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The Potential of the System of Rice Intensification (SRI) for Poverty Reduction in Cambodia

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Abstract

The system of rice intensification (SRI) was developed in the highlands of Madagascar and comprises a set of individual practices. In 2000, SRI was introduced to Cambodia and, since then, has attracted an increased number of farmers and projects. In order to facilitate the systematic analysis of experiences with SRI in Cambodia the Food Security and Nutrition Policy Support Project (FSNPSP)/GTZ together with the Community Based Rural Development Project (CBRDP)/GTZ and CEDAC initiated a survey on the potential of SRI for food security in Cambodia in early 2004.

The consultancy mission comprised a survey conducted in five provinces based on individual interviews covering 400 SRI and 100 non-SRI practicing farmers. In addition, farmer group discussions and stakeholder discussions supplemented the survey results.

Farmers applying SRI followed to a large degree the recommended practices. Timely weeding and water management with alternate flooding/drying were among the most difficult practices for farmers. However, SRI requires intensive training with a high demand for human and financial resources.

With significant lower fertilizer inputs SRI increased rice yields from 1629 to 2289 kg ha^{-1}, an increase of 41%. The increased yield levels could be maintained for at least three years, indicating sustainability at least for the medium term. However, fields chosen by farmers to apply SRI were close to the homestead and of higher soil quality. The potential of SRI for poor environments to increase yields was rather low.

A further advantage of SRI was its ability to break the labor peak during uprooting/ transplanting while the overall labor balance was neutral. SRI increased both the land and labor productivity compared to conventional practices.

Farmers using SRI for the first applied it on 21 % of their rice area while more experienced farmers doubled the proportion. Hence, at household level, the marginal profit due to SRI was sufficient to supply the household's needs for rice for 2.2 and 4.6 months, respectively. It was concluded that SRI is a promising management practice to be included into the national strategy for poverty reduction.

Keywords: Adaptability analysis, Cambodia, food security, labour, SRI, yields

Introduction

Rice is the main staple food and the most important crop, considering food security, for rural households in Cambodia, which account for 85% of the national population (Nesbitt 1997). About two-thirds of the rural population depends mainly on rice farming. Officially, the national average yield of rice for the wet season was estimated to be between 1.65 and 1.8 t ha^{-1} (FAO/WFP 1999).

Improvement of rice productivity is one of the main objectives of any agriculture and rural development program in Cambodia. In the last decades the Royal Government of Cambodia, NGOs and IOs have implemented agriculture productivity improvement programs with different approaches and strategies to increase rice yields of small farmers, which are expected to improve food security, increase rural incomes, and reduce the vulnerability of rural households. Fertilizer split application and the introduction of improved high-yielding varieties (Anthofer 2004), as well as integrated pest management (IPM), were promoted on a large scale. However, the economic viability of high input approaches for poor farmers are still questionable, especially taking into consideration that the production system has hardly been able to increase yields beyond the 2 tons per ha mark.

Another promising alternative to increase the profitability of rice production and food security is the System of Rice Intensification (SRI), which was originally developed in Madagascar. It comprises a set of management practices which are expected to apply flexibly (Uphoff 2002). The main components are: (1) shallow (1-2 cm) transplanting of strong, young (<15 days) seedlings without delay after uprooting into a moist but not flooded seedbed, (2) transplanting of 1-2 seedlings per hill at wider spacing between 25x25 cm and 50x50 cm ideally in square pattern or in rows to facilitate weeding, (3) alternation flooding and drying of the field during vegetative growth, (4) early and frequent mechanical weeding to control weeds and to aerate the soil, (5) add nutrients to the soil preferably in organic form.

Since 2000, with the assistance of CEDAC, a Cambodian NGO, the GTZ supported Rural Development Program (RDP) in Kampot and Kampong Thom, and several NGOs in various provinces have introduced SRI on a pilot level. In 2002, approximately 2600 farmers were working with SRI elements on various scales. In 2003, an estimated 9000 farmers were applying SRI practices. Preliminary results from the various projects indicated partly drastic yield increases while inputs such as seeds and mineral fertilizers could be reduced. Therefore, SRI may be a valuable alternative for small farmers with limited land endowment and little capital to invest in agricultural inputs. However the specific enabling and constraining factors for achieving these impacts, the economic net returns, and the feasibility of implementing this strategy for poor farmers on a broad scale in order to reduce household vulnerabilities and increasing food security were not well known. Although implementing government projects experimenting with SRI have been supported by relevant line ministries at the provincial level, at national level the approach was little known and had not found its way into policy documents and strategies.

