Evaluation of the System of Rice Intensification (SRI) Trials in Bangladesh: Results from PETRRA Sub-projects

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Abstract

The paper presents results of three sub-projects on SRI funded by DFID/PETRRA and implemented during two *boro* seasons 2002-04 in Bangladesh. In one sub-project, the performance of SRI was better than farmers' method during both seasons. First year average yields increased by 19% to 37% over farmers' practice, costs were lower and farmers' returns were 32% to 82% higher. Second year SRI yields and profitability were also higher in all areas. Farmer participation and acreage increased during second year by 62% and 90% respectively.

In a second sub-project conducted by BRRI and an NGO, favourable results were obtained in both seasons. First season yields for SRI (6.03 t/ha) were higher than BRRI method (5.79 t/ha) and farmers' method (4.06 t/ha). Net returns from SRI were 49% higher than farmers' method. Both number of participating farmers and acreage under SRI increased during second year, and results were encouraging.

In another BRRI sub-project with an NGO partner, the results were mixed. In one area, the SRI yields were 17.5% higher than farmers' method yields during first season and nearly 20% higher during the second season, though profitability was not much different due to higher production costs incurred in SRI. In two other areas, performance of SRI was not better during first year, but with some corrections in the application of SRI, second year SRI yields were higher. No cost-benefit analysis was made during second year of this evaluation. Even with many shortcomings, attitude of farmers was positive.

Overall results of on-farm trials in Bangladesh show a superior performance of SRI over farmers' practice, i.e., in most cases over current improved practices. Yields were higher, costs lower except in some cases, and profitability was also higher in most cases. Problems encountered included scarcity of organic manure and difficulty in managing intermittent irrigation management. Encouraging responses were received from farmers on SRI.

Glossary of Terms

<u>Abbreviations</u>

AAS	Agricultural Advisory Society, an NGO
AARD	Agency for Agricultural Research and Development
BRAC	A leading NGO in Bangladesh, formerly known as the Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
CARE	An international NGO (Cooperative for American Relief Everywhere)
DAE	Department of Agricultural Extension
FFS	Farmers' Field School
FP	Farmers' Practice
GO	Government Organisation
HYV	High-Yielding Variety
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
NGO	Non-governmental organisation
PETRRA	Poverty Elimination Through Rice Research Assistance, an IRRI-managed and DFID-funded project
POSD	Peoples' Organisation for Sustainable Development, an NGO associated with CARE
SAFE	Sustainable Agriculture and Farming Enterprise, an NGO

<u>Local Words</u>

Boro	Winter crop season
Kharif	Summer crop season
Taka	Unit of currency in Bangladesh
Upazila	An administrative unit, a sub-district

1. Introduction

What is SRI: The System of Rice Intensification (SRI) is considered to be a system of irrigated rice crop management through which production can be significantly increased by effective changes in and integration of the management of plants, soil, water and nutrients. SRI practices are likely to make rice cultivation more sustainable, enhancing rice production without heavy dependence on modern high-cost inputs, reducing costs of production, and being environmentally friendly. SRI is also quite accessible by resource-poor farmers, while its increases in yield enhance their food security.

Its relevance to Bangladesh: SRI is very much relevant for Bangladesh agriculture considering its main features and the present constraints faced by the rice sub-sector. Agriculture is the primary sector providing employment to 62% of the civilian labour force, with its share of GDP about 23% (Bangladesh Economic Review, 2003). The land-man ratio is very low as average farm size is less than 0.68 hectare. A majority of farmers are resource-poor. To meet the increasing demands for roads, housing, etc., cropped area has also been reducing every year. Rice is the staple food crop for Bangladeshis, with 75% of the cropped area devoted to production of rice.

As the most densely populated country in the world having over 900 people per sq. kilometre, Bangladesh has been striving hard to attain food self-sufficiency and food security. Adoption of modern seed-fertiliser-irrigation technology, popularly known as HYV technology, has more than doubled the production of food grains during the last three decades. However, yield growth of rice has levelled out. Yield response to modern inputs like chemical fertiliser and to water has declined. Soil and environmental degradation is accelerating. Profitability of rice growing for farmers has declined with increasing prices of inputs and a relatively stable producer price for rice.

