Sustainable Intensification of Rain Fed Lowland Rice Systems: A Case Study in Xieng Khouang Province in Lao PDR

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ABSTRACT

With the growing concern about food security in the northern uplands of Laos, it is critical to address the issue of sustainable intensification of food production. The objective of the study was to characterize the variability in rice cropping practices and to evaluate their performance and sustainability in Lao PDR. One, named Sustainable Rice System (SRS), was promoted by a national NGO as an adaptation of the System of Rice Intensification (SRI) to the local agro-ecological conditions. This innovation was compared to traditional rice growing practices in the study area in Kham District, Xieng Khouang Province. The study has enabled actors to better understand the real diversity of practices. We found a distinction between single seedling and multiple seedling transplanting practices. Then, focusing on single seedling transplanting (referred as SRS), the study demonstrated that despite no significant yield increase, farmers are interested in adopting it because it provides other benefits. These are notably the increase in the return on labor (57.8%) and savings on the global labor requirement (28.4%). As labor scarcity is and will remain the main concern for Lao farmers, our study shows the importance of considering performance indicators beyond crop yields. Regarding the environmental aspect of SRS, our results highlight that the common use of chemical fertilizer does not really fit with agroecological principles. Nevertheless, the significant increase in the use of manure in comparison with other practices can anticipate a positive trend in term of environmental conservation.

Key Words: Rain Fed Lowland Rice, Agroecological Practices, Farmers' Innovation, SRI/SRS

INTRODUCTION

In Laos, rice is the main staple food with an average consumption of about 160 kg of milled rice per inhabitant per year (Eliste and Santos, 2011). This makes Laos the 2nd largest rice consumer in Asia and one of the bigger consumers in the world (Eliste and Santos, 2012). Furthermore, according to IRASEC[5], 80% of the 4% of the country's arable land was used for rice cultivation in 2014. Although Laos has achieved rice-sufficiency for more than a decade, rice production is heterogeneous across the country and food security is not assured for all. There is a need for sustainable intensification of rice systems as exemplified by the support provided by SAEDA, a national NGO for the promotion of the Sustainable Rice System (SRS), a local adaptation of the well-known System of Rice Intensification (SRI). On the one hand, SRI is widely promoted for increasing the yield and labor-savings in the main rice producing countries (Uphoff and Kassam, 2009). But on another hand, several literature reviews question the real impact of these techniques and their capacity to adapt to constraining environment, such as those with poor water control and a limited labor force. In Laos, little literature exists about this technique. This is why this paper questions the place and performances of SRS, an adapted version of SRI.

MATERIALS AND METHODS

We conducted semi-structured interviews with individual farmers and key informants, and focus group discussions in two target villages. Two phases of interviews were conducted with farmers. The first one had the aim of describing the techniques and categorizing the different rice systems existing in the study area. The second one aimed at comparing their performances and understanding the conditions of dissemination of the SRS technique.

Description of the Study Area

The study was conducted in two villages, named XiengKiao and Hainiang, in the district of Kham, Xieng Khouang Province, Lao PDR. These villages were selected by cross-checking the information collected from other development projects conducted in the area.

1. Xieng Khouang Province and Kham District

Xieng Khouang province is located in the northeast of Laos, bordering Vietnam. It is one of the most bombed areas in the world, which adds an additional pressure on accessible land for agriculture because of the presence of unexploded ordinance. The province is mainly mountainous with valleys, except for the Plain of Jars which is a 1,000 km² plateau located at 1,000 m altitude. Since 2000, the area has changed from subsistence to commercial agriculture, adding cash income from upland crops such as hybrid maize to the rice-based lowland systems (Seguy, 2004). Kham district is characterized by a basin located at the lowest altitude of the whole province (Department of Science and Technology interview, 2017) and with optimal conditions (e.g. soil fertility and depths) for producing good crop yields. It includes 5,125 hectares of lowland rice but it remains one of the poorest districts of the country.

2. XiengKiao and Hainiang Villages

The two study villages were selected to illustrate the diversity of the area. XiengKiao is an old village created in 1875, and is easily accessible because it is located 3.8 km from the district capital. It has 117 households. The village's main activity is agriculture with two cropping systems: commercial hybrid maize in the uplands and rice for household consumption in the lowlands. It is characterized by favorable conditions of water access and soil quality. On the opposite extreme, Hainiang is a recent village, formed only in 2012, and is more remote. The two main cropping systems are the same

[5] IRASEC : Institut de Recherche sur l'Asie du Sud Est Contemporaine

as in XiengKiao but they are more constrained in terms of water access and soil quality.

