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YIELD OF BORO RICE UNDER SYSTEM OF RICE INTENSIFICATION WITH DIFFERENT WATER REGIMES AND MANURAL STATUS

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Abstract

A field experiment was carried out at the Agronomy Field, Sher-e-Bangla Agricultural University, Dhaka from December, 2011 to May, 2012 to study the yield of *Boro* rice under system of rice intensification (SRI) with different water regimes and manural status. The experiment consisted of two factors as three water regime viz., waterlogged condition (W_1), saturated condition (W_2) and alternate wet and dry condition (W_3) in the main plots, and six manure and fertilizer combinations viz., cowdung 100% (F_1), compost 100% (F_2), chemical fertilizer 100% (F_3), 50% chemical fertilizer + 25% compost + 25% cowdung (F_4), 50% chemical fertilizer + 50% cowdung (F_5) and 50% chemical fertilizer + 50% compost (F_6) in the sub-plots. Water regime had significant effect on yield and yield components except number of effective tillers m^{-2}, filled grains $panicle^{-1}$, weight of 1000-grain and harvest index. The highest grain yield (5.74 t ha^{-1}) was obtained from the waterlogged condition that was statistically similar with saturated condition (5.69), whereas alternate wet and dry (AWD) gave the lowest grain yield (4.36 t ha^{-1}). Manural status also significantly influenced yield attributes except 1000-grains weight. The combination of chemical fertilizer, cowdung and compost showed the best performance compared to other manural status. The highest grain yield (5.81 t ha^{-1}) was obtained from chemical fertilizer 50% + cowdung 25% + compost 25% and the lowest grain yield (4.71 t ha^{-1}) was obtained from compost 100%. The highest number of effective tillers $hill^{-1}$ (33.71) was obtained from compost 100%. Chemical fertilizer 50% + cowdung 25% + compost 25% showed the highest harvest index (46.78%). In case of interaction effect of water regime and manural status the highest grain yield was observed in chemical fertilizer 50% + cowdung 25% + compost 25% of saturated condition (6.80 t ha^{-1}).

Introduction

Rice is the foremost staple food for more than 50% of the world's population (Thakur *et al.,* 2011). There is an upward shift in demand for rice worldwide due to population increase and urbanization, as people change their food habits (Mishra, 2009), leading to high shelf prices. Between 2006 and 2008, average world prices for rice grew by 217%, compared to wheat which increased by 136%, corn by 125%, and soybeans by 107% (FAO, 2010). About 75% of the total cropped area and more than 80% of the total irrigated area is planted to rice in Bangladesh (Hossain and Deb, 2003). Almost all of the 13 million farm families grow rice. It provides nearly 40% of national employment (48% of rural employment), about 70-76% of total calorie supply and 66% of protein intakes of an average person in the country (Hossain and Deb, 2003; Greenfield and Dowling, 1998; Dey *et al.*, 1996). Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (Hossain, 2002). Thus, rice plays a vital role in the livelihood of the people. To be able to meet the world's food demand by 2025, it is estimated that rice production has to increase globally by 60% (Fageria, 2007). But there is little scope to increase the area under rice production with the current practices that involve high production costs of fertilizers and protective chemicals (Sinavagari, 2006). Thus, innovative ways for reducing inputs like water, chemicals, fertilizers and labor while increasing yields on the same piece of land need to be put in place to ensure sustainable rice production (Bouman *et al.*, 2005).

The System of Rice Intensification (SRI), offers an opportunity to improve food security through increased rice productivity by changing the management of plants, soil, water and nutrients while reducing external inputs like fertilizers and herbicides (Berkelaar, 2001; Thakur *et al.,* 2009; Uphoff, 2003; Vermeule, 2009). The system proposes the use of single, very young seedlings with wider spacing, intermittent wetting and drying, use of a mechanical weeder which also aerates the soil, and enhanced soil organic matter (Uphoff and Kassam, 2009). SRI is a technique that is a set of practices and a set of principles rather than as a "technology package" (Uphoff, 2004). SRI is not a technology like the seed of high-yielding varieties or like a chemical fertilizer or insecticide. It is a system for managing plants, soil, water or nutrient together in mutually beneficial ways, creating synergies (Laulanié, 1993). With SRI, management practices control or modify the microenvironment so that existing genetic potentials can be more fully expressed and realized. The most obvious advantage from SRI appears to be the yield increase in farmers' field without any new seeds or chemical and mechanical inputs (Stoop *et al.*, 2002) and that is reported to be from 50% to 200% (Uphoff, 2005).