As an alternative to attain a break through in increasing rice yields, hybrid seeds are being tried. But this technology is also heavily dependent on high cost modern inputs and has associated problems of soil and environmental degradation. Another alternative may be to explore the potentials of biotechnology for evolving new higher-yielding rice by effectively overcoming the complex problems of disease and pest incidence, increasing tolerance to biotic and abiotic stresses and also improving rice quality. But this technology will also be heavily dependent upon costly modern inputs and at the same time, it is still a debatable technology with apprehensions about possible health and environmental hazards (Husain et al., 2003).

Under the above circumstances, the needs of Bangladesh agriculture, especially related to rice, include:

- Substantial and sustainable increase in rice yield and release of surplus land for production of higher value crops;
- Reduction in costs of production and rise in profitability of rice production;
- Reduced need for high cost modern inputs like fertiliser, irrigation water and insecticides; and
- Promotion of environment-friendly sustainable agriculture.

Considering the main features of SRI and the above problems of Bangladesh agriculture with special reference to rice, SRI appears to have significant potentialities to answer to the needs of Bangladesh.

Growth and performance of SRI practices in different countries: SRI was first evolved in Madagascar in the early 1980s. This innovation was called to the attention of the rice-producing world by a paper presented by Prof. Norman Uphoff to a conference on sustainable agriculture held at Bellagio, Italy, in April 1999. A number of countries started experiments on a limited scale, including Bangladesh, where that paper was circulated after the conference. Three years after the conference in Italy, an international conference on SRI was held in Sanya, China, in April 2002, to advance understanding on SRI and assess its performance under diverse conditions in different countries (Uphoff et al., 2002). Reports were presented from 17 countries.

Benefits reported from SRI use included increased yield, increased returns to labour, water saving, improvement in soil quality, less dependence on external inputs, reduced requirement of seeds, lowered cost of production, accessibility for resource-poor farmers, better food quality, and environmental benefits. The disadvantages reported include requirement of good water control, more labour especially for weeding, and greater skill of farmers. SRI experiences reported suggest that these methods offer an unusual opportunity for 'win-win' outcomes in agriculture, though further evaluation was called for to assess problems and constraints as well as adaptations and ways to achieve even better results (Fernandes and Uphoff 2002).

The 'SRI effect' has now been seen in 21 countries of the world including the largest rice producing countries. Initial trials have shown high potentials for its acceptance as an improved method of rice production.

- For example, in the Sichuan province of China, during the 2004 summer, average yield gains were 3 t/ha over the usual yield of 7.5 t/ha. The highest SRI yield was recorded as 20.4 t/ha in Yunnan province. Water savings of 42% were recorded in Sichuan, while in Zhejiang province, incidence of sheath blight, a major rice disease in the area, was reduced by 70%. The subsequent harvest, almost 13 t/ha, set a record for that province (Uphoff, 2004).
- In Andhra Pradesh, India, results of SRI trials by 50 farmers during *rabi* season 2003-04 showed an increase of yield from 7.1 t/ha to 9.7 t/ha with the highest measured yields surpassing 15 t/ha (Satyanarayana, 2004). The Indian Council of Agricultural Research has been supporting several thousands demonstration trials during the current *kharif* season (2004).
- In Cambodia, evaluation of performance of SRI covering five provinces showed average yield gain of 41% with gross profits/ha increasing by 74%. Rather significantly, SRI was found there not to be labour intensive (Anthofer, 2004).
- In Sri Lanka, an International Water Management Institute (IWMI) evaluation in two districts found almost a 50% increase in yield, water productivity increase of 90%, reduction in cost of production by 17-27%, and 112% increase in net profit (Namara et al., 2004).
- In Indonesia also, the Agency for Agricultural Research and Development (AARD), based on evaluation of SRI practices for three years, made SRI part of its new national strategy for integrated crop resource management to restore growth in the rice sector.

