Community preparedness for climate change and increased water use efficiency for rice cultivation using principles of System of Rice Intensification (SRI) in Central Thailand

5/1/2011

SUMMARY REPORT

Dr. Abha Mishra (abhamishra@ait.asia)

Dr. Prabhat Kumar (pkipm@ait.asia)

Agricultural Systems and Engineering Field of Study
School of Environment, Resources and Development
Asian Institute of Technology (AIT); Klong Luang
PO Box 4, Pathumthani 12120, THAILAND

Summary Report

“Community preparedness for climate change and increased water use efficiency for rice cultivation using principles of System of Rice Intensification (SRI) in Central Thailand”

Supported by

APFED Showcase 2008 (http://www.apfed.net/)

Asia-Pacific Forum for Environment and Development

In collaboration with the

Department of Agriculture Extension, Royal Government of Thailand

AND

RICE-GROWING WOMEN AND MEN FARMERS OF RATCHABURI PROVINCE THAILAND

ACKNOWLEDGEMENTS

The authors would like to acknowledge the support of the project donors and also excellent support from collaborating partner, DoAE, Thailand, along with women and men farmers. Thanks are due to the facilitators, IPM trainers, and resource persons for their vital contributions, time and guidance; and, most importantly, thanks to all the participants for actively participating in the project. This summary report is based on a detailed final report submitted to the donors in April 2011. Finally, we acknowledge the excellent support received from the staff members of the Thailand Environment Institute (TEI), who were the Net-Res center for the project. Finally, we thank Prof. Norman Uphoff for his valuable comments and suggestions to improve this report.

Authors

Abha Mishra[1], and Prabhat Kumar[1]

[1] Asian Institute of Technology (AIT), Bangkok, Thailand

Other contributing persons/agencies:

Aroonpol Payakapanta[2], and Lakchai Mennekanit[2]

[2] Department of Agricultural Extension, Royal Government of Thailand

Staff members of the Thailand Environment Institute (TEI)

How to obtain the digital copy:

Digital copy of **Summary Report of the project 'Community preparedness for climate change and increased water use efficiency for rice cultivation using principles of System of Rice Intensification (SRI) in Central Thailand'** can be electronically requested from the authors and/or downloaded from SRI website (http://sri.ciifad.cornell.edu).

TABLE OF CONTENTS

SUMMARY

"Community preparedness for climate change and increased water-use efficiency for rice cultivation using principles of System of Rice Intensification (SRI) in Central Thailand" project has been funded by UNEP through its APFED project in 2008. The project with its partner, Department of Agriculture Extension (DoAE), RTG, rice farmers in Ratchaburi province, extension personnel, and scientists from AIT were able to successfully adapt several practices of SRI to achieve **higher yields with less amount of land, water and other external inputs**. Such practices are widely known to reduce the emission of greenhouse gases, thus, combining the best of science for climate-change adaption at community level.

Based on baseline survey and extensive discussions while formulating the various interventions (treatments), the existing Parachute method of rice transplanting was adapted using principles of SRI as one of planned innovative treatments in these participatory trials. Higher rice yields (over 8.0 tons/ha) coupled with higher water productivity and greater net returns in the planned interventions plots (SRI plots) (4 replications) resulted into development of locally-adapted technologies at plot scale, meeting the major aims of the project. A number of extension workers along with farmers were trained in these processes from the local government and are expected to carry forward this learning to newer places with new farmer groups. The farmers also shared their results with other visiting farmers from Southern Thailand during the field day, which aimed to showcase their hard work to other members of the local community and to encourage them to adopt climate-friendly rice production system. Average 82% attendances (at 18 weekly meetings) and 100% enhancement in knowledge are some of the immediate impacts that were established during the project, indicating its success in meeting set objectives.

However, enabling policy environment and proper incentives are seen as next major steps from the Government to further take advantage of these plot-scale demonstrations. Also, to sustain such momentum it is expected that further similar work will be supported where the best of science can be brought into the purview of farmers to adapt and then adopt locally-suitable climate-friendly agricultural practices.