In order to facilitate the systematic analysis of experiences with SRI in Cambodia, GTZ/FSNPSP in cooperation with CEDAC and GTZ/RDP organized a consultancy mission in early 2004. Findings of the mission were presented during a national workshop in April 2004 organized under the umbrella of The Council of Agriculture and Rural Development (CARD), a coordination structure for agriculture and rural development in Cambodia within the Council of Ministers. Findings are discussed within the National Food Security Forum (FSF) and should also find their way into discussions at MAFF, CARDI and MRD, respectively. The following paper is a condensed version of the consultancy report that can be obtained from the author.

Materials and methods

The study was conducted by a consultancy team comprising three consultants and six enumerators between 16 February and 9 April 2004. The major component was a survey based on individual interviews both of SRI and non-SRI practicing farmers. Group discussions with farmers and stakeholder discussions at various levels (project managers, implementing field staff, farmer promoters, village leaders) supplemented and verified the survey results.

The survey was carried out in the five provinces Kandal, Kampong Thom, Kampot, Takeo and Prey Veng, which were pre-selected ahead of the mission with the objective to cope with available logistic, to cover a diversity of farming environments and to cover target areas of different projects. In each of the five provinces, four villages were randomly selected, in which 20 SRI farmers were further identified at random for the interviews. In addition, 5 non-SRI farmers per village (20 per province) were randomly selected from village lists to serve as a control group. The interviews with the 400 SRI farmers and 100 non-SRI farmers were carried out by two survey teams, each comprising three enumerators and one co-consultant (supervision and data-entry) during the period from 1 to 25 March 2004.

All survey data were obtained through questionnaires. Standard procedures for yield measurements were not employed due to the short time frame of the survey and the quantity of farmers surveyed. To increase the accuracy of the estimates, only SRI fields of at least 30 are in size were included in any of the quantitative analyses like yields, man-days (labor) or gross-margins. For qualitative assessments, however, all farmers were included in the analyses.

Treatments consisted of SRI practices applied on one field and conventional practices applied on the same field before it was cultivated with SRI. Conventional practices comprise any rice technologies/practices the farmer applied on the particular field in question.

Unlike in many other on-farm trials, fields, which were affected by either flooding or drought, were purposely not excluded from the analysis. Such natural disasters occur quite frequently (Nesbitt, 1997) and are a part of the risk the farmers are facing when cultivating rice.

To assess the impact of SRI, only the SRI farmers were selected for the analysis. Fields cultivated with conventional rice practices were compared with data of the following year applying SRI components. Quantitative data were compared with paired-samples t-tests. The standard error of the difference (SED) was calculated. The level of significance was indicated by the number of asterisks: $P > 0.05$ (n.s.: not significant), $P = 0.05$ (*), $P = 0.01$ (**), $P = 0.001$ (***). Qualitative data were compared with simple Pearson chi-square tests.

Adaptability analyses (Hildebrand and Russell 1996) were applied to discover the distribution of yields at different farming environments and to identify whether SRI is more suitable for locations of low or of high productivity levels or whether it is a robust technology suitable for all farming environments. Based on the paired data of the SRI plots, the risk for a randomly chosen SRI farmer not to achieve a predefined yield difference with SRI compared to the conventional practice was estimated as well (Eskridge and Mumm 1992).

Partial budget analyses were employed to estimate the economic impact because only relative small changes on the farm business (seeds, fertilizer) had to be assessed while all other parts remained the same. The gross margin per hectare was calculated by subtracting variable costs from the gross return. To assess also the return to labor, the gross margin per man-day was calculated by dividing the gross-margin per hectare divided by man-days of family labor. To assess the labor force available in a household, male adult equivalents were assigned to different gender and age groups (Baum et al., 1999).