Table 1: *Set of principles for SRS and SRI techniques.*

Principles	SRS	SRI
Cultivar	Use traditional cultivar	Use traditional cultivar
Seed selection	Seed selection using salty water	Seed selection using salty water
Seedling age	12 to 25 days	8 to 15 days
Transplanting density	Transplant 20 x 30 cm	Transplant in line, 25 x 25 cm
Water management	Maximum water depth is 10 cm	Water must be drained
Fertilization	Organic fertilizers only	Fertilizer use (ideally organic)
Weeding	Manual weeding	Mechanical weeding

Characterization of Rice Cropping Practices

1. Interview Methodology

In each village, an exhaustive household survey was conducted to collect quantitative data about the structure of all farms in the village. This rapid survey led to a farm typology that helped capture the diversity of livelihood systems in the study area. The questionnaire was a quick description of farmers' production systems and rice plots. Based on this typology, a limited number of households were selected among each type for more detailed interviews about their cropping systems. This led to the selection of one plot per household on which detailed questions were asked about the cropping practices used the year before. The technical-economic study covered the different activities conducted on the plot, with the labor, costs, and input used, and the production results. A total of 34 individual plots were surveyed including 17 using a one-seedling technique and 17 using a more-than-one-seedling technique.

2. The Principles of SRS and SRI

The first step of the study was to understand the differences between SRS and SRI in order to measure their dissemination in the study area. With input from SAEDA (the NGO that promotes the SRS technique), the following set of principles was selected to characterize each technique (Table 1).

Using this set of principles, the adoption intensity (Roussy and al, 2015) of the technique was measured for each individual. This consists of measuring how many principles of each technique are applied for each individual plot.

SRS Dissemination and Performance

1. Interview methodology

A total of 60 farmers were interviewed. The interviews addressed the history of each farming household, the adoption process of innovative practices, especially for the SRS farmer, and the perceptions of benefits and limits of the technique.

Data Analysis

A notation system was used to rank the answers of individual households and economic performances were computed for each plot. We calculated the Production Costs (PC), the Gross Product (GP), the Added Value (AV), and the Return on Labor (RL), using the following formula:

- PC = (Seed Rate x Seed Price) + (Quantity of Fuel x Fuel Price) + (Quantity Manure x Manure Price) + (Quantity Chemicals x Chemicals Price); in (LAK/ha[6*])
- Gross Product = Production x Mean Price; in (LAK/ha)
- Added Value = GP – PC; in (LAK/ha)
- Return on Labor = AV / Total Men-Day

In the PC calculation, the material depreciation is not taken in account (Ferraton and Touzard, 2009). The prices used (seed, fuel, manure, and quantity) were collected during interviews and through observations in markets. The seed price is individual for each farmer regarding the cultivar used. In the GP calculation, the mean price is an average of the different selling prices during the year to facilitate the calculation. Finally, performances were assessed in relation with the work time per hectare for each operation. As RL is computed at the plot level, the working time is expressed as man-day.

RESULTS AND DISCUSSION

Rice Cropping Techniques

There was not a full adoption of SRI or SRS techniques, but rather an adaptation of the techniques by the farmers. We noticed that most of the farmers are using a technique closer to SRS principles than SRI principles. This result was expected, as SRS is an adaptation of SRI to the local constraints related to water management and labor availability. It confirms the importance of promoting techniques that are well-adapted to the local context, and that are ideally co-designed with end-users, the rice growers. The SRS was supposed to have been thought that way at the outset of the study. But more detailed analyzes showed that farmers were not all applying the same principles. They retained the principles they thought were most appropriate to their own context. These results even question the use of the term "technique" when referring to complex practices such as SRS or SRI. Can we say that those farmers are adopting one technique or another if they do not fully adopt it? What do they actually adopt? Finally, this study outlines an opposition between techniques based on single-seedling transplantation versus multiple-seedlings. It was thus decided that as long as a single seedling is transplanted, farmers in this area are practicing SRS. This choice is consistent with farmers' perception as revealed by the individual interviews. Indeed, as long as they transplant a single seedling, even though other principles are not met, this is SRS to them. In the rest of the study we thus only differentiated between single-seedling (referred as/named/called SRS), and multiple-seedling techniques.