1. BACKGROUND

In Thailand, rice is the most important crop grown (55% of cropped area), consumed (42% of daily caloric intake), and exported (40% share of global rice trade in 2008). It represents the core of agriculture and is grown in all four corners of the country in different rice-growing ecosystems, ranging from rainfed lowland production in NE Thailand to irrigated systems in the central part of the country. The central region accounts for about one-fifth of the total cultivated rice land of the country in the wet season. Almost 75% of the dry-season rice grown under irrigated conditions is located in this region. Water requirements for irrigated rice paddies are very high, and on an average, one kg of rice production needs 2,000-5,000 litres of water (Molden et al., 2007). At the same time, it is a well established fact that flooded rice paddies are a significant source of the greenhouse gas, methane (CH_4) (Neue & Boonjawat, 1998; Denier Van Der Gon, 2000; Li et al., 2002), contributing over 10% of the total anthropogenic methane flux to the atmosphere (Prather & Ehhalt, 2001), which may have substantial impacts on atmospheric chemistry and climate. Thus, the continuing impacts of increasing CO_2 and global warming on rice grain yield could have additional impacts on food supplies, not only to people in Thailand but in many parts of world where imported Thai rice is an important food source.

While water shortage in rice cultivation is an emerging challenge worldwide, the water use efficiency of rice is very low and is further lowered at the farmers' field level. It is widely believed that better on-farm management could significantly improve water productivity and increase water use efficiency with better rice yield (Molden et al., 2007). Moreover, CH_4 emission rates could also be modified through better crop management techniques (Cole, 1996). The rate of CH_4 emissions from rice fields depends on growth of the plants and the subsequent availability of carbon substrates in the soil, as well as cultural conditions that affect the soil, such as irrigation regime, fertilizer amount and type, return of organic residues to the soils, and seasonal climate (Neue, 1993; Neue et al., 1996). Movement of CH_4 from the soil to air is largely rice plant-mediated, as CH_4 diffuses from the rhizosphere through the stem, and out through micropores in the leaf sheaths (Nouchi et al., 1990).

The increasing international demand; an urgent need for a technological shift toward more sustainable and cleaner production systems, and more economically-rewarding production methods have impelled farmers and researchers alike in Thailand (Towprayoon et al. 2005) to explore alternative crop and water management options such as System of Rice Intensification (SRI).

The agroecologically-based SRI principles are well-established initiatives for innovation that offer synergy in their methodologies; presenting environmentally-sound practices for conservation of natural resources such as soil and water. The benefits extend to affecting climate change in that avoiding continuous soil saturation reduces methane emissions from rice fields without generating offsetting nitrous oxide (N_2O) emissions (Yan et al., 2009).

Several studies and farmers' field research in various countries and in NE Thailand have shown that SRI could provide a beneficial alternative to mitigate these challenges with improved rice production and economic returns in a sustainable way (Mishra et al, 2006; Mishra and Salokhe, 2008; Uphoff and Mishra, 2009; Mishra and Salokhe, 2010, Mishra and Uphoff, 2011). Therefore, considering the varied socio-economic and bio-physical realities of farming and rice farmers, there is urgent need to adapt and adopt such farmer-friendly agronomic practices as a means to address both challenges facing the rice sector, i.e., to deal with location-specific heterogeneity which is the main factor for yield gap experienced at farmers' fields, and to reduce CH_4 emissions and increase water productivity, especially for irrigated rice paddies.

In light of these concern, AIT in association with Department of Agriculture Extension (DoAE), Royal Thai Government (RTG), (the initial project partner was the Rice Department, RTG) and with funding support from the United Nations Environment Programme (UNEP), its Asia-Pacific Forum for Environment and Development (APFED) showcase project 2008 -- investigated, documented and assessed the results of collaborative action research, undertaking season-long learning and training to address the above-stated challenges.

