mail: eds8@cornell.edu

M. A. Attaher
Government's Regional Agricultural Service, Timbuktu, Mali

H. Guindo
Government's Regional Agricultural Service, Gao, Mali

H. Ibrahim · M. Diaty · I. Abba · M. Traore
Africare Timbuktu Food Security Initiative,
Goundam, Timbuktu, Mali

Introduction

The Goundam and Dire circles in the Timbuktu region are among the most food-insecure areas in Mali (CSA 2005). Due to the very low annual rainfall of 150–200 mm, recessional agriculture is practiced along river branches, ponds, and lakes that are seasonally flooded by the Niger River. The intensity of this flooding determines how much land is cultivated, so cropped area is highly variable from year to year. Yield levels in this cultivation system are low, with deep-water rice producing, on average, 750 kg ha^{-1}, and sorghum between 600 and 900 kg ha^{-1} (DRA Tombouctou 2007).

In recent years, the NGO Africare has worked with local farmers to build village-based, small-scale irrigation schemes of 30–35 ha each that can be irrigated by one diesel motor pump. These irrigation systems give farmers more water control so they can achieve higher, more reliable yields compared to the traditional recessional agriculture.

As 80–100 farmers share the land irrigated by such schemes, the average irrigated crop area available per household is only about one-third of a hectare. Getting maximum yield from these small landholdings is essential for reducing poverty in the area. These irrigation schemes have been making an important contribution to an improved food security situation of the region. There is enough land and water availability in this region to make further improvements in production by extending the area under rice cultivation.

In 2007, Africare worked with a farmer in the Douegoussou village of the Goundam Circle to undertake a first test of the System of Rice Intensification (SRI) in Goundam circle. After witnessing a yield of 9 t ha^{-1} of paddy compared to 6.7 t ha^{-1} in the control plot, farmers in the area expressed much interest in larger scale testing of the SRI system (Africare Mali 2008). SRI is a methodology for increasing the productivity of irrigated rice cultivation by changing the management of plants, soil, water, and nutrients, while reducing external inputs. It was developed in the 1980s in Madagascar by Father Laulanié and its advantages have been demonstrated now in over 40 countries worldwide (http://sri.ciifad.cornell.edu).

SRI is based on six principles: (i) transplanting young seedlings, (ii) transplanting single seedlings, while (iii) providing wider spacing between the plants, (iv) application of organic matter for fertilization (in preference to chemical fertilizer), (v) soil aeration through mechanical weeding, and (vi) reduction of irrigation water application, keeping soils moist but not flooded (Uphoff 2007).

Based on the first results and farmers' interest, the Better U Foundation of Los Angeles, California, made a grant to Africare for a larger project: to assess the performance of SRI in 12 villages during the 2008–2009 growing season in the circles of Goundam and Dire. The main objectives were to: (i) adapt SRI principles to the local rice cropping system conditions, and (ii) compare SRI practices with farmer practices in 12 sites within two administrative circles of the Timbuktu region.

Methods and materials

The Goundam and Dire circles are characterized by a Sahelo-Saharan or Saharan climate with annual rainfall of 150–200 mm, a rainy season extending over 3 months, and a mean annual temperature of 29.1°C. Twelve villages participated in this SRI evaluation. They are located on seasonally flooded arms of the Niger River. The distance to the Niger River determines when the water arrives at the village irrigation perimeter (*Périmètre Irrigué Villageois*, PIV); only then can the rice season begin. The SRI plots were planted over a two-month period between June 26 and September 2, 2008, and harvest extended from October 31 to December 23, 2008.

Each participating communities selected 5 farmers, who collaborated entirely on a volunteer basis. Farmers did not receive any inputs (seed, fertilizer) as payment or inducement, although two cono-weeders (a tool previously unknown to the area) were provided to each village to be shared by the experimenting farmers. Africare and the Goundam Government Agriculture Service provided ongoing technical support.

Each farmer was entirely responsible for managing his or her own trials, installing both SRI and control plots, side by side, and starting the nursery for both plots on the same day, using the same seed. Farmers supplied their own seed and were free to choose the variety themselves, as well as the plot size. Average plot size was 400 m^2, ranging from 81 to 828 m^2.

