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Original Research

On-farm testing of the System of Rice Intensification (SRI) in lowlands ecology in Niger

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ABSTRACT:

Lowlands's ecology represents nearly half of the agro forestry region irrigated for rice in Niger. This research aimed at evaluating practices of System of Rice Intensification (SRI) in these ecologies. On-farm testing was conducted in three (3) different regions (Tahoua, Zinder and Dosso). SRI practices in these regions were compared to conventional rice production system. Forty-five (45) producers were selected and each implemented the two (2) systems for comparison. Variables compared included tillers production and paddy yield. Results showed clearly that relative to conventional practice, SRI package increases tiller production by 45% and paddy yield by 58.2%. Furthermore, results showed that 55.5% of producers implemented thoroughly SRI package, and 11% of producers applied it moderately. Despite their moderate usage of SRI package, this last group of producers also got promising gain on their investment. Up scaling SRI practices of rice growers in lowlands ecology has a high potential of increasing rice growers returns.

Keywords:

System of Rice Intensification (SRI), On-farm testing, Lowlands, Niger, Rice field, Irrigation.

Abbreviations

CFA: Communauté Financière d'Afrique (African Financial Community); cm: Centi-meter; CP: Conventional practice; Ha: Hectare; INS: Institut national de statistique (National Institute of Statistics); ns: Non-significant; p<5% : probability at the 5% threshold; s: Significant; Sd: Standard deviation of the mean; SRI: System of Rice in-tensification; t: Tones; *t*: Student t-test

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INTRODUCTION

Niger is a landlocked sahelian country with huge land areas of 1,267,000 km^2. Of this land area only 12% is suitable to agriculture, and staple crops are millet and sorghum which solely account for about 80% of the country's cereal production. Rice is the third cereal grown on irrigated fields along the 550 km of river Niger in the western part of the country, and along the much shorter river Komadougou in the easternmost part of the country. Rice grown on irrigated fields has an estimated annual production of 1,32,030 tons (Sido *et al*., 2015), which barely covers a third of country's needs. To make up for this deficit, government imports processed rice every year for nearly 85 billion CFA francs (INS, 2014), which is a major outflow of foreign exchange. Rice import is likely to worsen in future if no robust action to bend down the trend is rapidly taken.

Agronomic research has sought to create and to introduce new productive varieties to increase rice production. Research and development strategies to increase rice production are mainly based on genetically improved varieties. These improved varieties make use of new agrochemical inputs which do not take into account impacts of such rice growing conditions on producer's health and their environmental impact. For 2016 alone, needs of rice producers in all production systems for agrochemical inputs have been estimated at 30,000 tones (Idi, 2016), which contribute to polluting rivers and aggravating soil salinity. Increasing salinity, results over the years in stagnant or even dropping yields (Gaya *et al*., 2018).

Traditional method to increase rice production is now being challenged by new method, the System of Rice Intensification (SRI) (Haougui *et al*., 2015). The SRI was developed in early 80's by Jesuit priest and French agronomist, Henri de Laulanié. Following many years of observations and field testing with small farmers in Madagascar, the latter developed the System of Rice Intensification (SRI) which violates all established rules of wet rice cultivation. Studies undertaken in West Africa from 2000 showed great benefits of the SRI practice. Results subsequently favoured rapid expansion of technic to larger scale in Mali starting in early 2007. In 2010, Malian practitioners of SRI started training farmers and technicians in other West African countries (Styger and Traore, 2018).

In Niger, SRI was initiated in the year 2012 and was viewed as a potential to reach the production benchmark of rice self-sufficiency by the years 2025 set by political authorities (Maigary and Haougui, 2015). Indeed, on-farm tests carried out between 2014 and 2016 in six rice-growing perimeters along river Niger Valley were conclusive because SRI practice allowed nearly 40% increase the paddy yield production relative to the conventional practice (Haougui *et al*., 2018). Objective of this study was to evaluate the SRI practice in lowlands ecology which represents nearly half of the areas with total control of water.