To increase quality yield of rice in Bangladesh it is necessary to improve nutrient management of rice field. Proper utilization of different sources of nutrients in context of crop-soil productivity must be explored for sustaining the productivity. The sources of nutrient for crops are nutrient reserve in soil, organic and inorganic fertilizers. None of the sources are complete and therefore, no one is sufficient to sustain soil fertility and productivity. Combination of organic and chemical fertilizer is being stressed now a day. It established that the application of different fertilizers and manures influence the physical and chemical properties of soil and enhance the biological activities. Application of both chemical and organic fertilizers is needed for the improvement of soil physical properties and quick supply of essential plant nutrients for higher yield as well as to keep the soil physical properties (Davarynejad *et al.*, 2004; Singh and Singh, 2000). Because of these variable information's about the effect of manural status on yield of *Boro* rice, a detailed study was undertaken to identification of SRI effectiveness in respect of fertilizer management and yield increase.

Materials and Methods

The experiment was conducted to study the optimum fertilizer and water management in SRI concept for optimum yield in rice during the period from December, 2011 to May, 2012 at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. The soil belongs to Tejgaon Series under Agro-ecological zone of The "Modhupur Tract", AEZ-28. The soil of the site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH ranged from 6.1-6.5 and had organic matter 1.29%. The experiment was laid out in a split-plot design with three replications having two factors i.e. Factor-A: Three type of water regime viz. W_1= Waterlogged (The level of water in each pot was maintained at about 5 cm above the soil surface throughout the growing period of the crop until near maturity. Irrigation was scheduled at 4 day intervals starting 7 days after transplanting (DAT). Plots were equipped with drainage irrigation system for continuous flood irrigation (up to 5-6 cm depth) throughout the rice-growing season.), W_2= Saturated (water was applied just to saturate the soil (without flood) throughout the growing period of the crop. For maintaining field capacity, periodic irrigation was applied to maintain the soil at about field capacity from transplanting to maturity. Plots were watered every day in the morning by sprinkling.), W_3= Alternate wet and dry (Alternate wet and dry (AWD) is a water management system where rice fields are not kept continuously submerged but are allowed to dry intermittently during the rice growing stage. Intermittent irrigation was scheduled at 10 day intervals starting 7 days after transplanting (DAT) up to maturity. Water level was maintained about 5 cm above during the wetting period. Water level was dried in such a level that hairline cracks were develop in the field) and Factor-B: six type of fertilizer management viz. F_1= Cowdung 100% (The selected plots were applied with 10000 kg ha^{-1} cowdung. The entire amount of cow dung was applied as basal dose at final land preparation.), F_2= Compost 100% (The 10000 kg ha^{-1} compost was applied to the selected plots. The entire amount of compost was also applied as basal dose at final land preparation.), F_3= Chemical fertilizer 100%. The experimental plots were fertilized with 195, 95, 65, 70 and 10 kg ha^{-1} Urea, TSP, MOP, Gypsum and zinc sulphate, respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied as basal dose at final land preparation. Urea was top-dressed in four equal installments. First installment was done after seedling recovery and the rest three installments were done at 20 days interval.), F_4= Chemical fertilizer 50% + cowdung 25% + compost 25%, F_5= Chemical fertilizer 50% + cowdung 50%, F_6= Chemical fertilizer 50% + compost 50%. BRRI dhan45 was used as plant material. Seeds were sown in the portable trays on December 28, 2011. The 12 days old seedlings were uprooted from the trays and transplanted on January 10, 2012. The trays were brought to the main field and seedlings were planted in the prepared plot just after uprooting. The spacing was maintained plant to plant 30 cm and row to row 30 cm. Data on yield attributes was determined from randomly selected five hills of each plot and grain and straw yields were recorded from the inner rows leaving border lines at harvest stage. 6 m^2 areas crop of each plot were separately harvested, bundled, tagged and then brought to the threshing floor for recording grain and straw yield. Threshing was done using pedal thresher. The grains were cleaned and sun dried to a moisture content of 14%. Straw was also sun dried properly. Finally grain and straw yields were determined and converted to ton ha^{-1}. All the collected data were analyzed following the analysis of variance (ANOVA) technique using IRRISTAT package and the mean difference were adjusted by LSD technique (Gomez and Gomez, 1984).