Results and discussion

Crop and nutrient management

Many farmers applying SRI followed to a large degree the recommended management practices. The seed rate was reduced from 90 kg ha^{-1} with conventional practice to only 30 kg ha^{-1} applying SRI, which is particularly important because the farmer can save input costs at a time when financial resources are scarce. The most difficult practice to apply in the predominantly rainfed rice systems was obviously the water management with alternating flooding and drying of the rice fields.

Practicing SRI was connected to a sharp reduction of mineral fertilizers which was compensated by an increased use of compost. Most farmers have used animal manure also for conventional practices but with the use of SRI, animal manure is now converted to higher quality compost. On the other hand, green manures are hardly used by farmers despite being promoted by the projects.

Partial N and P balances only considering mineral fertilizers, animal manure and compost as inputs and rice grain yields as outputs resulted in positive balances for both systems in this study. However, nutrient losses due to volatilization, leaching or flooding and nutrient inputs due to sedimentation were not considered in that balance. Moreover, it should be considered that the difference between the two systems has a negative balance for both N and P which means that the additional nutrient losses caused by increased grain yields and reduced mineral fertilizers are not compensated by additional organic inputs. To assure sustainability, the aspect of the nutrient balance should be further investigated with adequate research methods.

Impact at field level

Over a wide range of farming environments and years, rice grain yields increased from 1629 kg ha^{-1} with conventional practices to 2289 kg ha^{-1} with SRI, an increase of 660 kg ha^{-1} (***) or 41%. This trend of considerably higher yields when changing from conventional practice to SRI under farmers' management was consistent when analyzing the data separately for different provinces and years. Therefore, regardless of the province and year average grain yields obtained with SRI clearly outperformed the conventional practices.

It is often claimed that SRI is a promising technology for poor farming environments, while at locations with better resource endowments, other technological options are superior over SRI (DOBERMANN, 2004). Results of the adaptability analyses conducted separately for each province demonstrated the opposite (Fig. 1). Highest yield increases can be expected under favorable environmental conditions. Such conditions are met where soil fertility is higher, rainfall is sufficient and well distributed, the risk of crop losses due to flooding or drought is minimal and crop management is sufficiently good. Conversely, the potential of SRI to increase yields in poor environments is rather low. These findings were confirmed by the farmers' choices of fields to apply SRI. SRI fields were usually located closer to the homestead and assessed by farmers to be of higher soil quality.

SRI has been introduced to Cambodia only recently. Hence, long-term yield trends are not available so far. However, at least in the medium term, the achieved yields have not declined. There was a sharp increase in yields when changing from conventional practice to SRI. These levels could be maintained for at least three consecutive years. Therefore, at least in the medium term, no adverse effects are expected.

Different views on the labor demand for SRI exist. While SRI is thought to increase the labor demand in Madagascar (Moser and Barrett, 2003) the opposite is reported from Cambodia (CEDAC, 2002), at least for more experienced farmers. A quantification of the overall labor demand for SRI during the current study showed that SRI is rather labor neutral with respect to family labor. However, it reduced the need for hired labor significantly, although at a fairly low level.