MATERIALS AND METHODS

Choice of sites and producers

Test sites were selected on the basis of accessibility and availability of water source (fed up, backwater, river) throughout the rice development cycle. On the basis of recommendation by local agricultural technical agents, nine (9) sites were chosen for test implementation. Producers' selection was based on following criteria:

- Working ability and willingness; all time availability of the producer in the village;
- Ownership of the field; willingness to share acquired knowledge.

Forty-five (45) producers, five per site, were selected, and each given group of five (5) producers was supervised by a local agricultural technician trained for this purpose.

Table 1. Information on sites and rice varieties used in the tests

S. No	Regions	Sites	Rice variéties	Geographical Coordinates
1	Dosso	Boboye	Local	13.249 : 2.851
		Tanda	Gambiaca	11.986 ; 3.328
		Gaya	Local, Samosagoumi	11.868 ; 3.480
		Dioundiou	Maijawa	12.618 ; 3.540
		Karakara	Maialewa	12.786 ; 3.658
2	Tahoua	Kalfou-Bagaye	Not determined	14.829
		Karofane	Gambiaca (2 producers) and Djimidi (3 producers)	-
3	Zinder	Dogo	Local	13.149 ; 9.017
		Guidan Elhadj	Local	-

Plant material (rice varieties used)

The rice varieties used in this study are given in Table 1.

Conducting tests

Test was to compare conventional rice growing technics with that of SRI in its accompanying technological package according to the method of Baxter (2008). Thus each producer used two (2) plots; one with farmer's practice and the other with SRI practice Table 2. In both cases, plots were plowed using bovine plow, and hovered with harrow. Mud was done after weed removal and leveling. Dykes were built in both cases to protect plots from runoff and also to maintain water on plot as long as desired. In each SRI plot, organic manure was incorporated during plowing.

Measured variables

- Total number of tillers / hill;
- Yield in ton/ha.

For statistical analysis, a student t-test (Gomez and Gomez, 1984) was used to compare the two methods of rice growing,

$$t = \frac{(Y_1 - Y_2)}{Sd}$$

where, Y_1 = Mean of SRI plots variables; Y_2 = Mean of conventional plots variables; *Sd* = Standard deviation of the mean.

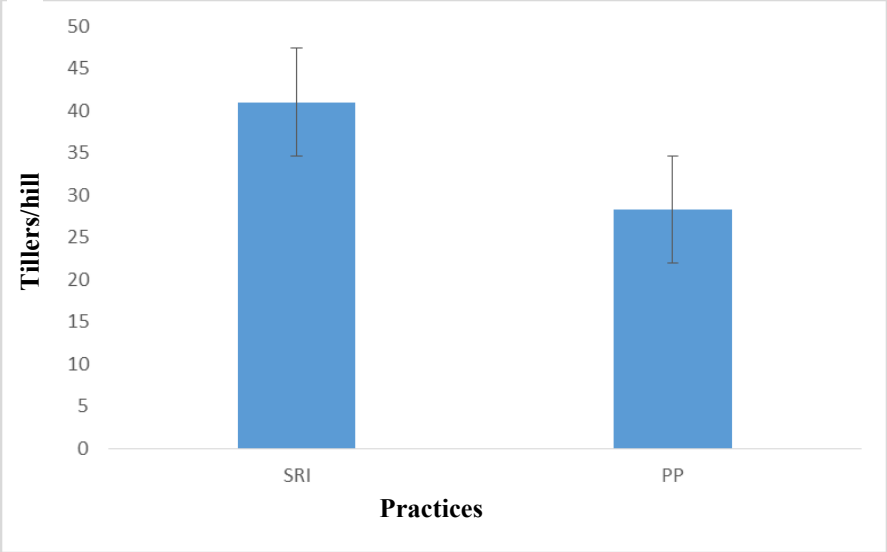

Figure 1. Average number of tillers per hill

Table 2. Treatments with the composition of technological packages of SRI and conventional rice cultivation