2. SRI Experience in Bangladesh

Initial trials: The recent experiences with SRI performance in various countries reported above show the high potentials of SRI for improving rice productivity and profitability, along with other benefits. That is why trials and experimentation were initiated to determine the suitability of SRI for large-scale adoption in Bangladesh. Initial trials in the country were started in 1999 after the Bellagio Conference. CARE Bangladesh and the Department of Agricultural Extension (DAE) first started trials in farmers' fields during 1999 *boro* season.

The Bangladesh Rice Research Institute (BRRI), the government's scientific arm responsible for rice development; Syngenta Bangladesh, a private sector company; and BRAC, a leading NGO, followed the next year. Encouraging results from the initial trials were presented at the international conference on SRI held in China (Husain, 2002).

BRAC started its trials after the first visit of Prof. Uphoff in December 2000. During his second visit in January 2002, a workshop was held where decision was made to conduct well planned and co-ordinated trials and evaluations on SRI. A Steering Committee was formed for this purpose, concept papers on SRI were prepared and proposals for funding were submitted to the IRRI/PETRRA project.

PETRRA sub-projects on SRI: Three sub-projects on SRI were approved and funds were provided by the IRRI/PETRRA project for two winter (*boro*) seasons. One sub-project (SP 36 02) was implemented by three NGOs (BRAC, POSD and SAFE) together with a private sector company (Syngenta Bangladesh Ltd). A second sub-project (SP 34 02) was implemented by BRRI in collaboration with Uttaran, a local NGO in Satkhira. The third sub-project (SP 35 02) was conducted by BRRI with an NGO named AAS.

2.1 Findings of the PETRRA sub-projects

The three SRI sub-projects received funding support from DFID/ PETRRA project to conduct trials during two consecutive *boro* seasons, for 2002-03 and 2003-04. These sub-projects focused on the districts of Rajshahi, Bogra, Comilla, Noakhali, Satkhira, Habiganj and Moulvibazar. The results of the trials under the three sub-projects are briefly summarized below, based mainly on the completion reports submitted to PETRRA at the end of the sub-projects.

2.1.1 Sub-project SP 36 02: In this PETRRA sub-project farmer-level trials were conducted in eight areas of four districts. The sub-project activities involved motivation of farmers, organising them into farmers' field schools (FFS), giving training on different aspects of SRI practices, monitoring production activities, collecting and analysing data to derive results, participatory evaluation of the findings, and communicating the results (Husain et al*.,* 2004).

The trials for two consecutive *boro* seasons showed positive results. The number of participating farmers increased by 62% during the second year, while area under SRI increased by 91%. Agronomic findings showed that in all sub-project areas, number of tillers per hill was higher, panicle length was larger, and grain weight per 1000 grains was more, while unfilled grains were less under SRI than under farmers' conventional practices (FP) (Tables 1A and 1B).

Farmers' practices in this comparison are their improved practices in most cases, based on BRRI recommendations as demonstrated by DAE extension workers and advised by them to be followed by the farmers. In actual practice, there remains a gap between what has been recommended by BRRI and what the farmer follows. The main reasons are that while BRRI recommendations are based on some theoretically optimal use of various inputs and agronomic practices to obtain maximum yields, the farmer makes his own decisions based on practical considerations to maximize outputs and profits from his total farm enterprises, by allocating different inputs including labour to various enterprises. Especially for resource-poor farmers, resource limitations often compel them to modify the recommended practices. In such a situation they make adjustments in farm management practices to obtain the best possible results. The same kind of considerations often modified the use of SRI practices in this study.

The number of tillers under SRI was 95% higher during the first season, and 60% higher during the second season than under FP. Effective tillers were also 94% and 122% higher under SRI during the two years, respectively. Length of panicle was 11% higher during both seasons, while the weight of 1000 grains was 14 to 18% higher.

Yield gains achieved by SRI over FP yields were observed to be significantly higher in all sub-project areas during both seasons (see Table 2 and Figures 1 and 2). According to revised estimates, yield gains of SRI over FP in the different sub-project areas ranged from 19% to 37% during 2002-03, and from 23% to 30% during 2003-04. It is interesting to note from the figures that while yields under SRI increased in all areas during the second season, there was also a relatively higher increase in yields under FP during the second season. This may indicate that there would have been some influence created by SRI practices that helped farmers to improve their yields from existing practices.