2. OBJECTIVE AND PROCESS

2.1 AIM OF THE PROJECT

The overall project aim was to strengthen farmers' capacity by encouraging innovation and experimentation to deal with location-specific heterogeneity and to develop area-specific '*green*' and robust technologies for rice production. More specifically, the project focused on optimal use of purchased inputs and water in rice production in order to help farmers to prepare their operations against the negative externalities of climate change, and achieve higher net returns from their rice farming. In order to achieve this ambitious goal, the project focused on two main activities:

2.1.1 COLLABORATIVE ACTION RESEARCH SET-UP: Collaborative action research involving farmers, researchers, trainers and other resource persons was set up using Farmers' Field School (FFS) platform. The Department of Agricultural Extension (DOAE), which has been on the forefront of implementation of Farmers' Field Schools (FFSs) in Thailand and which has required capacity in assisting farmers to undertake action research, partnered with AIT in this project implementation at Ban Nongri, Nongkob sub-district, Ban Pong district, Ratchaburi province of central Thailand.

The field experiments – undertaken in the mode of action research – started 25 November 2009, and final harvesting was completed 10 March 2010. Based on a consensus among farmers, extension workers and scientists, six seats of agronomic management practices were compared, with 4 replicates of each treatment, plot size being 16 x 12.5 meters) in a randomized block design. Details of these six agronomic management practices are given in the Annex. Weekly data on plant growth and development, along with data on insect pests, were collected, compiled and discussed as part of the FFS during the period of the experiments. Data on harvests along with cost-benefit analysis are presented in section 3 below.

2.1.2. KNOWLEDGE-SHARING AND DISSEMINATION:

<u>At farmers' level:</u> After completion of field experiments, the farmers and the cooperating organizations organized a "Field Day" on 10 March 2010 to share and disseminate the learned knowledge to neighboring farmers and other stakeholders interested in healthy and profitable rice production systems. 30 male and female rice farmers along with 5 trainers from DoAE directly participated in this action research and the FFS. In addition, approximately 100 outside farmers were invited from time to time to participate and learn from the key activities. In addition to the DoAE, other local agriculture departments and officials regularly visited the project site and were briefed by the AIT project team, which provided weekly backstopping to the project. A project overview could be further accessed at http://www.ait.ac.th/news-and-events/2010/news/climate-friendly-rice-production-demonstrated-in-central-thailand/view.

At provincial level: Following this, a final workshop was organized in Ratchaburi in September 2011 involving Office of Agricultural Promotion; Office of Agricultural Product Quality Development; Center of Pest Management (Suphanburi Province); Office of Agriculture, Banpong District; Office of Agriculture, Ratchaburi Province; DoAE; and AIT along with farmers (FFS and non-FFS) to share and exchange the learning and get feedback from various stakeholders. Prior to the workshop, a field visit was made in the project area to gather information from farmers' fields on the adoption and adaptation of learned techniques.

At regional and international level: various international workshops and meeting were used as platform to share and disseminate project learning to a wider audience (see http://www.iges.or.jp/en/ad/activity20110131.html)

2.2. OBJECTIVES OF THE PROJECT

The overall objective of this study was to develop innovative location-specific crop and water management techniques in order to intensify sustainable rice production using less water and less physical inputs with involvement of rice farmers, extension personnel, rice scientists from AIT, and officials from DoAE, RTG, using a Participatory Action Research (PAR) approach at selected farmers' fields in Ratchaburi province, Central Thailand.

Box 1: Parachute

Parachute Transplanting: In this method, seedlings are grown in seedling trays (see Box 2). Each tray contains approximately 435-450 holes. Holes are filled with light soil, and 8-10 seeds are sown in each hole. Normally, seedlings are grown for 20-25 days and then transplanted in the puddled and levelled field by throwing, which is why it is called Parachute transplanting. During transplanting, seedlings clumps are removed from the hole and thrown into the wet field. Usually 75-80 trays are required to transplant 1 rai (0.62 hectare) in conventional parachute transplanting. For SRI and SRI-Parachute practices, seedling trays were prepared by sowing 1-2 seedlings/hole.