Results and Discussion

The number of effective tillers hill^{-1}, filled grains panicle^{-1}, 1000-grain weight and harvest index were not significantly influenced by water regime. The numerical maximum number of effective tillers hill^{-1} (30.50) was given by W_2 condition, filled grains panicle^{-1} (75.61) in W_1 condition, 1000-grains weight (22.63g) in W_2 and harvest index (46.16%) in W_2 condition (Table 1). Stoop (2005) found higher harvest index in SRI comparing the conventional method, though, Barison (2003) found no difference for the same. The total number of grains panicle^{-1} was significantly influenced by water regime. The highest number of grains panicle^{-1} (96.22) was obtained from W_1 condition statistically similar with W_2 condition and the lowest number of grains panicle^{-1} (82.98) was obtained from W_3 condition. This result was similar with Bouman, *et al.* (2005). The highest grain yield (5.74 t ha^{-1}) was obtained from the W_1 condition that was statistically similar with W_2 condition and the lowest (4.36 t ha^{-1}) was from W_3 condition. Bouman and Tuong (2001) suggested that there is a reduction in the grain yield in alternate wetting and drying when compared with rice grown with standing water. The highest straw yield (6.74 t ha^{-1}) was obtained from the W_1 condition that was statistically similar with W_2 condition and the lowest

(5.22 t ha^{-1}) was from W_3 condition. The highest biological yield (12.48 t ha^{-1}) was found from W_1 condition and the lowest biological yield (9.59 t ha^{-1}) was found from W_3 condition.

Table 1. Influence of water regime on different yield contributing characters of *Boro* rice transplanted in SRI

Treatments	Effective tiller no. $hill^{-1}$	Total grains $panicle^{-1}$ (No.)	Filled grains $panicle^{-1}$ (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_1	26.92	96.22a	75.61	22.58	5.74a	6.74a	12.48a	46.02
W_2	30.50	95.82a	74.70	22.63	5.69a	6.65a	12.33a	46.16
W_3	28.20	82.98b	71.76	22.18	4.36b	5.22b	9.59b	45.55
$LSD_{(0.05)}$	NS	10.706	NS	NS	0.383	0.458	0.819	NS
CV (%)	16.48	12.59	6.24	5.36	7.86	7.98	7.71	2.04

W_1 = Waterlogged, W_2 = Saturated, W_3 = Alternate wet and dry and NS= Not Significant.