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Table 1A: Agronomic Comparison between SRI trials and FP (2002-03)

	BRAC	*POSD*	*SAFE*	*Syngenta*	*Average*
SRI Practice					
Tillers per hill	33	55	31	52	43
Effective tillers	26	40	24	32	31
Length of panicle (cm)	19	20	18	22	20
Weight of 1000 grains (g)	24	23	29	22	25
% Unfilled grains	14	7	14	9	11
Farmers' Practice					
Tillers per hill	17	30	16	26	22
Effective tillers	12	23	13	17	16
Length of panicle (cm)	17	18	16	20	18
Weight of 1000 grains (g)	21	21	26	20	22
% Unfilled grains	23	15	19	25	21

Table 1B: Agronomic Comparison between SRI trials and FP (2003-04)

	BRAC	*POSD*	*SAFE*	*Syngenta*	*Average*
SRI Practice					
Tillers per hill	30	54	36	39	40
Effective tillers	28	36	28	31	31
Length of panicle (cm)	20	20	20	23	21
Weight of 1000 grains (g)	23	23	32	24	26
% Unfilled grains	15	7	13	11	12

Farmers' Practice					
Tillers per hill	19	35	17	28	25
Effective tillers	13	22	13	23	18
Length of panicle (cm)	18	18	18	21	19
Weight of 1000 grains (g)	19	20	28	21	22
% Unfilled grains	22	13	16	19	18

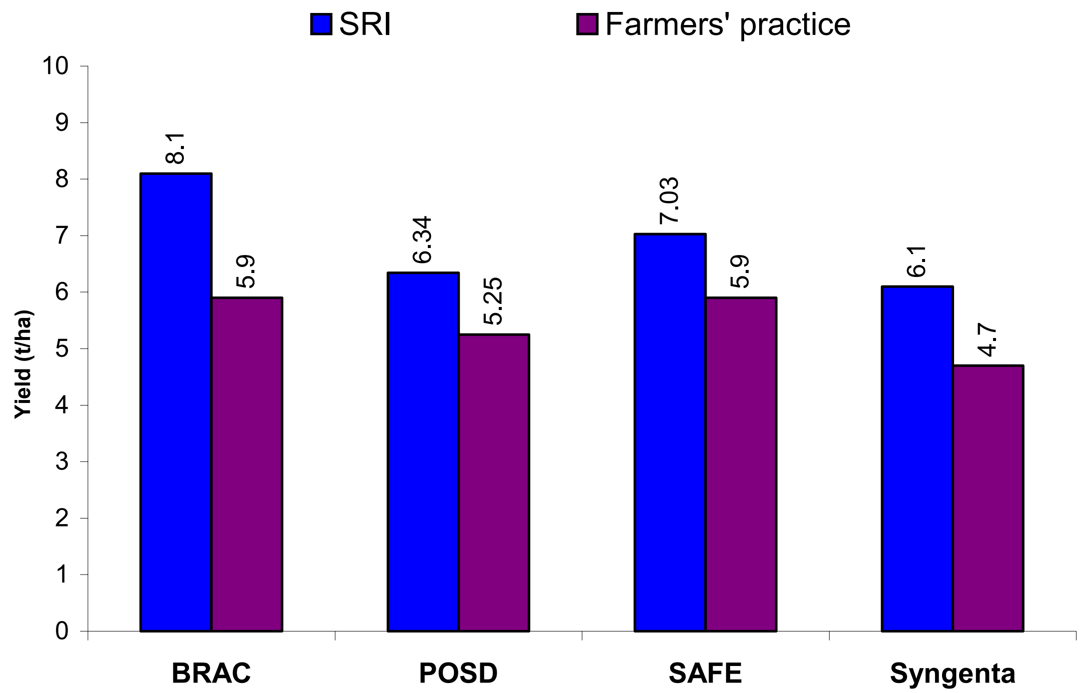

Figure 1. Comparative yield of rice under SRI and farmers' practices by partner organisations, 2002-03