Box 2: SRI-Parachute

Seeding raising using plastic trays: First, sift the dry soil at 0.5 cm (soil should not mix with the rice weed). After that, bring the plastic tray to a prepared area (the area should be smoothed equally) in rolls (2-4 plastic trays per one roll according to need). Then, scatter the soil 50-70% and follow by the pure seed (soak 1 night and cover one night or dry seed) at rate of 3-4 kilograms (50-60 trays per rai). Finally, scatter the soil properly and equally. Soil should not be over the hole because the root will be engaged itself when it is parachuting.

People to be used in sifting the soil should be 1 person per 150-200 trays per day (this can be used for 2-3 rais). First when watering the seeds, this should be dropped in tiny drops (water should be as small as it can). Be careful of the seed, as it will throw off by too much water. Moreover, the seed should be not be flooded by the water. However, if there is much rain, an old gunnysack should be taken to cover the seed until the rice roots germinate. This method can be used indoors or outdoors. After the seed has sprouted, at around 12-16 days when roots are around 3-5 inches long (according to the quality of the material), the seedling in its block of soil can be parachute planted. The area for planting is around 12-15 square meters per tray of 50-60 plants which can be scattered for 1 rai.

This method can create an accurate method to put out the seedlings. It can control the soil and the number of seedlings as wanted. Moreover, this method can be further refined in the future.

3. KEY RESULTS

1) **Higher productivity with less water and less chemicals:** Rice productivity and water productivity were increased under SRI practice compared to the farmers' and other evaluated practices (see Figure 1a & 1b and Annex 1 for description of all practices).

   SRI practices used:

- Younger seedlings (12-days-old);
- Single seedling transplanting with 30 x 30 cm;
- Alternate wetting and drying of the field at the vegetative stage;
- No pesticide use.

Experimental lay-out

2) **Higher economic returns:** With SRI, the cost of cultivation was reduced and the net profit increased (Figures 2a & 2b).

3) **Innovation for location-specific adaptation:** To address the increasing labor constraint in rice farming and to facilitate adaptation of SRI principles to local condition, farmers were stimulated to integrate the Parachute transplanting method with SRI principles. This reduced labor, transplanting time, and costs associated with transplanting. This innovation was named as SRI-Parachute (SRI-P). The results showed that SRI-P significantly increased yield, water productivity and net returns compared to farmers' practice (see Figures 1 & 2).


SRI-Parachute planting

4) **Changes in knowledge and attitude of the participating farmers:** The average score obtained by the majority of the participants at pre-test was around 30%, which rose to the level of about 60% in post-test, indicating a positive impact on farmer's knowledge. The lowest individual score obtained was 40% whereas highest was 70% in post-tests.

5) **Sharing and dissemination of learned knowledge:** The project experience was shared with like-minded organizations, networks, and policy makers through workshops, seminars, etc., to provide

stakeholders with qualitative and some quantitative evidence that such activities can create a more favourable environment for low-input intensification in agriculture. Also, this will encourage the recognition of such collaborative work in changing agricultural production systems that reduce climate forcing.