S. No	Conventional practice (CP)	SRI practice
1	30 to 50 kg of seeds/ha	6 to 10 kg of seeds/ha
2	Transplanting 31-day-old plants	Transplanting 12-day-old plants
3	Spacing of 20cm x20 cm	Spacing of 25cm x25 cm
4	5-10 plants/hill	1 plant/hill
5	Zero organic fertilization	Application of 10 ton/ha of compost
6	Mineral fertilization: 92 units urea/ha in 2 applications and 30, 30, 30 units of NPK/ha in one application	20 units urea/ha (on request)
7	Use of herbicide	Manual weeding (no herbicide application)
8	Permanence of water in the plot (more than 10 cm of water)	Alternation of wet (2 to 3 cm of water) and dry periods

RESULTS

Number of rice tillers

Overall average number of tillers produced per hill is 34.63 and range was from 28.27 to 41 for conventional and SRI plots respectively. Thus tillering gap was 12.71 tiller/hill, which represent an increase of 44.96% from conventional plots to SRI plots (Figure 1). Number of tillers per hill and per practice is shown in Table 3. It ranges from 16.6 in Dogo (Zinder) to 49.25 in Dioundiou (Dosso) on the SRI plots and from nine in Dogo to 44.4 in Karofane (Tahoua). Table 3 shows also that sites of Zinder (Dogo and Garin Elhadji) and Boboye (Dosso) have lowest tillering rate.

For tiller/hill variable, percent change range from 35% in Kalfou (Tahoua) to 84.4% at Dogo (Zinder), with an overall mean increase of 51.79%. Differences varied between four tillers per hill at Boboye to 19.6 tillers/hill in Karofane (Tahoua) and Tanda (Dosso). Statistical analysis showed that these differences are significant in all sites except Dogo and Garin Elhadj (Zinder) and Boboye (Dosso) (ns).

Paddy yield

Figure 1 shows that the average paddy yield (SRI and CP) was 2.46 ton/ha. This yield ranged from 1.90 ton/ha on CP to 3.01 ton/ha on SRI. Statistical analysis showed that SRI significantly improved rice

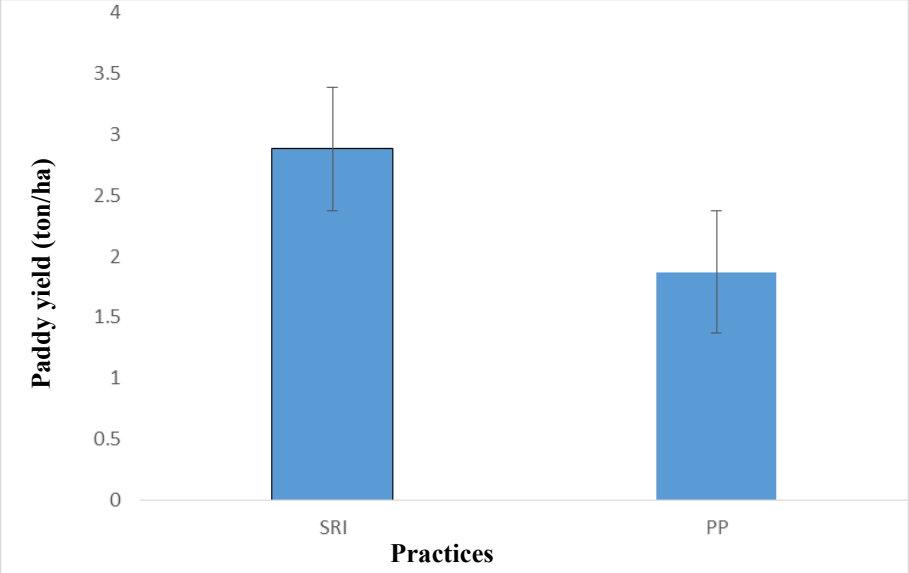

Figure 2. Rice yield

Table 3. Number of tillers/hill per practice and per site*

S. No	Sites	Tillers SRI	Tillers CP	Gap	% Increase
1	Dioundiou	49.25	36.5	19.5^{s}	53.42
2	Karofane	64	44.4	19.6^{s}	44.14
3	Dogo	16.6	9	7.6^{ns}	84.44
4	Garin ElHadj	22.6	15.4	7.2^{ns}	46.75
5	Karakara	49.5	34.75	14.75^{s}	42.45
6	Tanda	54.4	34.8	19.6^{s}	56.32
7	Kalfou	54.8	40.6	14.2^{s}	34.98
8	Boboye	16.75	10.75	6^{ns}	55.81
9	*Sd*	19.13	14.18	5.89	14.92