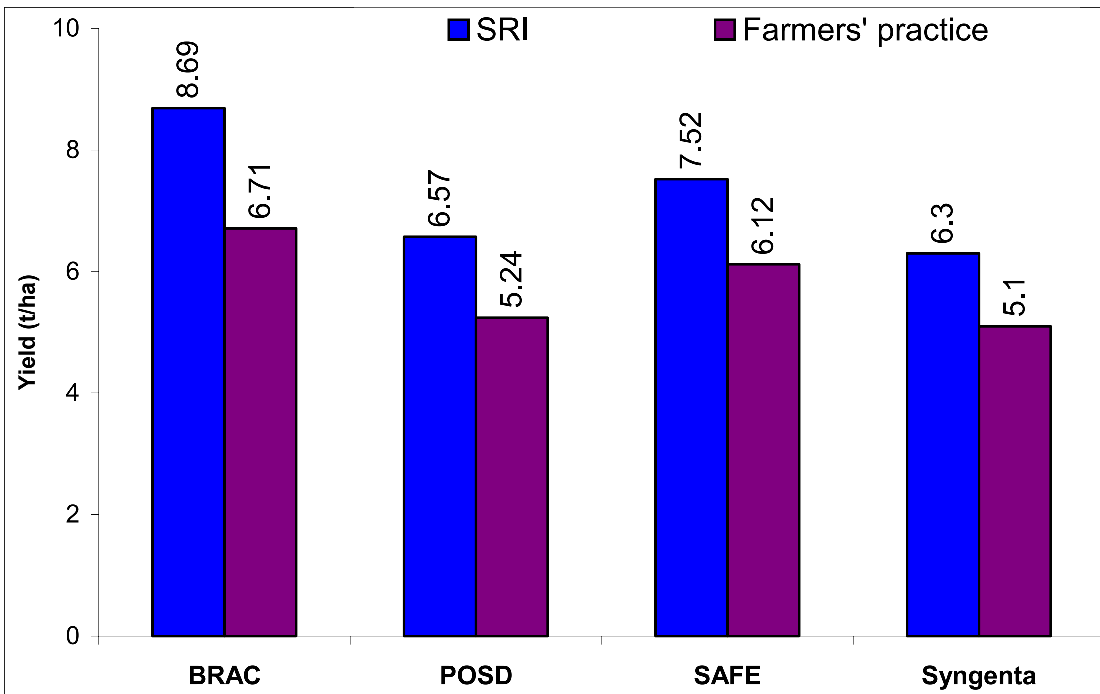

Figure 2: Comparative yield of rice under SRI and farmers' practices by partner organisations, 2003-04

Table 2: Comparative yields under SRI and FP and yield gains of SRI

Partners	2002-03			2003-04		
	SRI	FP	SRI yield gain (%)	SRI	FP	SRI yield gain (%)
BRAC	8.1	5.9	37	8.69	6.71	30
POSD	6.34	5.25	21	6.57	5.24	25.4
SAFE	7.03	5.9	19	7.52	6.12	23
Syngenta	6.1	4.7	30	6,3	5.1	24

Revised estimates on cost-return analyses showed gross costs/ha lower under SRI than under FP in all areas in both seasons. There was significant seed cost saving under SRI. Among other inputs, cost of insecticides and fertiliser was less. Irrigation costs could not be reduced substantially because of certain irrigation management problems and irrational fixation of rates by tube-well owners. In the BRAC evaluation, which kept track of labour costs, hired labour costs were lower for SRI during both seasons (ibid., 2004).

All sub-project areas also showed consistently higher net returns for SRI during both the seasons. SRI returns were 32% to 82% higher during 2002-03 and from 35% to 73% in different sub-project areas during 2003-04 (Table 3). The relative returns in different regions were not consistent in terms of relative yield increases and cost differences because the estimation of gross returns based on the current local prices of paddy and by-products varied among different regions.