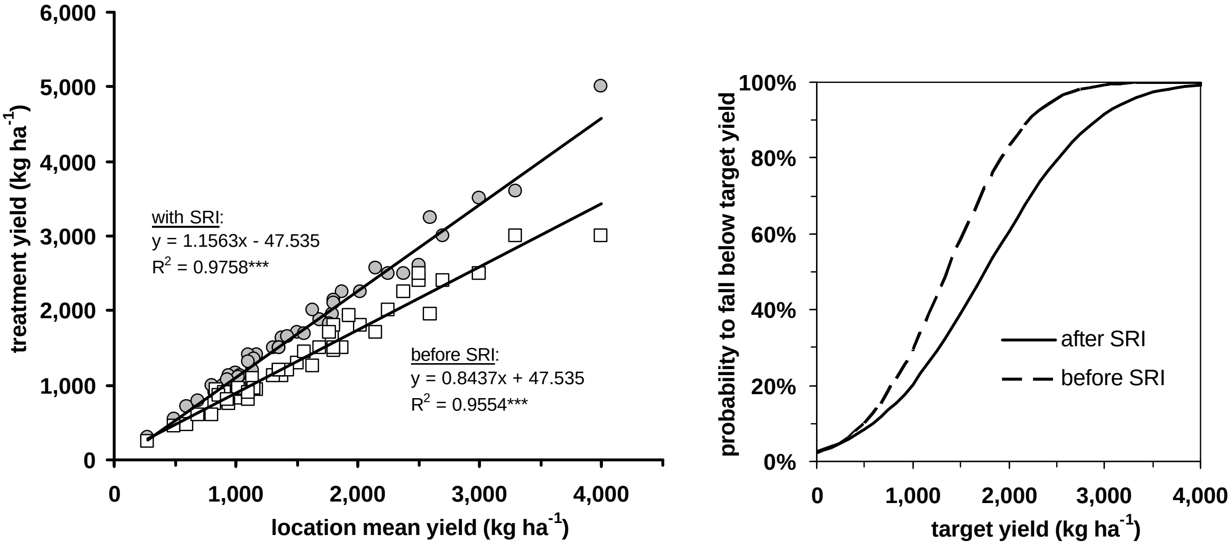

Figure 1 Adaptability analysis comparing yields on fields before applying SRI (conventional practice) and the succeeding year with SRI in Kandal province (left) and risk (probability in %) for a randomly chosen farmer not to achieve a desired target yield on fields before using SRI (conventional practice) and with SRI (right)

Analyzing the individual rice cultivation activities, two major labor peaks could be detected which has been reported earlier (Nesbitt 1997): the first one for uprooting the rice seedlings and transplanting them to the field and a second peak for harvesting. While for most Cambodian farmers the second peak is of less relevance the first peak is a major labor bottleneck, which can severely affect the overall productivity of the whole farm. The reasons for the labor reducing effect of SRI during uprooting and transplanting is two-fold: (1) It is much easier to uproot the much younger seedlings and, (2) transport and transplanting of the much lower quantity of seedlings planted at wider spacing is time-saving. Unskilled farmers often require more time during the first year of SRI experimentation but with some experience, a substantial quantity of time could be saved during the uprooting and transplanting activities. The survey data revealed that SRI is able to cut down the most critical labor bottleneck by 10 man-days ha^{-1}, which is a reduction of 26%.

SRI increased the labour demand for weeding. Among the SRI farmers 93%, 26% and 7% of them weeded the SRI fields at least once, twice or tree times respectively, while only 40% of the same farmers weeded the same fields only once when using conventional practices. However, labor allocation between transplanting and harvesting is more frequently available except in cases when farmers leave their farm to look for other income opportunities.

Economics

On average, gross margins increased from 120 US \$ ha^{-1} to 209 US \$ ha^{-1}, an increase of 89 US \$ ha^{-1} (+74%) (Table 1). The economic marginal difference is equivalent to 890 kg rice grain ha^{-1}. Two factors contributed to the large difference. Farmers saved 23 US \$ ha^{-1} for variable costs like seeds and mineral fertilizers, and SRI substantially increased rice yields leading to an increased gross benefit by 66 US \$ ha^{-1}. Gross margin calculations do not consider the timing effect. However, saving costs for inputs might be even more valuable to the farmers than increasing yields because costs for purchased inputs are saved at a time of year when financial resources in small-scale farming households are particularly scarce. Hence, the farmers presumably value the economic advantage even higher than it already appears. Moreover, saving monetary inputs reduces the economic risk of investing money for purchased inputs and losing everything in case of flooding or drought.

An economic risk assessment revealed a lower risk for SRI to achieve the same desired gross margin per hectare than with conventional practices. For example, the probability not to achieve a gross margin of 100 US $ ha^{-1} was 42% for common rice practices, while the probability not to achieve 100 US$ with SRI was only 17%. Moreover, the risk for SRI to be economically outperformed by other methods was only 12%, 16%, 13%, 2% and 12% in Kandal, Kampong Thom, Kampot, Takeo and Prey Veng, respectively.
The return to labor was much more variable than the return to land. Therefore, the slopes of the risk curves were gentler. Likewise to the return to land, the risk to fall below a defined gross margin man-day^{-1} was always lower. It was concluded that SRI is an economically very attractive methodology for rice cultivation with a lower economic risk compared to other cultivation practices.