Manural status significantly influenced the number of effective tillers $hill^{-1}$. The highest number of effective tillers $hill^{-1}$ (33.71) was obtained from F_2 which was statistically similar with F_1. The lowest effective tillers $hill^{-1}$ (25.42) was obtained from F_6 that was statistically similar with F_3 and F_5. Hossaen *et al.* (2011) conducted an experiment to evaluate the efficacy of different organic manure and inorganic fertilizer and recorded maximum number of effective tillers $hill^{-1}$ from the treatment of 70% NPKS + 2.4 t manure ha^{-1}. The highest number of total grains $panicle^{-1}$ (107.98) was obtained from F_3 and the lowest number of grains $panicle^{-1}$ (86.80) was recorded from F_1 that was similar to F_2. The highest number of filled grains $panicle^{-1}$ (84.78) was obtained from F_1 that similar to the F_3 and F_4 and the lowest number of filled grains $panicle^{-1}$ (65.51) was obtained from F_5 (Table 2). Basunia (2005) reported that frequent combined application of cowdung plus inorganic fertilizer rates increased production from successive filled grains $panicle^{-1}$. There was no significant effect among the different manural status in respect of weight of 1000-grains though the numerically maximum 1000-grains weight (22.73g) was observed at F_2 and the minimum (22.18) in F_3. Manural status has significant effect on grain yield. F_4 produced significantly the highest grain yield (5.81 t ha^{-1}) that was statistically similar to F_3. The lowest (4.71 t ha^{-1}) grain yield was from F_2 that was similar with F_1. Das (2003) earlier stated that soils with high fertility influence the grain yield.

Table 2. Influence of manural status on different yield contributing characters of *Boro* rice transplanted in SRI

Treatments	Effective tiller no. $hill^{-1}$	Total grains $panicle^{-1}$ (No.)	Filled grains $panicle^{-1}$ (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
F_1	30.24ab	80.02c	84.78a	22.44	4.72c	5.43c	10.13c	46.28ab
F_2	33.71a	86.80bc	72.80bc	22.73	4.71c	5.43c	10.16c	46.37ab
F_3	26.44cd	107.98a	74.27abc	22.18	5.77a	6.80a	12.56a	45.92ab
F_4	29.98bc	95.73b	79.84ab	22.51	5.81a	6.64ab	12.48a	46.78a
F_5	25.44d	91.00b	65.51c	22.38	5.36b	6.26b	11.64b	46.04ab
F_6	25.42d	89.91b	66.93c	22.53	5.21b	6.66ab	11.84b	44.06b
$LSD_{(0.05)}$	3.563	9.392	11.489	NS	0.355	0.463	0.578	2.597
CV (%)	13.70	10.62	16.00	3.00	7.01	7.77	5.23	5.88

F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%), F_6 = Chemical fertilizer (50%) + compost (50%) and NS= Not significant

Das (2003) found that yield of boro rice was significantly influenced by organic matter, cation exchange capacity, nitrogen, phosphorus and potassium. The highest straw yield (6.80 t ha^{-1}) was obtained from F_3 that was similar with F_4 and F_6. The probable reasons of increased straw yield in the F_3 might be due to higher total number of tillers m^{-2} and taller plants. The lowest straw yield (5.43 t ha^{-1}) was obtained from F_1 and F_2. Hossain and Deb (2003) was found lowest straw yield in conventional method than SRI for BRRI dhan32 variety. The highest biological yield (12.56 t ha^{-1}) was found from F_3 which was similar with F_4. The lowest biological yield (10.13 t ha^{-1}) was found from F_1 that was statistically similar with F_2. The highest harvest index (46.78%) was found from chemical F_4 that was similar with all other treatments and the lowest (44.06%) was from F_6.

The number of effective tillers $hill^{-1}$ was significantly influenced by the interaction effect of water regime and manural status. The maximum number of effective tillers $hill^{-1}$ (28.80) was obtained from W_1F_4 which was similar with W_1F_1, W_1F_2, W_2F_2, W_2F_5, W_2F_6, W_3F_1 and W_3F_2. The lowest number of effective tillers $hill^{-1}$ (20.53) was obtained from W_1F_6 (Table 3).