Table 3: Relative net returns of SRI and FP and gains in profitability of SRI over FP (2002-03 and 2003-04)

	2002-03			2003-04		
Partner organisations	SRI (Tk/ha)	FP (Tk/ha)	Profitability gain of SRI (%)	SRI (Tk/ha)	FP (Tk/ha)	Profitability gain of SRI (%)
BRAC	45262	24863	82	44772	25939	73
POSD	38257	24120	59	39801	24584	62
SAFE	42100	31865	32	51557	38124	35
Syngenta	27765	16655	67	28238	18988	59

The perception of participating farmers as well as neighbouring farmers who observed the positive performance of SRI was positive. As stated already, the number of participating farmers and the area under SRI significantly increased during the second season. Findings from field observation and verbal perceptions of farmers confirmed the higher yield from SRI; they did not face any major pest/insect problem since they thought healthier SRI plants were more resistant to pests and insect attacks; a larger number of farmers applied organic manure and sought training on preparation of compost; they faced irrigation management problems that need a community approach for solution; and many neighbouring farmers have started SRI at least partially. They have already adopted practices that are easier to adopt such as early transplantation, wider spacing and transplanting a reduced number of seedlings. The difficult-to-adopt practices include use of organic manure due to shortages, and alternate drying and wetting of the plots. However, even partial adoption of SRI practices had a positive impact on their future rice productivity and profitability (ibid., 2004)

2.1.2 SP 34 02: This sub-project was conducted by BRRI in partnership with Uttaran, an NGO in Satkhira district. A participatory research and extension approach was adopted to conduct the study for two consecutive *boro* seasons, 2002-03 and 2003-04. Results of the study showed very encouraging performance of SRI over both farmers' practice and compared with BRRI-recommended practices (Sarker, 2004). Yields, net returns and Benefit Cost Ratio (BCR) were highest for SRI practices followed by BRRI and FP (Table 4). It is significant that the performance of SRI was not only better than FP but also than BRRI practices because sceptics have often criticized evaluations of SRI by saying that it was not being compared with 'best modern practices'. Total costs under SRI were marginally higher than the two other methods, but relatively much higher yields gave considerably higher net returns under SRI than with the two other methods.

Table 4: Comparative yields, returns and BCR of SRI, BRRI and FP
in PETRRA sub-project, Satkhira (2002-03)

Indicator	SRI	BRRI	FP
Yield (t/ha)	6.03	5.79	4.06
Net returns (Tk/ha)	51,255	49,215	34,510
Benefit:cost ratio (BCR)	1.9	1.8	1.3

Agronomic data show that highest panicle development was observed in case of SRI (296/m^2), followed by BRRI (270/m^2) and FP (226/m^2). Filled grains produced per panicle were highest for SRI practice (78), followed by BRRI (65) and FP (52). Lowest sterility was observed in SRI. Grain weight per 1000 grain was not significantly different among different practices. Yield data showed SRI yields to be 49% higher than that under FP.

Highest cost saving could be attained for seeds and seedbed preparation, followed by pesticides. Net returns from SRI were 49% higher than from FP and 4% higher than those with BRRI methods.

Detailed data on the second season's results are not yet available. However, overall performance of SRI was reported to be favourable during the second season. The number of farmers practicing SRI increased by 75%, and the cropped area also increased during the second season. Many more farmers tried to follow at least partial SRI practices during the second year. All of the participating farmers endorsed the SRI method and considered it to be a very beneficial method of rice production, especially for resource-poor farmers.

2.1.3 SP 35 02: The third SRI sub-project under PETRRA funding (SP 35 02) was conducted in the Comilla, Habigunj and Moulvibazar districts. This was the second sub-project undertaken by BRRI with a local NGO (AAS) as a partner.

The results of the trials were less encouraging than from the first two sub-projects. The completion report and the evaluation report of the sub-project contain some results that are somewhat inconsistent, however. During the first season (2002-03), SRI yields were about 17.5% higher than that under FP in Comilla; in Habigunj and Moulvibazar, on the other hand, SRI yields were lower than FP yields (Latif et al., 2004). Since many of the SRI practices followed in the latter two districts were faulty, the comparisons may not be accepted as valid [1].

Cost-benefit analysis was done only during the first season (2002-03), not during the second one. Costs of production were estimated to be higher for SRI than for either BRRI or FP. Labour and irrigation costs for SRI were, respectively, 19% and 33% higher than for FP. Three more irrigations were given for SRI, and tube-well owners charged a fixed cost according to the number of applications, not for the volume of water supplied. Thus irrigation costs were disproportionately higher for SRI farmers.