Farmer's Participation

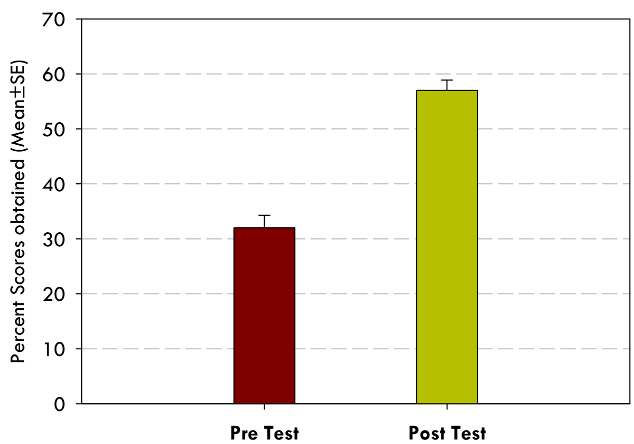
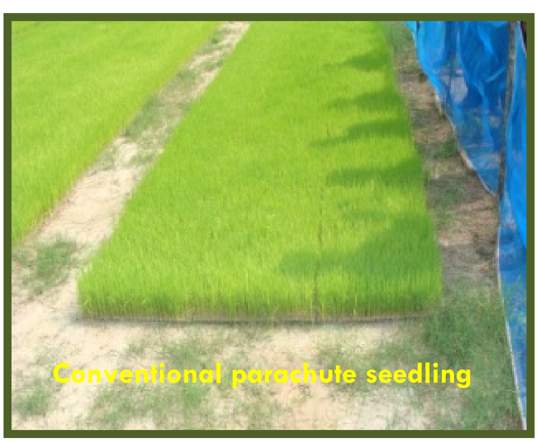
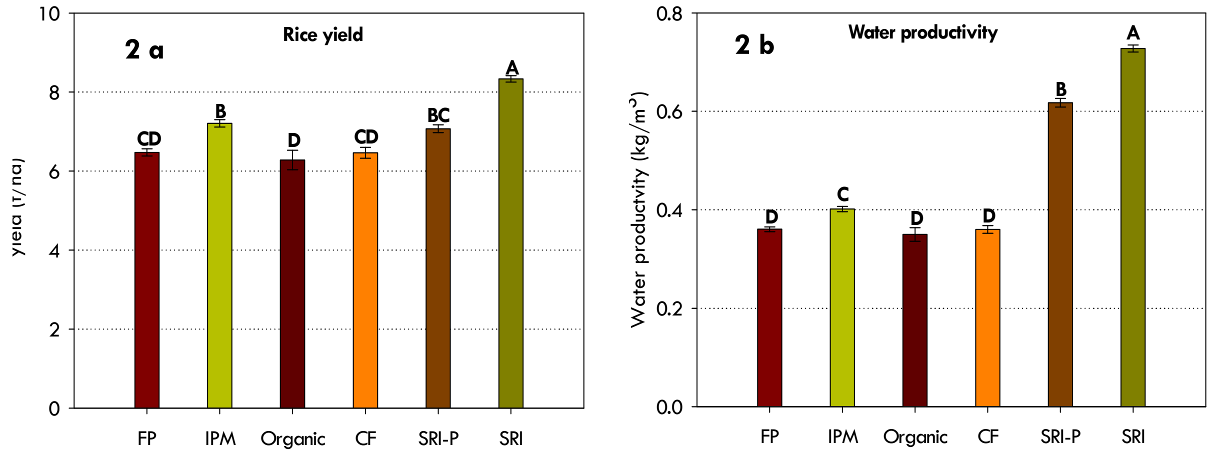


Figure 1: The average percent (SE) scores obtained by the participating farmers in pre and post ballot box test. The ballot box tests was designed to learn the changes in knowledge-attitude-behavior of the farmers who took part in the FFS-PAR cycles and in follow-up meetings of the project at Ratchaburi, Thailand (n = 22).