Technical SRI guidelines to be followed by the 60 farmers were developed by the technical team based on the six SRI principles, adapted to local rice cropping and agroecological conditions (see Table 1) (Africare Mali et SAC Goundam 2009). Technical and economic data were collected on a weekly basis from all 60 farmers for the SRI and control plots, including data on field establishment and management, crop performance, labor requirements, cost of inputs, and finally harvest and yield data.

In each SRI and control plot, three squares of 4 m^2 (2 m × 2 m) were harvested. The grain was threshed immediately on location and weighed using a precision PESOLA™ scale. At the same time, the moisture content of grain was measured using a FARMEX MT-PRO™ moisture meter. The grain yield results were later computed to 14% grain moisture content. Additionally, six

Table 1 Cropping practices in SRI and control plots (average for 60 farmers) in Goundam and Dire, Timbuktu

Cropping practices	SRI $n = 60$	Control $n = 60$
Soil preparation		
Base fertilization	Organic matter 13 t ha^{-1} and 8 kg ha^{-1} DAP	Organic matter 3t ha^{-1} and 34 kg ha^{-1} DAP
Tilling	Yes for 100% farmers	Yes for 48% farmers
Puddling	Limited	No
Plot leveling	Yes	No
Nursery and transplanting		
SRI nursery	Tilling; mix of clay, sand, manure; use of watering can 1–2 times day^{-1}	Tilling; organic matter surface application, surface irrigation every 3-4 days
Seed preparation	24 h seed soaking in water	No seed soaking
Seedlings emerge	2 days	5 days
Transplanting (age of seedlings)	11.6 days (8–12 days)	29.4 days (22–45 days)
Number of leaves plant^{-1}	2	5
Number of plants hill^{-1}	1	3 (2–5)
Spacing between plants	25 cm × 25 cm; 30 cm × 30 cm	23.7 cm × 23.7 cm
Planting pattern	Planted in lines, aligned in both directions	not planted in lines
Number of hills ha^{-1}	160,000; 111,111	177,833
Number of plants ha^{-1}	160,000; 111,111	533,499
Seeds used ha^{-1}	6.1 kg	40–60 kg
Seed saving under SRI	85–90%	–
Crop management		
Weeding practice	Cono-weeding (first time 20 days after transplanting, to be repeated every 7–10 days, up to 4 times in total) and hand weeding	Hand weeding
Number of weedings	2.4 (1–4) times cono-weeding, and 1.2 times hand weeding	1.8 times hand weeding
Pest and diseases	None	None
Fertilization recommendations	organic matter 10-15 t ha^{-1}, inorganic fertilizer to correct for deficiencies	100 kg/ha DAP, 200 kg/ha Urea
Organic matter applied	13 t ha^{-1}	3 t ha^{-1}
DAP applied	8 kg ha^{-1}	34 kg ha^{-1}
Urea applied	120 kg ha^{-1}	145 kg ha^{-1}
Irrigation	Alternate wetting and drying	Flooded plots

panicles per plot were randomly selected to measure panicle length and to count the number of grains per panicle.

A 1 m^2 frame was placed within the 4 m^2 square, within which plants were cut at the base, and number of hills m^{-2}, number of tillers and number of panicles hill^{-1} were counted. From the total of 60 plots, seven SRI and seven control plots were disqualified. Three SRI plots were not irrigated for 1 week after planting, resulting in a high plant mortality rate; one farmer harvested the plots in absence of the technicians; and migrating birds destroyed three plots, both SRI and control, before they could be harvested.

During the field evaluation, we noticed that some of the control plots were better weeded and more fertilized than the surrounding fields in the village irrigation scheme (PIV). Based on these observations and intending to compare the SRI field performance to the average rice fields within each PIV, five randomly selected fields surrounding the SRI and control fields were harvested according to the same procedures as for SRI and control plots. Also, soil preparation methods, variety and amount and type of fertilization were noted. These additional plots evaluated are called 'farmer practice' plots or PIV plots in this paper.

Results

Changes in cropping system practices

Crop establishment and crop management practices for the SRI and control plots are summarized in Table 1.