Even so, average net returns for SRI and FP were found to be similar. During the second season (2003-04), SRI yields were actually higher than FP yields in all areas. In Comilla, SRI yields were 20% higher in one location and over 13% higher in another location. In the two other districts, with some modification in the practices, such as reducing plant spacing from 40x40 cm to 30x30 cm, SRI yields became 6.3% higher than FP yields. During the second season, SRI yields were thus higher than FP yields in all three districts as the overall relative performance of SRI improved during the second season.

The report states that acceptability of SRI among farmers was mixed. However, opinion in favour of some partial or modified adoption of SRI was reported to be universal among farmers. Some practices, such as large-scale use of organic manure and alternate drying and irrigating, were said to be difficult. The evaluation report stated that DAE and other extension organisations were showing interest to disseminate SRI among farmers as a new technology. It is also stated that a great achievement of the SRI trials was to change farmers' attitude regarding seedling age for transplantation. Instead of using seedlings 60-70 days old, they are now using seedlings about 35 days old, and they are also using compost in their fields. The report recommended further field verification of SRI methods before a final conclusion can be reached.

2.2 Further evidence from the national workshop on SRI in Bangladesh

The first SRI National Workshop on SRI in Bangladesh was held at IDB Bhaban in Dhaka, December 24, 2003, with the participation of NGOs, DAE, BRRI, donors, policy makers, and the private sector to share experiences with SRI. Seven papers were presented, three by BRRI researchers, three by NGO researchers/practitioners, and one by a DAE extension specialist. Two of the BRRI papers did not have much positive to say about SRI, but the third reported very encouraging results. The other four papers all reported positive results from SRI trials in farmers' fields. There was thus some gap in the findings between BRRI scientists, on the one hand, and NGOs and extension specialists, on the other. In the open discussion session, the polarisation between these two groups became more evident.

The most interesting feature of the workshop deliberations was the firmly positive attitude expressed by farmer-participants regarding SRI based on their experience and evaluations. Nine of the ten farmer-representatives expressed strong support for SRI.

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[1] In the latter two districts, the SRI practices followed were not ones as recommended. For example, in areas with poor soil quality, spacing was 40x40 cm, much more than recommended for beginning SRI if the soil is not good. Also, only compost and no mineral fertiliser was applied. Transplantation was done with seedlings plunged straight down into the soil, so roots had a J shape rather than the L shape recommended with SRI. Further, 15-day-old SRI seedlings were transplanted on the same date(s) along with 40 to 50 day-old seedlings under FP, which created problems of plant management under SRI, especially at later stages. Plants further suffered from water stress since farmers were instructed not to go for the next irrigation before the soil cracked after drying.

They informed other participants that they had gotten significantly higher yield through SRI practices than from their own usual practices based on BRRI recommendations.

The SRI farmers at the workshop also expressed their willingness to adopt SRI practice on a larger scale by developing their skills and capacity. This is very significant in relation to expansion of SRI practices on farmers' fields because in spite of some mistakes made by farmers at the introductory stage of SRI adoption, their SRI yield gains during the initial trials were significant compared to FP in many areas, and their profitability as well as resource-saving were impressive. Farmers' views provided testimony to the motivation created among farmers to try and adopt SRI practice.

The participants made some recommendations for future action. These included, among other things, initiating an integrated and co-ordinated approach by involving farmers, researchers, and extension workers (GO/NGO) to conduct further SRI trials and experiments to determine the potentials of SRI in Bangladesh, and seeking donor assistance to cover the necessary cost and support for the same.

2.3 Some limitations of the Bangladesh experiences

In spite of the largely favourable results achieved by SRI sub-project trials in Bangladesh, there were certain limitations of the trials. The trials under the PETRRA project were conducted for only two production seasons. During this short period, certain practices could not be followed properly such as application of organic manure to improve soil fertility, alternate drying and wetting for reducing irrigation cost, and adequate weeding for better soil aeration.