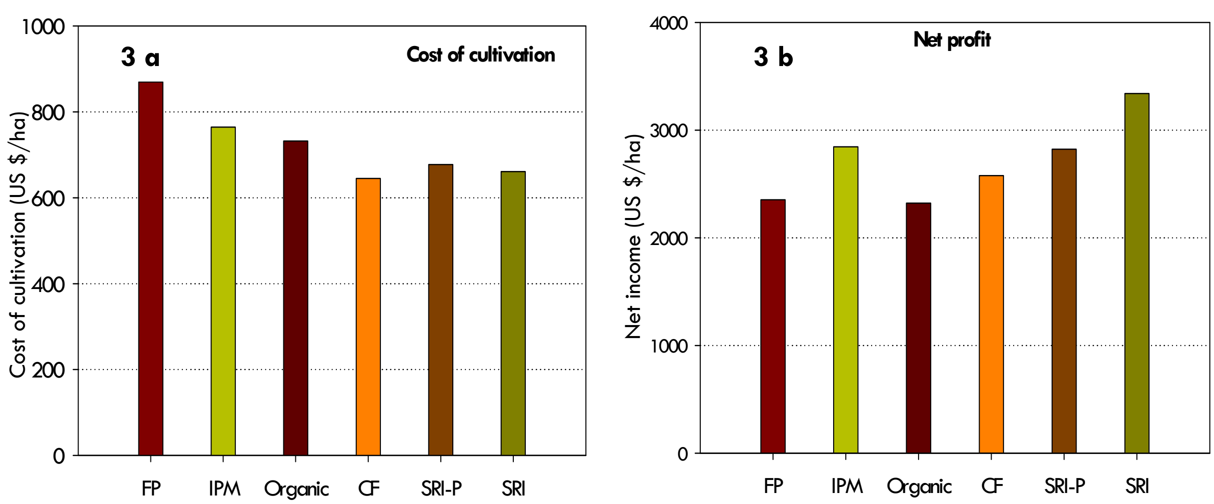
Yield and water productivity



Figures 2a & 2b: Rice yield (2a: P 0.001; F = 31.04; df = 5,23) and water productivity (2b: 0.001; F = 371.35; df = 5,23) under various agronomic management practices in participatory research (SAS Institute 1999, Tukey's HSD test).

Treatment codes: FP = Farmer Practice; IPM= IPM practice; Organic, CF= Chemical Free FP, SRI-P = SRI Parachute; and SRI = SRI practices (agronomic management details in Annex).

Costs of cultivation and net return



Figures 3a & 3b: Costs of cultivation (3a) and net profit (3b) under various agronomic management practices in participatory research

4. CONCLUSIONS

The project helped rice farmers to become partners for climate-change mitigation and adaptation, *preparing for and coping with climate change* with strategies through adapting and adopting improved crop and water management practices such as intermittent irrigation, which is a well-known and scientifically established way for reducing CH_4 emission. A proven concept like SRI, on other hand, increased crop and water productivity and crop health to prepare farmers to intensify sustainable production with less water and less chemicals. The resulting higher yields were both an incentive and a reinforcement for the behavioural changes involved in changing crop, soil, water, and nutrient management practices. The positive impact of this plot-scale effort addressing emerging scenarios of climate change and need for food security needs similar broader and collaborative efforts at national and regional level.

5. LESSONS LEARNED

- The research process helped establish new and sustainable partnership between all stakeholders. It raised farmers' awareness for optimizing input use, encouraging them to adapt new methods for addressing their site-specific problems, such as water productivity, soil fertility, and labour availability. Farmers' appreciation and willingness to adapt new practices revealed a flexibility and ability to tailor management strategies to changing circumstances and experience.
- Although the project was successful at plot level in achieving higher yield and economic return and generating broader consensus among stakeholders engaged in rice production systems in Ratchaburi province of Thailand, it was felt that the positive results of these plot-scale efforts need to be scaled-up to realize the larger potential benefits of such efforts and to galvanize support from policy-makers.
- It was also felt that for the sustainability of such an approach, a value-added alternative production system that rewards saving of water and reduction in chemical and other inputs is required to sustain climate-friendly crop management practices such as SRI. Existing agricultural policy needs to be revisited in the context of climate change to benefit farmers, consumers, and environment.

REFERENCES

Cole, V. (1996). Agricultural options for mitigation of greenhouse gas emissions. pp. 745-771. In: Watson, R.T., Zinyowera, M.C., Moss. R.H., (Eds.), Climate Change 1995 Impacts, Adaptations and Mitigation of Climate Change: Scientific Technical Analyses. Cambridge University Press, New York, 878 pp.

Denier Van Der Gon, H. (2000). Changes in CH4 emission from rice fields from 1960s to 1990s: 1. Impacts of modern rice technology. *Global Biogeochemical Cycles*. 1: 61–72.

Li, C. S., Qui, J.J., Frolking, S., Xiao, X.M., Salas, W., Moore, B. (2002). Reduced methane emissions from large-scale changes in water management of China's rice paddies during 1980–2000. *Geophysical Research Letters*. 29, (art. no.-1972).