Table 3. Interaction effect of water regime and manural status on different yield contributing characters of *Boro* rice transplanted in SRI

Treatments	Effective tiller no. $hill^{-1}$	Total grains $panicle^{-1}$ (No.)	Filled grains $panicle^{-1}$ (No.)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_1F_1	30.47a-d	96.53b-e	88.00a	22.73ab	5.77de	6.45c-e	12.20c-d	47.17a
W_1F_2	34.67a	93.80b-g	66.27bc	22.80ab	4.99f-h	5.65e-h	10.67e-h	46.89a
W_1F_3	25.27d-g	115.60a	80.67a-c	22.23ab	6.89a	6.83b-d	12.83bc	46.79a
W_1F_4	28.80a-e	103.20a-c	85.60ab	22.57ab	6.00cd	7.16a-c	13.17bc	45.59a
W_1F_5	21.80fg	95.93b-f	67.20bc	22.73ab	6.46a-c	6.81b-d	13.27b	48.71a
W_1F_6	20.53g	76.47hi	65.93bc	22.40ab	5.22e-g	7.53ab	12.73bc	40.95a
W_2F_1	28.20b-e	79.80f-i	82.73ab	22.50ab	4.69g-i	5.62f-h	10.57f-h	46.90a
W_2F_2	33.53ab	88.00c-h	73.93a-c	22.87a	4.99f-h	5.73efh	10.90e-g	47.61a
W_2F_3	28.20b-e	108.53ab	70.53a-c	22.60ab	6.21b-d	7.43ab	13.63ab	45.46a
W_2F_4	33.33ab	101.67a-c	85.33ab	22.73ab	6.80ab	7.71a	14.53a	46.85a
W_2F_5	30.27a-e	88.53c-h	68.27a-c	22.27ab	5.18c-g	6.39c-f	11.60de	44.77ab
W_2F_6	29.47a-e	108.40ab	67.40bc	22.83ab	5.80c-e	7.00a-c	12.77bc	45.35ab
W_3F_1	32.07a-c	63.73i	83.60ab	22.10ab	3.42k	4.20i	7.63j	44.77ab
W_3F_2	32.93ab	78.60g-i	78.20a-c	22.53ab	3.95jk	4.91hi	8.90i	44.60ab
W_3F_3	25.87d-g	99.80b-d	71.60a-c	21.70b	5.55d-f	6.13d-f	11.20de	45.49a
W_3F_4	27.80b-f	82.33e-h	68.60a-c	22.23ab	4.18ij	5.05gh	9.73hi	47.92a
W_3F_5	24.27e-g	88.53c-h	61.07c	22.13ab	4.45h-j	5.59f-h	10.07gh	44.63ab
W_3F_6	26.27c-g	84.87d-g	67.47bc	22.37ab	4.61g-j	5.45f-h	10.03gh	45.87a
$LSD_{(0.05)}$	6.171	16.268	19.899	1.139	0.615	0.803	1.001	4.498
CV (%)	12.97	10.62	16.12	3.04	7.01	7.77	5.23	5.88

W_1 = Waterlogged, W_2 = Saturated, W_3 = Alternate wet and dry, F_1 = Cowdung (100%), F_2 = Compost (100%), F_3 = Chemical fertilizer (100%), F_4 = Chemical fertilizer (50%) + Cowdung (25%) + Compost (25%), F_5 = Chemical fertilizer (50%) + Cowdung (50%) and F_6 = Chemical fertilizer (50%) + compost (50%)

The highest (115.60) number of grains $panicle^{-1}$ was obtained from W_1F_3 statistically similar with W_1F_4, W_2F_3, W_2F_2 and W_2F_6. The lowest (63.73) number of grains $panicle^{-1}$ was obtained from W_3F_1 which was similar with W_1F_6, W_2F_1 and W_3F_2. The highest number of filled grains $panicle^{-1}$ (88.00) was obtained from the W_1F_1 followed by W_2F_3, W_2F_2, W_1F_1, W_1F_2, W_1F_3, W_1F_4, W_1F_5, W_3F_1, W_3F_2, W_3F_3 and W_3F_4. The lowest number of filled grains $panicle^{-1}$ (61.07) was obtained from W_3F_5. The highest weight of 1000-grains (22.87 g) was obtained from W_2F_2