* the site of Gaya did not measure this parameter

yield by a significant (P<0.05%) difference of 1,11 ton/ ha that represent an overall increase of 58.42% relative to CP (Figure 2). Table 2 shows average yield of rice on SRI plots and CP plots. This variable ranges on the SRI from 1.08 ton/ha at Kalfou (Tahoua) to 5.5 ton/ha in Gaya (Dosso). In CP plots, it ranges from 0.63 ton/ha to 2.90 ton/ha on the two aforementioned sites. Difference between average yields of the two practices varies from 0.42 ton/ha at Kalfou to 2.17 ton/ha in Gaya. Rate of increase varies from 40% at Karakara to 74.96% in Gaya. Difference (gaps) between yields of SRI plots and CP plots was statistically significant at all sites, with the exception of Boboye (ns).

Producers household classification

Below dendrogram shows existence of three (3) distinct groups of farms household on the basis of number of tillers per hill and the paddy yield per hectare. Group 1 (blue in color) has 25 farmers and represents farms with very high tillering (56.68 tillers/ hill) and an average yield of 4.22 ton/ha. Group 2 (red in color) has 5 farmers with an average of 47.6 tillers/ hill and an average yield of 3.16 ton/ha, and Group 3

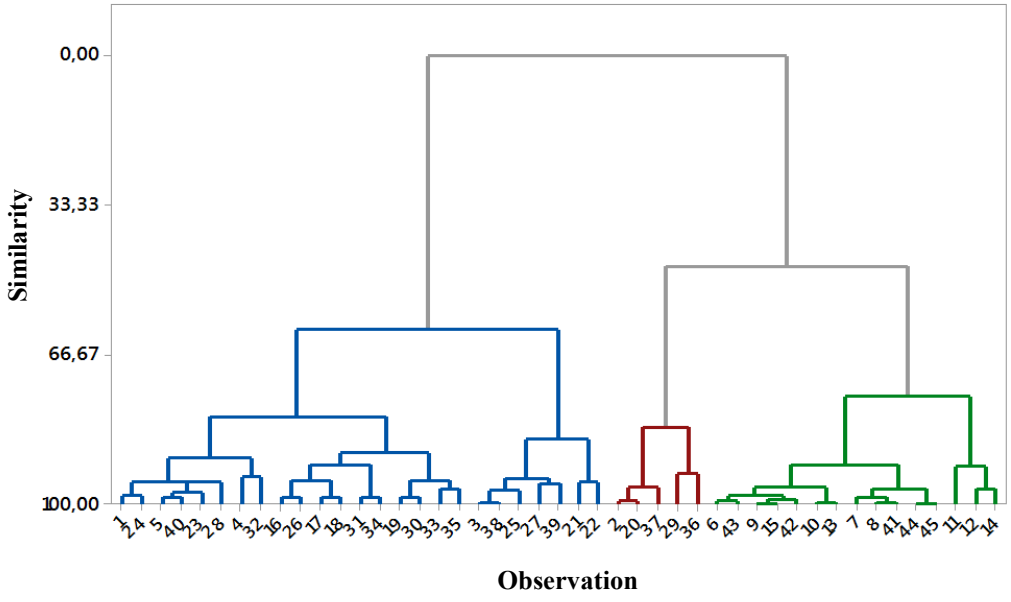

Figure 3. Dendrogram showing grouping of holdings

Table 4. Rice yields under both practices according to the sites

S. No	Sites	SRI	CP	gaps	% Increase
1	Dioundiou	3.69	2.25	1.44^{s}	64
2	Karofane	3.44	2.1	1.34^{s}	64
3	Dogo	1.9	1.05	0.92^{s}	87.62
4	Garin ElHadj	1.97	1.34	0.63^{s}	47.01
5	Karakara	4	2.85	1.15^{s}	40
6	Tanda	3.06	2.14	0.92^{s}	43
7	Kalfou	1.08	0.63	0.42^{s}	66.67
8	Boboye	2.89	1.86	1.03^{ns}	55.17
9	Gaya	5.06	2.9	2.17^{s}	74.96
10	*Sd*	1.22	0.77	0.51	15.59

(green in color) contains 15 farmers with 18.47 tillers and a yield of 2.16 ton/ha.