Traditionally, farmers do not till their land, but rather irrigate a plot and transplant the rice seedlings directly the following day. Since 2006, certain farmers in some villages have had their plots plowed by tractor; 48% of control plots in this study were tilled by tractor or by hand, whereas for the PIV as a whole, the proportion was 20%. All SRI plots were tilled, incorporating 13 t ha^{-1} of manure and 8 kg ha^{-1} of DAP at the same time. In the control plots, farmers applied 3 t ha^{-1} of manure and 34 kg ha^{-1} of DAP, whereas in the PIV plots generally, it was 20 kg ha^{-1} of DAP only. Puddling and field leveling were new concepts to most farmers. For SRI plots, limited puddling was done, followed by field leveling with a hoe or with a wooden board, which was manually pushed or pulled across the soil surface.

For SRI plots, seedlings, on average 11.6 days old, were transplanted one plant hill^{-1} at the two-leaf stage, with spacing of 25 cm × 25 cm between hills (a few farmers applied 30 cm x 30 cm) and aligned in both directions. This allowed farmers to cross-weed with a cono-weeder, which was used on average 2.4 times during the season. In the control plots, farmers planted 3 plants hill^{-1} at 29.4 days of age. Spacing between the plants averaged 23.7 cm, not planted in lines. Hand weeding was done 1.8 times in the season.

In the SRI plots, additional inorganic or organic fertilization could complement initial organic matter application, to correct for observed nutrient deficiencies. Decisions as to what type of fertilizer and how much was to be used remained with the farmers. SRI farmers used, on average, 8 kg ha^{-1} of DAP and 120 kg ha^{-1} of urea, whereas in the control plots it was 34 kg ha^{-1} of DAP and 145 kg ha^{-1} of urea. Thus, SRI farmers reduced inorganic fertilizer application by 28% compared to the control.

Alternate wetting and drying was done by applying a thin water layer of 2.5 cm to the plot. The soils were left to dry until cracks became visible, when another thin layer of water was applied again. This could not be ideally respected in this first test. Farmers were at first reluctant to reduce their irrigation water applications for fear of crop desiccation, but they became more confident over time. Also, it was not possible to change the irrigation water distribution within the PIV for only a few test plots, thus SRI and control plots were irrigated with the same frequency. Thus, reduction in irrigation water per plot was estimated to be only 10%.

Yields and yield parameters

Grain yield from the 53 SRI plots averaged 9.1 t ha^{-1}, which was 66% higher compared to the control yield of 5.49 t ha^{-1}, and 87% higher than yields from the farmer practice plots at 4.86 t ha^{-1} (Table 2). All reported yield data were adjusted to 14% grain moisture. The lowest yield attained with SRI methods was 5.4 t ha^{-1}. More than 50 and 60% of the control and farmer practice yields, respectively, were less than this yield. On the other hand, a third of all SRI farmers achieved yields of more than 10 t ha^{-1}, the highest yield being 12.4 t ha^{-1} (Fig. 1).

All measured yield parameters were superior for SRI, followed by the control, and then by the farmer practice plots (Table 2). Although SRI plots had from 3.5 to 5 times fewer plants at the time of transplanting (see Table 1), at harvest the number of panicles m^{-2} was 31% higher in SRI plants than in the control plots. Also, the one-plant SRI hills produced 50% more tillers than the three plants per hill in the control plots.

The percentage of fertile tillers (tillers with a grain-bearing panicle as compared to the total number of tillers) reached almost 100% in the three treatments. Panicles of SRI plants were on average 13 and 20% longer, and the

Table 2 Grain yield (t ha^{-1}) and yield parameters for SRI, control and farmer practice plots

	Yield		Tillers hill^{-1}		Panicles hill^{-1}		Fertile tillers
	t ha^{-1}	SE	Number	SE	Number	SE	%
SRI ($n = 53$)	9.10	0.24	24.1	0.73	23.5	0.69	98
Control ($n = 53$)	5.49	0.27	16.2	0.50	15.9	0.49	98
Farmer practice ($n = 60$)	4.86	0.18	14.7	0.56	14.2	0.52	97