which was similar with all other interaction effect of water regime and manural status except W_3F_3. The lowest weight of 1000-grains (21.70 g) was obtained from W_3F_3 which was similar to the all other interaction effect of water regime and manural status except W_2F_2. The highest grain yield was observed in W_2F_4 (6.80 t ha^{-1}) which was similar with W_2F_3 and W_1F_5. The lowest yield (3.42 t ha^{-1}) was observed in W_3F_1 that similar with W_3F_2. The highest straw yield (7.71t ha^{-1}) was recorded in W_2F_4 similar with W_1F_4, W_1F_6, W_2F_3 and W_2F_6. The lowest straw yield (4.20 t ha^{-1}) was found in W_3F_1 which was statistically identical with W_3F_2. Akbar (2004) found highest straw yield in the combination of inbred variety and 15 day old seedlings. The highest biological yield (14.53 t ha^{-1}) was recorded in W_2F_4 similar with W_2F_3. The lowest biological yield (7.63 t ha^{-1}) was found in W_3F_1. Bouman and Toung (2001) found highest biological yield in combination of the chemical fertilizer and saturated condition. The highest harvest index (48.71%) was recorded in W_1F_5 that followed by all other treatments. The lowest harvest index (44.60%) was found in W_3F_2.

Conclusion

Based on the results of the present study it can be concluded that the highest yield was observed in waterlogged condition and that was statistically similar with saturated condition. The crops with chemical fertilizer 50% + cow dung 25% + compost 25% showed the higher yield that is similar to chemical fertilizer 100% but more friendly for the environment than chemical fertilizer 100%.

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References

Akbar, M. K. 2004. Response of hybrid and inbred rice varieties to different seedlings ages under system of rice intensification in transplant aman season. M. S. Thesis. Dept. Agron., BAU, Mymensingh.

Barison, J. 2003. Nutrient use efficiency and nutrient uptake in conventional and intensive (SRI) rice cultivation systems in Madagascar. Near final draft of Master's thesis, Department of Crop and Soil Sciences, Cornell University, Ithaca, NY. [http://ciifad.cornell.edu/sri/theses/madgjoelithesis.pdf].

Basunia, M. N. 2005. Influence of inorganic fertilizer and cowdung on the growth yield and quality of Binadhan-5. MS Thesis. Department of Agricultural Chemistry. Bangladesh Agricultural University, Mymensingh.

Berkelaar, D. 2001. SRI, the System of Rice Intensification: Less can be more. ECHO Develop. Notes. 10: 1-7.

Bouman, B. A., S. Peng, A. R. Castaneda and R. M. Visperas. 2005. Yield and water use of irrigated tropical aerobic rice systems Agric. Water Mng. 74: 87-105.

Bouman, B. A. M. and T. P. Toung. 2001. Field Water Management to Save Water and increase its productivity in irrigated rice. Agric. Water Mang. 49: 11-30.

Das, L. 2003. Verification and refinement of the System of Rice Intensification in selected areas of Bangladesh. Trial Monitoring Report. SAEF Development Group. [http://ciifad.cornell.edu/sri/countries/bangladesh/bangpetfrep.pdf].

Davarynejad, G. H., G. H. Haghnia and A. Lakzian. 2004. Effect of municipal compost in combination with chemical fertilizers and manure on growth and yield of wheat. Agril. Sci. Technol. 18(1): 101-108.

Dey, M. M., M. N. Miah,, B. A. A. Mustafi and M. Hossain. 1996. Rice production constraints in Bangladesh: Implication for further research priorities. In: Rice Research in Asia: Progress and Priorities. CAB International and IRRI Phillipines.

Fageria, N. K. 2007. Yield physiology of rice. J. Plant Nutr. 30: 843-879.

FAO (Food and Agriculture Organization). 2010. World food situation, the FAO food price index. [www.fao.org/worldfoodsituation/en/689].

Gomez, K. A. and A. A. Gomez. 1984. Statistical Procedures for Agricultural Research. 2nd Edn. John Wiley and Sons. New York. Chichester, Brisbane, Toronto, Singapore.p.680.