In most cases, farmers could not apply organic manure due to lack of its availability. Proper water management in most of the SRI plots was not possible due to the general practice of flood irrigation. Farmers faced problems to start up irrigation equipment on time, which can be addressed through a community approach with farmers' participation to solve this problem. In some areas, transplantation was somewhat delayed due to cold temperature, and often two seedlings instead of one were used per hill. Proper weeding also was not done in many cases, thinking this would save labour cost. The fact that farmers in Bangladesh were getting such higher yields with less costs even without following all of the SRI practices recommended indicates that there is still scope to further raise the SRI productivity and benefits from SRI in Bangladesh, if the various existing shortcomings could be removed.

Further studies and trials are thus necessary to determine how best these constraints could be removed to realise the full potentials of the SRI method. Institutional arrangements also need to be made for imparting training to extension workers and farmers to develop human skills. Even though the understanding of SRI farmers was preliminary and all the practices could not be followed properly, most farmers were happy to obtain higher yields from SRI at relatively lower cost compared to yield from conventional practices. These sub-projects arrived at a better understanding on SRI, and more farmers are on the verge of extending it. However, the government, NGO and private sector people involved with farmers are convinced that some more work needs to be done in terms of extension and supportive research initiatives to have SRI methods adopted widely and well by rice farmers of Bangladesh, tackling the various technical and social problems that are faced.

3. Overall Findings on SRI from Bangladesh

The experiences gained from limited trials on SRI in Bangladesh in different regions of the country show an encouraging picture. Agronomic findings show, in most cases, more tillers per hill, longer panicles, and less unfilled grain. Grain quality was also found to be better. Yield increases in general may appear to be less spectacular than in some other Asian countries, but have ranged up to 49% over farmer practice. Costs of production were found to be consistently less in one sub-project area covering four districts; but in many areas these could be substantially reduced by better management of labour and irrigation facilities and use of rotary weeder. With increased practice of SRI, the skill of farmers is most likely to improve, which in turn will contribute substantially to reduction of production costs. Profitability of SRI also has been found to be encouraging in the different areas.

The most important aspect revealed from the SRI trials in Bangladesh is the highly positive attitude of the farmers towards the method. It has been reported from all areas that even those farmers who were not directly involved with the SRI sub-projects became interested in adopting the methods at least partially once they saw SRI plants growing in fields like their own. They modified their practices by going for early transplantation, wider spacing, using single or at most two seedlings per hill, and using more organic fertiliser and less pesticides.

The extension personnel of the DAE also held positive attitudes and have been helping the farmers to disseminate SRI practices. It is reported that the DAE has already started setting up demonstration trials on SRI method for rice production in different areas of the country and has included SRI methods in its training programmes.

Among BRRI rice scientists, while some have shown a positive attitude, some are still sceptical about SRI. However, it is hoped that they will conduct trials in farmers' fields following the SRI practices more systematically before coming to any final conclusions. They should also conduct trials to assess scientific explanations and the validity of SRI methods objectively without sticking to pre-conceived notions. Once farmers become convinced about the merits of SRI and decide to go ahead with SRI practices, any co-operation received from government and NGO extension workers would make SRI more popular, and a lack of conviction of scientists would not stand in the way in the long run. On the other hand, the collaboration of the scientists can contribute to the further success of SRI and help in increasing yield and profitability of rice farming in a more sustainable manner and contribute to greater food security.

4. Conclusion

The SRI has shown its potentials for substantially improving yield and profitability of rice production in a sustainable manner without depending on high cost modern inputs or genetic improvements in Bangladesh and many other rice growing countries of the world. However, SRI is still evolving. More systematic trials and experiments need yet to be made regarding its superiority over conventional farmer practices, and to remove the gap between the results in researchers' fields and farmers' fields. Unlike most agricultural innovations, we have the paradoxical situation where researchers are often not able to replicate on-station the results that farmers are getting in their own fields. This may be due to factors of soil biology that have not been systematically studied.

All three PETRRA sub-projects completion reports and the national workshop on SRI recommended more systematic trials and experiments on SRI to further substantiate the potentials of SRI in the country. The implications of evaluations done in Bangladesh under the PETRRA project are that all necessary help and co-operation should be provided for evolving and adapting SRI methods to have a more economic, efficient, pro-poor, environment- friendly and sustainable rice production system.

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