	Tillers m^{-2}		Panicles m^{-2}		Panicle length		Grains panicle^{-1}	
	Number	SE	Number	SE	cm	SE	Number	SE
SRI ($n = 53$)	371	9.88	361	9.08	24.0	0.73	133	4.86
Control ($n = 53$)	283	9.23	276	9.17	21.3	0.30	97	3.31
Farmer practice ($n = 60$)	266	12.18	257	11.77	19.8	0.30	86	2.38

Yield is reported at 14% grain moisture content

SE standard error, *n* sample size

Fig. 1 SRI and associated control plot rice grain yields (kg ha^{-1}) for 53 farmers in Goundam and Dire circles of Timbuktu, 2008/2009

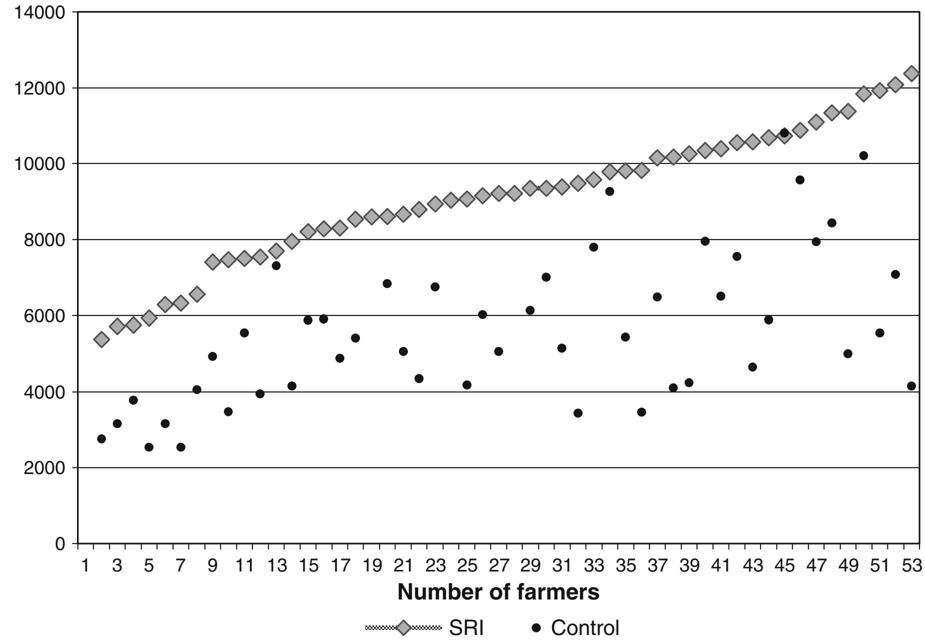

Table 3 Rice grain yield (t ha^{-1}) for five varieties in SRI, control and farmer practice plots

Variety	SRI		Control		Farmer practice		SRI increase over control (%)	SRI increase over farmer practice (%)	Crop cycle (Days)
	t ha^{-1}	SE (*n*)	t ha^{-1}	SE (*n*)	t ha^{-1}	SE (*n*)			
BG90-2	10.01	0.26 (20)	6.94	0.46 (20)	5.29	0.31 (24)	44	89	141
Wassa	9.59	0.53 (6)	6.10	0.77 (6)	5.34	0.36 (5)	57	80	133
Adny 11	8.75	0.53 (14)	4.44	0.37 (14)	4.39	0.42 (12)	97	99	133
D52	7.73	0.24 (6)	4.56	0.67 (6)	4.58	0.36 (9)	69	69	118
RPKN2	6.95	0.57 (8)	3.94	0.34 (8)	4.78	0.56 (5)	76	45	109

average number of grains was 37 and 55% higher, than in the control and farmer practice plots, respectively.

Yield performance of five varieties

Farmers used five varieties in this evaluation. Best-performing varieties under SRI were BG90-2 and Wassa, with yields of 10 and 9.6 t ha^{-1}, followed by Adny-11 with 8.75 t ha^{-1}, and D52 and RPKN2 with 7.73 and 6.95 t ha^{-1}, respectively (Table 3). Compared to the control and farmer practice yields, SRI yields increased between 44 and 99%, showing that high yield increases could be obtained with all varieties used.