Greenfield, S. M. and N. G. Dowling. 1998. Introduction and Overview. *In*: Sustainability of Rice in the Global Food System. N. G. Dowling, S. M. Greenfield and K. S. Fisher, (*eds.*).

Hossaen, M. A., A. T. M., Shamsuddoha, A. K. Paul, M. S. I. Bhuiyan and A. S. M. Zobaer. 2011. Efficacy of different organic manures and inorganic fertilizer on the yield and yield attributes of *boro* rice. The Agriculturists. 9(1&2): 117-125.

Hossain, M. and U. K. Deb. 2003. Liberalization of rice sector: Can Bangladesh withstand regional competition? Poster paper presented at PETRRA communication fair 2003 held at hotel Sheraton, Dhaka on Aug. 10-11.

Hossain, M. Z. 2002. Performance of BRRI dhan32 in the SRI and conventional methods and their technology mixes. M. S. Thesis. Dept. of Agron., BAU, Mymensingh. pp.28-71.

Laulanie, H. 1993. Le systeme de riziculture intensive malgache. Tropicultura (Brussels). 11: 110-114.

Mishra, A. 2009. System of rice intensification (SRI): A quest for interactive science to mitigate the climate change vulnerability. Asian Institute of Technology, Agricultural systems and Engineering; School of Environment, Bangkok, Thailand. IOP Conf. Series: Earth Environ. Sci. 6(24): 20-28.

Sinavagari, P. 2006. Traditional and SRI methods of paddy cultivation: a comparative economic analysis. Master of Science thesis submitted to the University of Agricultural Sciences, Department of agricultural economics, Dharwad-580005.

Singh, C. P. J. and S. S. Singh. 2000. Studies on the growth and yield parameters of wheat (*Triticum aestivum* L.) to urea and sludge based compost application. Madras Agril. J. 87(10-12): 727-728.

Stoop, W. A., N. Uphoff and A. Kassam. 2002. A review of agricultural research issues raised by the System of Rice Intensification (SRI) from Madagascar: Opportunities for improving farming systems for resource-poor farmers. Agril. Sys. 71(3): 249-274.

Stoop, W. A. 2005. The System of Rice Intensification (SRI): Results from exploratory field research in Ivory Coast, Research needs and prospects for adaptation to diverse production systems of resource-poor farmers. West African Rice Development Association (WARDA), 01 BP 2551, Bouaké, Ivory Coast. [http://ciifad.cornell.edu/sri/stoopwarda05.pdf].

Thakur, A. K., S. Rath, D. U. Patil and A. Kumar. 2011. Effects on rice plant morphology and physiology of water and associated management practices of the System of Rice Intensification (SRI) and their implications for crop performance. Paddy Water Env. 9: 13–24.

Thakur, A. K., N. Uphoff and E. Antony. 2009. An assessment of physiological effects of System of Rice Intensification (SRI) practices compared with recommended rice cultivation practices in India. J. Expt. Agric. 46(1): 77-98.

Uphoff, N. 2003. Higher yields with fewer external inputs? The system of rice intensification and potential contributions to agricultural sustainability. Intl. J. Agric. Sust. 1: 38-50.

Uphoff, N. 2004. What is being learned about system of rice intensification in china and other countries? Agroecological Perspectives for Sustainable Development Seminar Series. Cornell University. 15 Sept.

Uphoff, N. 2005. Agroecologically sound agricultural systems: Can they provide for the world's growing populations? The global food & product chain-dynamics, innovations, conflicts, strategies. Deutscher Tropentag, Oct. 11-13. Hohenheim. [www.tropentag.de/2005/abstracts/links/uphoff_sdkbqnqq.pdf].

Uphoff, N. and A. Kassam. 2009. Case study: System of Rice Intensification (SRI), in agricultural technologies for developing countries. Final report. Annex 3. European Technology Assessment Group, Karlsruhe, Germany.

Vermeule, M. 2009. More from less, from less to more. Scaling up: Dissemination of a rice cultivation technique. Farming Matters. Amsterfoort, the Netherlands. p.3.