Mishra, A. and Salokhe, V. M. (2008). Seedling characteristics and the early growth of transplanted rice under different water regimes. *Experimental Agriculture*. 44 (3), 365-383.

Mishra, A. and Salokhe V. M. (2010). The effects of planting pattern and water regime on root morphology, physiology and grain yield of rice. *Journal of Agronomy and Crop Science*. Published online (early view -Feb. 28, 2010) by Wiley Interscience. DOI : 10.1111/j.1439-037X.2010.00421.x.

Mishra, A. and Salokhe V. M. (2011). Rice root growth and physiological responses to SRI water management and implications for crop productivity. *Paddy and Water Environment*. Paddy and Water Environment. DOI: 10.1007/s10333-010-0240-4. Published online (early view: 22 December 2010) by springerlink.

Mishra, A. and Salokhe, V. M. (2008). Growing More Rice with Less Water in Asia: Identifying and Exploring Opportunities through System of Rice Intensification, pp 173-191. In: *Agricultural Systems: Economics, Technology and Diversity,* Oliver W. Castalonge (Eds). ISBN 978-1-60692-025-1, Nova Science Publishers, Hauppauge, NY.

Mishra, A. and Uphoff, N. (2011). System of rice intensification: 'less can be more' with climate-friendly technology. *SATSA Mukhapatra - Annual Technical Issue*, Vol. 15 (ISSN: 0971-975X).

Mishra, A., Ketelaar, J. W., Chhay, N. and Arnst, R. (2006). Exploring System of Rice Intensification: Capturing opportunities for engaging farmers, extension workers and researcher into action research. *In: International Forum for Water and Food,* 9-13 November 2006, Vientiane, Lao PDR.

Mishra, A., Whitten, M., Ketelaar, J.W. and Salokhe, V.M. (2006). The system of rice intensification (SRI): a challenge for science, and an opportunity for farmer empowerment towards sustainable agriculture. *International Journal of Agricultural Sustainability*. 4(3):193-212.

Molden, D. (2007). Water for Food Water for Life: A comprehensive Assessment of water management in agriculture. London: Earthscan, and Colombo: International Water Management Institute.

Neue, H., & Boonjawat, J. (1998). Methane emissions from rice fields. In J.Galloway, & J. Melillo (Eds.), Asian change in the context of global climate change (pp. 187– 209). Cambridge University Press.

Neue, H.-U. (1993). Methane emission from rice fields. *BioScience*. 43, 466-474.

Neue, H.-U., Lantin, R.L., Alberto, M.C.R., Aduna, J.B., Javellana, M.A., Wassmann, R. (1996). Factorsaffecting methane emission from rice fields. *Atmos. Environ*. 30, 1751-1754.

Nouchi, I., Mariko, S., Aoki, K. (1990). Mechanism of methane transport from the rhizosphere to the atmosphere through rice plants. *Plant Physiol*. 94, 59-66.

Satyanarayana, A., Thiyagarajan, T.N. and Uphoff, N. (2007). Opportunities for water saving with higher yield from the system of rice intensification. *Irrigation Science*. 25: 99-115.

Towprayoon, S., Smakgahn, K. and Poonkaew, S. (2005.) Mitigation of methane and nitrous oxide emissions from drained irrigated rice fields. *Chemosphere*. 59:1547–1556.

Uphoff, N. (2007). The System of Rice Intensification: Using alternative cultural practices to increase rice production and profitability from existing yield potentials. *International Rice Commission Newsletter*, Number 55, U.N. Food and Agriculture Organization, Rome.

Uphoff, N. and Mishra A. (2009). Climate-proofing' crop production in response to climate change: Opportunities with the System of Rice Intensification (SRI). *The Hindu Survey of Indian Agriculture, 12-13*.

Yan, X., Akiyama, H., Yagi, K. and Akimoto, H. (2009). Global estimations of the inventory and mitigation potential of methane emissions from rice cultivation conducted using the 2006 Intergovenmental Panel on Climate Change Guidelines. *Global Biogeochemical Cycles*, 23, doi :10.1029/2008GM003299.