Labor requirements

Data on labor and costs were collected during the cropping season by monitoring the time required to carry out the various tasks, and by doing a survey in each of the 12 villages. It is expected that SRI labor requirements will reduce in the future as farmers become accustomed to SRI practices. The data from this first season are therefore preliminary. Labor data for SRI and for farmer practice cultivation are reported in Table 4. Changes in labor allocations were observed for most of the field and crop management tasks under SRI compared to farmer practice.

Soil preparation, transplanting, and threshing took more time using SRI techniques than under farmer practice. On the other hand, nursery management, seedling removal and transportation, and weeding time were more labor-intensive under farmer practice. Farmers have only recently begun to till their soils by tractor or by hand. Breaking up soil chunks, puddling, and field leveling was all done without machinery, which required a large amount of labor.

SRI nurseries required less work because: (i) they are much smaller, (ii) they required only 11 days of attention instead of 29 days as under farmer practice, (iii) SRI seedlings are quickly removed from the nursery bed with a

Table 4 Labor needed for cropping activities (person days ha^{-1}) for SRI and farmer practice systems, taking into account different soil preparation options

Crop management	SRI Tractor (person day ha^{-1})	SRI Manual tillage (person day ha^{-1})	Farmer practice Tractor (person day ha^{-1})	Farmer practice No tillage (person day ha^{-1})
Plot boundary	5	5	5	5
Tillage	30	34	30	0
Breaking up chunks	30	7	8	0
Leveling	14	14	0	0
Total soil preparation	79	60	43	5
Nursery	8	8	23	23
Transplanting	77	77	24	35
Hand weeding	6.5	6.5	28	28
Cono-weeding	7	7		
Harvest	31	31	31	31
Threshing	56	56	34	34
Total	265	246	183	156

1 person day = 8 h of work, is paid 1,000 CFA

hoe, whereas under farmer practice, women sit for hours in flooded plots, pulling the plants out of the ground one by one, (iv) transporting small seedlings is easier than older heavier seedlings, and (v) fewer seedlings are needed per planted surface area using SRI techniques than under farmer practice.

Transplanting SRI plots took about three times longer than in the control plot. This is not unexpected given that SRI use required learning new planting techniques—handling small seedlings and planting with precise spacing in straight lines—and farmers had never done this before. In many instances, a large number of villagers would come to the PIV, wanting to take part in the planting. Often these first-experience events were difficult to keep well organized, and people's labor was not used very efficiently.

It is expected that farmers will reduce their SRI planting time considerably once they are used to handling the small seedlings and gain expertise in in-line planting techniques. Weeding SRI plots took about half the time required for weeding plots under farmer practice. We assumed that time required for harvest would be the same under both SRI and farmer practice, and that increased time required for threshing would be proportional to the increased yield under SRI.

Costs and benefits

Input costs, production value, and net revenue are shown in Table 5, comparing SRI, control, and farmer practice plots, based on the data presented in this article and on information from farmers in the 12 villages. Net revenue from rice production for SRI farmers was more than 1 million FCFA ha^{-1}, compared to 490,000 FCFA ha^{-1} for the control plots, and 426,000 FCFA ha^{-1} for the farmer practice plots. Although input costs for SRI were slightly higher, 15 and 25% compared to the control and farmer practice plots, respectively, SRI revenues were 2.1 and 2.4 times higher compared to these plots, indicating a markedly higher profitability for SRI over the conventional system.

Comparing the ratio of input costs to the value of the rice produced, input costs with SRI were only 32% of the total production value, whereas for control and farmer practice plots this was 46 and 47%. Considering the cost of producing one kilo of paddy rice, SRI production costs were less by one-third: For the control plot the costs of production were 76 CFA kg^{-1}, for the farmer practice plots 77 CFA kg^{-1}, whereas for SRI, the costs were 52 CFA kg^{-1}.

Conclusions and further developments

With this season's larger-scale evaluation with 60 farmers, SRI practices were successfully adapted to the local rice cropping system of the Timbuktu region in Northern Mali, which created the basis for developing technical guidelines for the region (Africare Mali et SAC Goundam 2009). Yield was increased with all five tested varieties, and income improvements were so markedly improved with SRI methods that farmers expressed continued interest in working with and further adapting SRI practices.