DISCUSSION

Effect of SRI practice on number of tillers / hill and the paddy yield was studied over 45 rice farmers in the lowland ecology. Those farmers span three (3) lowland ecology regions of Niger. Results showed almost all involved farms, a substantial increase in average number of tillers/hill produced. Similarly, on the same fields, yield was equally induced by SRI practice relative to farmer practice.

These results corroborate those obtained by Haougui *et al*. (2015) on irrigated perimeters along Niger river banks with total control of water. Also, several authors have shown that the SRI allows an improvement of these two parameters relative to conventional rice cultivation. Average number of tillers per hill was 41 in SRI against 28 in conventional practice (CP), that is an increase of 13 tillers, eg. 46.43%. Bouet *et al*. (2016) have found a marked improvement in number of tillers by the SRI with a gain of up to 32.9% compared to the CP. However, at sites like Boboye, Dogo and Garin Elhadj, tillering was very low. This phenomenon is attributed either to the growing conditions (sowing/transplanting date) or to the variety or even the nature of the soil as in Boboye soil is very saline.

Paddy yield was 3.01 ton/ha which is higher than national average in lowlands ecology. In fact, according to Idi (2016), average national yield of rice under lowland conditions is 1.5 ton/ha. SRI practice has increased paddy yield by 58.42%. These results are consistent with those obtained in several West Africa countries. In Burkina Faso, Côte d'Ivoire, Mali and Benin rates of increase in paddy yield by SRI relative to conventional system were 47%, 22%, 47% and 75% respectively (Styger and Traore, 2018).

Earlier, Styger (2009) already reported worldwide yield increases of 50 to 100%. Styger (2010) gave average yields using SRI of 7.0 ton/ha in Timbuktu (Mali), 7.84 ton/ha and 7.85 ton/ha in Gao and Mopti, respectively. During same period in these previous localities, CP plots yields were only 4.19 ton/ha Timbuktu, 4.78 ton/ha in Mopti and 5.59 ton/ha in Gao. In Asia, several authors have shown similar performance of SRI relative to conventional system (Thakur *et al*., 2011; Kassam *et al*., 2011; Thakur *et al*., 2014; Paramasivan and Selvarani, 2017).

Substantial yield gain observed under SRI technics might be due to several factors of which one can cite:

(i) Contribution of organic manure in SRI practice to the

plot. Indeed, manure improves agronomic and biological fertility of soil. It makes mineral elements available to the plant and also improves soil structure. Under such conditions, the rice roots easily explore the soil thus increasing its rhizosphere.

(ii) Higher tillering generated by SRI is due to combined effects of on one side usage of higher seeding space (25 cm x 25 cm) relative lower spacing (20 cm x 20 cm) of conventional system, and on the other side greater tillering capacity when rice seedlings are transplanted at a very young age (Thakur *et al*., 2010).

Grouping of rice farms showed three categories, largest of which has 25 farmers, *i.e.* 55.56%. These are farms in which the producers have applied correctly the SRI technique. Those in the second group (11.11%) obtained only a very slight improvement compared to the conventional practice while the producers of the 3rd group (33.33%) produced little tillers and low yields. Latter group consists of Zinder (Dogo and Garin Elhadj) and Boboye (Dosso) holdings, where all the producers used a local variety of very low tillering. In these sites, rice also suffered from drought both at the beginning and at the end of the cycle, in the case of Zinder or soil salinity in Boboye (Dosso).

CONCLUSION

The improved yield of paddy rice obtained with the SRI practice suggests that this practice could potentially become an approach to increase rice production in Niger. It is environmentally friendly with an economy and efficiency of agricultural water productivity and an improvement of soil fertility. It would be interesting to carry out economic studies to better understand all the benefits of this practice.

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