Table 1. Gross margin calculation for rice production on fields with common cultivation practices (before SRI) and for the succeeding year with SRI (US $)

	Before SRI	With SRI	difference
Gross benefit	**161.33**	**226.89**	**+65.56**
Variable costs:			
Seeds	9.26	3.01	-6.25
Plant nutrition	21.43	6.61	-14.81
Plant protection	0.38	0.12	-0.26
Hired labor	9.45	6.60	-2.85
Threshing	0.86	1.72	+0.86
Sum variable costs	**41.37**	**18.06**	**-23.31**
Gross margin ha^{-1}	**119.96**	**208.83**	**+88.87**
Gross margin man-day^{-1}	**1.55**	**2.54**	**+0.99**

Impact at household and national level

In rural Cambodia, having enough rice and other foodstuffs to eat 12 months a year is synonymous with being not poor or food insecure (CSD, 2002). Those affected by chronic food insecurity include subsistence farmers, landless and marginal land holders, while transitory food insecurity is caused by natural disasters such as flooding or drought.
To assess the contribution of SRI to poverty reduction, the SRI practicing farmers were asked about the changes of rice sufficiency/insufficiency from the time before they practiced SRI (conventional practice) compared to afterwards when applying SRI at least on parts of their fields (Table 2). Since farmers started applying SRI, the proportion of farmers facing rice insecurity declined from 34 to 28%. At the same time, farmers being able to produce a surplus increased from 20 to 33%.

Table 2 Changes in sufficiency of rice production when changing from conventional practice to SRI.

Rice technology	Not enough	Enough	Surplus
Conventional	138 (34%)	182 (45%)	80 (20%)
SRI	112 (28%)	157 (39%)	131 (33%)
Difference	-26 (-6%)	-25 (-6%)	+51 (+13%)

As anticipated, the effect of SRI on rice sufficiency depends on the area where farmers apply the new practice. There was no effect on food security in farming households where the area under

SRI was lower than 30 are (Fig. 2). Conversely, applied on 30 are and above, SRI significantly reduced the number of months deficient in rice supply.
Farmers using SRI usually do not convert their whole rice fields to SRI, partly because it is a new and unknown practice to them. When applied for the first time, the area under SRI was 28 are, representing 21% of the total farm (Fig. 2). Farmers with more experience with SRI applied SRI on 66 are or 42% of the total rice area. These results lead to two conclusions: (1) Farmers are generally satisfied with SRI and, therefore, increase the proportion of SRI on their farm, (2) About half of the rice area continues to be cultivated with conventional practices, indicating that there are certain constraints for farmers not to apply SRI on all of their farm land. Farmers' intentions for the next season confirm these findings: Averaged over all SRI farmers, 0.42 ha (29%) were cultivated with SRI last year (2003). The same farmers expressed their intention to increase the area this year (2004) to 0.52 ha (37%). The lower increase can be explained by farmers included in the analysis, who have already converted all of their suitable rice area to SRI. As many as 17% of all SRI farmers had converted the total rice area to SRI. These figures alone document that SRI works well at least for a substantial part of farmers.