Yang, C., Yang, L., Yang, Y. and Ouyang, Z. (2004). Rice root growth and nutrient uptake as influenced by organic manure in continuously and alternately flooded paddy soils. *Agricultural Water Management*. 70: 67-81.

ANNEX 1: DETAILS OF THE AGRONOMIC MANAGEMENT PRACTICES COMPARED IN THE FIELD EXPERIMENT

To cover the various areas related to the project objectives, the following agronomic alternatives were evaluated.

a. SRI: ***System of Rice Intensification (SRI) principles for achieving higher yield with less seed and less water****:*

Selected management practices of SRI were used for this trial. *Younger seedlings*, 12-days-old, were transplanted @ 1-2 seedlings/hill with 25 x 25 cm spacing, and water management using *alternate wetting and drying* at early growth stage. Other cultural operations such as weeding and fertilizer application (rate and methods) were the same as farmers' practice (see below). Agrochemicals such as pesticides and herbicides were not used in this treatment. Seedlings were prepared using seedling trays with 1-2 seeds/hole (see Picture 3) instead of using the conventional wet seedbed.

b. ***SRI-P: Integration of SRI principles with the 'parachute' method of transplanting for achieving higher yield with less seed and water and also with lower labour costs (SRI–Parachute):***

Instead of the conventional Parachute technique (see Box 1) the seedlings were prepared by sowing *less seed*, 2-3 seeds/hole, in seedling trays (see Box 2) instead of 6-7 seeds/hole as conventionally practiced. Also, the age of seedlings at transplanting was kept *younger,* 12-days-old, instead of relatively older seedlings of 21-30 days. Transplanting was done using the same method as conventional parachute, i.e., by removing seedlings from the seedling tray and throwing uniformly in the puddled and levelled field. Fertilizers and other cultural operations were the same as farmers' practice.

c. ***IPM: Integrated Pest Management process for growing pesticide-free crops and for making informed decisions in the crop field:***

In this trial, planting was done by direct sowing with a seed rate @ 15 kg/Rai (approx. 93.75 kg/ha). Fertilizers used are based on the recommendation by government agencies, 16-20-0 (NPK) @ 25 kg/rai (156 kg/ha) as a basal dose, and 25 kg/rai at 20 days after seeding/sowing (DAS). Urea (46-0-0) was applied @ 25 kg/rai at 55 days after sowing (DAS). Weekly field monitoring was performed and decisions on crop management were taken on the basis of crop's condition and agro-ecosystem analysis.

d. ***Org: Organic rice cultivation using cow extract with farmers' practices****:*

In this trial, chemical fertilizers were not used except rock phosphate. Cow manure were used @ 500 kg/rai (3.15 t/ha) incorporated during final land preparation, and rock phosphate @ 50 kg/rai (312 kg/ha) was applied at 20 DAS. Field monitoring was performed the same as in IPM plots.

e. CF: ***Yield potential and net return of chemical-free rice with farmers' practice (Control-chemical free):***

This plot received no chemical fertilizer. Cow manure was used @ 500 kg/rai (3.15 t/ha). Weekly field monitoring was carried out to observe and compare with other plants in terms of crop morphology, ecosystem differences, and yield comparisons eventually. Broadcasting method was followed for planting, with a seed rate @ 25 kg/rai (156.25 kg/ha), as in local farming practices.

f. FP: Conventional rice-growing practice (*Farmer's Practice*):

This plot followed all the field operations commonly agreed on by the local participating farmers in the area in relation to their seed, fertilizer, herbicide, insecticide, and fungicide uses. This plot used seed @ 25 kg/rai, pellet manure 10 kg + urea 25 kg at 20 DAS, and NPK (16-20-0) amount 25 kg/rai at 56 DAS. Weekly field monitoring was carried out to observe the crop condition and ecosystem effects. Decisions made by farmers were those that they usually practice in their fields.