The main constraints identified during the season's evaluation related to farmers' need to learn and practice new technical skills, and the investment of increased labor for land preparation and for transplanting. Also, if SRI becomes more popular, there will likely be a lack of sufficient animal manure for all the SRI fields in the area.

Based on these findings, Africare and the Government agriculture service—with funding from USAID and the Better U Foundation—continued to provide technical support to over 270 farmers in 28 villages during the

Table 5 Rice production costs, production value and net revenue for SRI, control and farmer practice plots (FCFA ha^{-1})

	SRI	Control	Farmer practice	SRI		Control		Farmer practice	
	Quantities	Quantities	Quantities	FCFA ha^{-1}	% of total cost	FCFA ha^{-1}	% of total cost	FCFA ha^{-1}	% total cost
Inputs									
Irrigation(diesel fuel 200 l × 550 FCFA)[a]	90%	100%	100%	99,000	21	110,000	27	110,000	29
Amortization of motor pump (yearly)	90%	100%	100%	40,500	8	45,000	11	45,000	12
Seeds (380 FCFA kg^{-1})	6 kg	50 kg	50 kg	2,280	0.5	19,000	5	19,000	5
Urea (350 FCFA kg^{-1})	120 kg	145 kg	97 kg	42,000	9	50,750	12	33,950	9
DAP (350 FCFA kg^{-1})	8 kg	34 kg	20 kg	2,800	0.5	11,900	3	7,000	2
Manure (300 FCFA 100 kg^{-1})	13 t	3 t	0	39,000	8	9,000	2	0	0
Labor[b] (person days, paid at 1000 FCFA day^{-1})	251	169	161	251,000	53	169,000	41	161,000	43
Total input costs				476,580	100	414,650	100	375950	100
Production (paddy) (165 FCFA kg^{-1})	9.1 t	5.49 t	4.86 t	1,501,500		905,850		801,900	
Net Revenue (FCFa ha^{-1})				1,024,920		491,200		425,950	
Production cost for 1 kg paddy (FCFA)				52		76		77	
Input costs as % of total production value				32		46		47	
Labor costs as % of total production value				17		19		20	

[a] 1 USD = 450 FCFA

[b] Labor was calculated with Table 4: For SRI: 40% tractor, 60% hand;Control: 33% tractor, 15% hand, 52% no till, Farmer practice: 20% tractor, 80% no till

2009/2010 season. Additionally, SRI practices were introduced to the regions of Gao, Mopti, Segou, other circles of Timbuktu, and also to the rainfed systems of the Sikasso region through a USAID-funded project, *Initiatives Intégrées pour la Croissance Économique au Mali* (IICEM) and an SRI project of the *Institut d'Economie Rural* (IER), funded by the Syngenta Foundation for Sustainable Agriculture. Africare SRI farmers have also begun tests of adapting SRI techniques to growing the off-season wheat crop (Styger and Ibrahim 2009).

In the third season (2009/2010), the average SRI paddy yield for 130 randomly selected farmers in Timbuktu was 7.71 t ha^{-1} compared to 4.48 t ha^{-1} in farmers usual practice fields, which represents a 72% yield increase (Styger 2010a). Average SRI yields in the Gao and the Mopti region were 7.84 and 7.85 t ha^{-1}, respectively (Styger 2010b). The advantages achieved with SRI practices could therefore be confirmed for the third year and extended to two other main growing rice regions.

While introducing SRI practices into new areas, and scaling the practices up within a certain intervention zone, associated innovation development remains critical. Africare introduced and tested a hand tractor, which is manufactured and used in the Office du Niger rice growing zone of Mali. This facilitates good-quality paddy preparation, reduced labor requirements and reduced costs for soil preparation. Africare also began working with SRI farmers to produce in situ compost based on rice straw and manure to assure continued organic fertilization of their rice fields (Styger 2010a).

Farming communities have begun to develop their own farmer-to-farmer extension approach to pass the SRI technical knowledge on to their fellow farmers. A number of villages regrouped their SRI plots within a single location of the PIV, in order to apply SRI irrigation principles correctly. These farmers were able to reduce their water use by more than 30% compared with usual farmer practice (Styger 2010a).

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