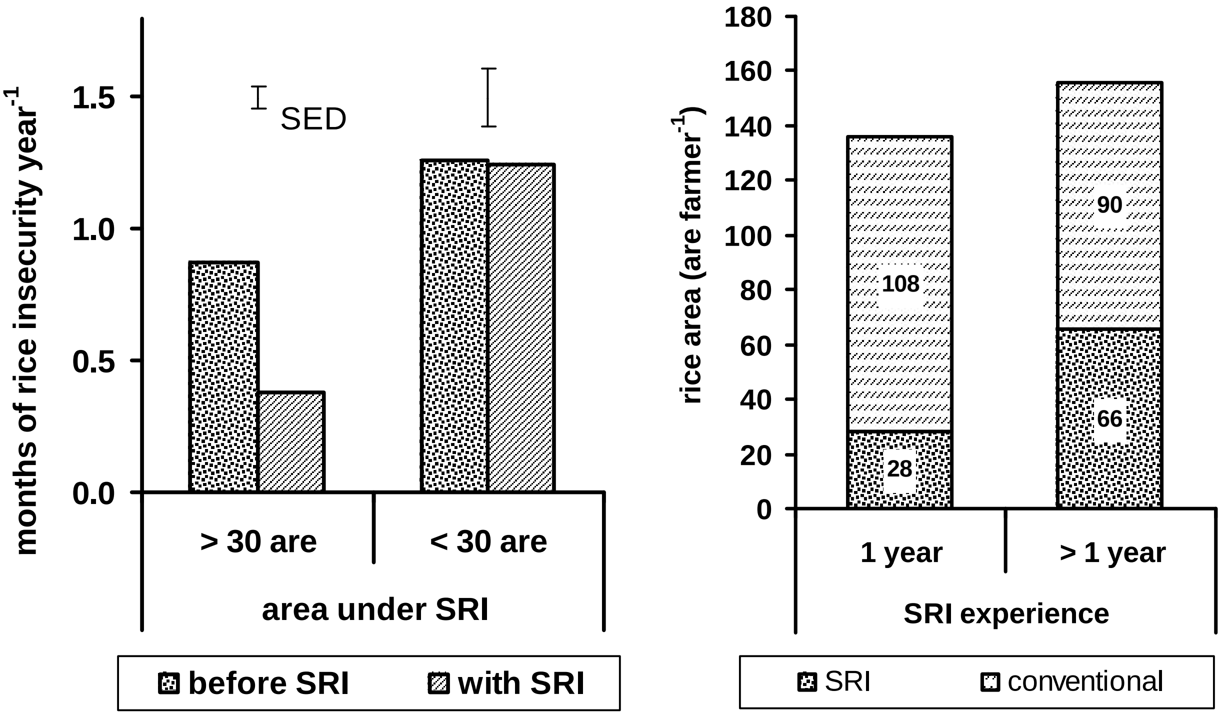

Figure 2 Months of rice insufficiency before applying SRI (common practices) and with SRI depending on the area under SRI (left) and proportion of rice area cultivated with SRI practices to rice area cultivated with conventional practices depending on the experience of the farmer with SRI (right).

Using the proportions of rice area the farmers were applying SRI and conventional rice practices resulted in an average gross margin of 192 US \$ household^{-1}, an increase of 26 US \$ (+15%) for farmers using SRI the first time (Table 3). The more experienced farmers with 42% of their rice area cultivated with SRI practices enjoyed an increase of the average gross margin household^{-1} by 52 US \$ (+31%).
The average monthly rice consumption per household was 114 kg. That means that in households using SRI for the first time, the surplus produced with SRI was equivalent to the household's rice needs for 2.2 months. For the more experienced farmers, the rice surplus from SRI was equivalent to the household's need for as much as 4.6 months. Hence, SRI significantly contributes to rice self sufficiency of farming households.

Table 3. Economic impact of SRI at field level and at household level considering the experience of the farmer with SRI (difference to conventional practices in brackets)

	Field level	Farm level (1^{st} year)*	Farm level (succeeding years)*
Gross margin ha^{-1} (US $)	208.83 (+88.87)	138.39 (+18.43)	157.51 (+37.55)
Gross margin household (US $)	-	192.36 (+25.62)	218.94 (+52.19)
Gross margin man-day (US $)	2.54 (+0.99)	1.79 (+0.24)	1.98 (+0.43)

* experience with SRI

Estimations by CEDAC indicate that the number of SRI farmers has reached more than 9,000 in 2003. A scenario with different adoption rates documents the economic potential of SRI at the national level. Assuming that farmers convert the same proportion of their rice area to SRI, even low adoption rates would lead to substantial economic benefits. For instance, an adoption rate of 10% of experienced SRI farmers who apply SRI on 42% of their rice area would account for an annual benefit of 36 Mio. US $. Such benefits are high enough to justify additional costs for training in SRI within the agricultural extension system.

Conclusions

Despite many open questions still to be investigated by researchers, SRI has proven to be a worthwhile practice to be promoted and should be included in any rice intensification program. Although some of the constraints limit its use on larger proportions within a farm and certain farming households might not be able or willing to apply it, its potential should not be missed.

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