[6*] LAK refers to Lao KIP

SRS Performance

SRS farmers' saved a total of 28.4% labor in their rice field. The main savings came from the work in the nursery, with up to 88% time saved using SRS, as compared to the traditional techniques (Table 2). When focusing on women's labor, it seems that the SRS technique increases it, but only by 2.6%, but not significantly. Such increase is mostly related to the fact that the weeding, which is more time consuming in SRS compared to multiple seedling practice, is carried out by women.

Table 2: *Comparison of labor requirements for main operations in rice cultivation.*

Technique	Transplanting (Man-Days)	Weeding (Man-Days)	Harvesting (Man-Days)
SRS	22.4	22.2	30.1
Multiple-seedlings	39.3	17.9	40.6

SRS is less labor intensive than other techniques except for weeding. This may be due to a lower competition capacity of the young seedlings. These five additional days spent on weeding are seen as a constraint by farmers, whereas in total 28.4% of the labor is saved by using SRS. This may be related to the hardship of manual weeding work or labor peaks due to competing farm activities. But, apart from this weeding constraint, the study outlined that the SRS technique fits well with farmer expectations. The SRS technique meets most of farmers' criteria for performance. It appears that on average, the SRS plots are smaller than the ones with the other techniques. But this result is not statistically significant as it is about 5,700 m² against 6,700 m². However, we can notice that these plot sizes are smaller than the provincial average which is around 1.27 ha for paddy fields (Chanthavongsa, 2015). Moreover, SRS allows a 50.2% increase in land productivity in comparison with multiple-seedlings techniques. These results are interesting in a context of limited capacity for paddy terracing in the study area.

Regarding yield, which is the main factor why extension agents are pushing SRS forward, it appears that there is no significant increase in yields compared with multiple-seedlings techniques. Indeed the mean of SRS was 5.7 tons/ha while the mean with other techniques was 5.2 tons/ha. Compared to what is usually written about rice production in this area, we found a high yield for the multiple-seedling techniques. In 2015, the average yield of rainfed lowland rice was about 4.4 ton/ha in Xieng Khouang province (Lao statistics Bureau, 2015). But, even if the yield differences recorded here through farmer interviews are not significant, farmers are satisfied with SRS because they perceive that they get heavier panicles and more homogeneous grain weight. This was also noticed by Serpantie and Rakotondramanana (2013) in Madagascar with the 'Improved Rice System', which is also a local adaptation of SRI. They noted a significant difference of up to 15% increase. In the same study, Serpantie noticed that the yield obtained using SRI techniques was about the same or even less when compared to other techniques. It thus questioned the real impact of SRI and our study comes to support these results.

Regarding economic results, it appears that, contrary to what is promoted, the production costs are higher for the SRS technique. This may be explained by the high amount of manure used. Indeed, SRS uses much more manure on average (19 kg for non-SRS vs 200 kg for SRS), but only 6.2% less chemicals. Moreover, most of the farmers who use manure also use chemical fertilizers. Thus, even if the manure is less expensive, this cost is added to the cost of the chemicals. Nevertheless, it is important to note that most of the farmers don't buy their manure because they produce it directly on their farm. Even if SRS farmers use more inputs, they get a higher gross product (up to 14%), and thus an increased added value up of 9.9%. That means that the gain due to the increased production offsets the loss due to the higher input use. Finally, the SRS technique gives a better return on labor than the traditional techniques. For the labor investment, SRS farmers get 57.8% higher remuneration. According to Eliste and Santos (2012), one of the main issues of Lao rice cropping is the low return on labor, leading many farmers to abandon rice farming. The use of SRS techniques may potentially revive rain fed lowland rice production in the area and thus preserve rice sufficiency and food security.

Regarding fertilization, SRS is supposedly a pesticide-free technique. But it appears that farmers cropping SRS use an average of 112 kg of chemical fertilizer per hectare. This is only 6% less than the other techniques. Despite the higher use of manure, SRS is not an environmental performance technique. As we interviewed 3 farmers who cropped both an SRS plot and a traditional rice plot, we compared the use of fertilizer for each farmer. They all used chemical or no fertilizer for the non-SRS plot, and manure for the SRS-plot. SRS farmers were eager to stop using chemicals and only use manure in the future. But, to reach that objective, farmers will need to receive increased support from extension agents to reduce their use of chemicals. Those farmers who do not use fertilizer at all requested help to use only organic fertilizers in the future. Indeed, farmers are taught to make their own bio-fertilizer, bio-pesticides etc. but this involves much work for them to produce enough organic inputs to spread on their whole rice field.

SRS Dissemination

Several constraints on the dissemination of SRS were highlighted during the interviews. First of all, one of the largest constraints was the social mistrust of the population regarding this new technique, which comes from the long established practice to transplant more than one seedling per hole. Moreover, in the study area, the labor exchange through mutual help is the only way for farmers to get enough workers to face key labor peaks, such as transplanting or harvesting. Mutual help means that when a farmer goes to work in the field of another one for one day, he gets one day of work in his field in return. But people think that transplanting only 1 seedling is too hard and they refuse to provide mutual help for this job that they are not comfortable with. It may thus be more difficult for farmers to find the needed labor force for SRS. Another key factor of dissemination is the quality of the authority's involvement in the dissemination of this new technique. Indeed, the two main paths of dissemination are the government (represented by the District Agriculture and Forest Office) and the head of village. Levard and Apollin (2013) support this observation. Indeed, they bring forward that the state involvement is important to develop agroecology, because it is not only a short-term concept but also has a long-term performance that needs a solid basis to be effective. Once farmers have heard about the technique, their main motivation to adopt it is to see the results on someone else's field. This is called the imitation effect (Ruf, 2012) and has been observed many times, notably in rubber cultivation or cacao cultivation.

Discussion

Several constraints on the adoption of SRS technique have been highlighted. Furthermore, the age of the seedling and their resistance to climate events should be addressed. Young and fragile seedlings require a flat, even area that is not submerged by water and can facilitate weeding. Flattening a plot requires renting a tractor-based leveling service, which costs between 2 million and 4 million kip per hectare. This is an important investment regarding the minimal annual wage per inhabitant in Laos, which in 2016 was around $1,150 (or 9.8 million LAK) (Le Corre, 2016), which is not affordable for all farmers. Moreover, we noticed that the differences in yield are not significant because of poor control of water resources by most farmers due to the poor quality of irrigation systems. Is it then worthwhile for farmers to invest in and take risks by adopting an innovative practice that does not show big differences in yield? This study was conducted to go beyond the "yield per acre" indicator as the main measure of progress. Indeed, we could show that this technique allows labor savings and increases the return on labor. It appears that the labor is the criterion of main importance in the context of Laos with very low population densities. Therefore, it seems that even if the technique is not accessible to all farmers and they feel it requires additional work for weeding, it may still provide a suitable alternative. Mechanical weeding may even increase the rate of adoption, as it would relieve one of the main constraints that SRS farmers are facing.

Following-up on the subject of farmer perceptions, we found that the opposition between SRI and SRS created by development and government agencies does not exist for farmers. In their opinion, this is the same technique with only different technical constraints. This questions the differences in the logic of action between the different actors. Rather than promoting their own flagship technique with a potential misunderstanding for the beneficiaries, development agencies should start from a thorough understanding of the existing cropping techniques to steer new techniques towards more sustainable practices. As the study is only based on a retrospective, declarative approach, without field measurements, it introduces key aspects of the problems but does not intend to be scientifically generalizable. Tt would be interesting to support results of other case studies that combine declarative surveys with direct field observations.

CONCLUSION

The results show that even if the SRS in the context of Kham District does not increase the yield obtained by farmers significantly, they are still interested in adopting it because it provides other benefits. These are mainly the increase in the return on labor (57.8%) and a savings on the global labor requirement (28.4%). As labor scarcity is and will remain a concern for Lao farmers, this study shows the importance of considering performance indicators beyond crop yield. Regarding the environmental aspect of SRS techniques, these results show that the common use of chemical fertilizer does not really fit with agroecological principles. Nevertheless, the significant increase in the use of manure in comparison with multiple-seedlings cropping systems shows a positive trend in terms of environmental conservation. This study presents a first overview of the place of SRS techniques in rainfed lowland rice cropping systems after two years of promotion of the innovative practice only. These results are therefore promising but the long-term sustainability of these new rice-based production systems will still have to be studied.

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