Journal of RNR Bhutan

Volume 4, Number 1 August 2008

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ISBN 99936-680-3-6

Printed at **Q ReproGraphics**, PO Box 222, Thimphu, BHUTAN.

August 2008 JOURNAL OF RENEWABLE NATURAL RESOURCES BHUTAN Volume 4

Volume 4, Number 1, August 2008 ISBN 99936-680-3-6

JOURNAL of RENEWABLE NATURAL RESOURCES BHUTAN

COUNCIL FOR RNR RESEARCH OF BHUTAN
MINISTRY OF AGRICULTURE
THIMPHU, BHUTAN

Yield Response of Rice under System of Rice Intensification (SRI) Management at Kanglung, Bhutan

Karma Lhendup[1], Ugyen Tshering[2], Janchu Dorji[2] and Sangay Phuntsho[2]

ABSTRACT

Of late, the System of Rice Intensification (SRI) has emerged as a promising and an innovative method of growing rice organically under irrigated and even rain-fed conditions. Studies in a number of countries have shown significant increases in rice yield compared to conventional methods; with seed, water, and cost savings. However, yield response of SRI in Bhutan has not been reported. This has prompted the study reported in this paper. Three location-specific trials, both on-farm and on-station, were carried out at elevations of 1600-2000 masl to assess the respective responses to SRI practices of different rice varieties (cultivars) popularly grown at Kanglung. The trials assessed SRI methods that could be most easily introduced in Bhutan.

The yield results of these SRI trials in Bhutan and an analysis of the yield-contributing parameters showed a positive effect using SRI methods, similar to what has been observed in many other countries. Higher mean yields of 6.0 ton/ha using Khangma maap in the study site 1 and 4.2 ton/ha with Paropa and Verna varieties at other two sites, compared to the average yield of 3.6 ton/ha with prevailing methods, were recorded. Among the treatments, best result was obtained with 30 x 30 cm spacing, 3 - leaf stage seedling in all the sites. It was observed that 80% of the SRI plots had a large number of secondary tillers (more than in the control plots of conventional methods) with filled but immature grains, so some further adjustment of agronomic practices might contribute to further improvements in yield.

KEYWORDS:

Bhutan, System of Rice Intensification, trials, yield contributing parameters, yield

INTRODUCTION

The System of Rice Intensification (SRI) is a new and promising resource-conserving method of growing rice under irrigated and even rain-fed conditions (Laulanié, 1993; Stoop et al., 2002). Since its first trial outside of Madagascar in 1999 - 2000, it has been gaining acceptance and popularity in the farming community in view of the associated benefits viz., saving seed, water, cost, increased soil health and grain yields vis-à-vis traditional method of rice cultivation (Lhendup, 2007). SRI has been successfully tested in more than 30 rice-growing countries such as China, India, Indonesia, Philippines, Cambodia, Myanmar, Sri Lanka, Bangladesh, and Nepal (Uphoff, 2005). The bumper rice harvest obtained by farmers in Nepal (BBC, 2006) is a testimony of SRI success next door to our country, Bhutan, making the controversy about SRI raised inter alia by McDonald et al. (2006) moot. Besides increasing rice crop productivity, other benefits of SRI that have been experienced by farmers include earlier crop maturity, higher grain and straw yields, and reduced cost of production as less inputs of seeds, water, manure, fertilizers and pesticides are required (Uphoff, 2005).

It is worth mentioning that SRI techniques of rice cultivation are not entirely different from conventional methods. They involve changing certain management practices for rice plants, soil, water and nutrients, so as to produce better growing conditions, particularly in the root zone, for rice plants than those prevailing for plants that are grown under traditional practices (Uphoff, 2001). Early transplanting at 8 - 12 days or 2 - 3 leaf stage, planting single seedlings at wider spacing, careful transplanting, moist but un-flooded soil conditions during the vegetative growth phase, early and timely weeding with rotary weeder, and application of organic manure are the recommended practices of SRI. Many claim that these practices assert synergistic effects resulting in higher yield than the conventional rice production methods (Uphoff, 2001; Vallois, 1996).

Farmers in Bhutan grow different varieties of rice, both local and introduced, in a wide range of elevation from subtropical lowlands (150 m) in the south up to elevations as high as 2600 masl in the north (Chettri et al., 2000). Several innovations have been in place to increase the rice productivity in the country. However, the present average productivity of rice is less than 3 ton/ha (MOA, 2004), which reflects low performance of the current practices used for cultivation. Further, the productivity is constrained by a lack of farmer education on rice planting and rice ecosystems in the country.

Given the above context, a study was undertaken to assess the performance or response of three rice varieties, namely Khangma maap, Paropa and Verna, cultivated at Kanglung, in relation to seedling spacing and age of SRI practice. This practice include careful transplanting of younger seedling (2 - 3 leaf stage usually), wider spacing (above 20 x 20 cm), water managment

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(alternate wetting and drying during vegetative stage followed by continuous water supply in reproductive stage), and early weeding and active soil aeration using rotary weeder in our conditions.

MATERIALS AND METHODS

Site Profile

The evaluation trials were carried out at three sites at Kanglung geog (1800 masl) during the rice-growing season in 2006 (Figure 1). Kanglung is one of the 16 geogs of Trashigang district with a total of 588.5 acres under paddy cultivation. The total rice production is recorded at 408.3 tons (equal to 3.6 ton/ha), which is higher than the average yield of 2.9 ton/ha in the country (MOA, 2004). Kanglung falls within the mid and high altitude rice-growing zones with a mean temperature of 17.2 °C and 850 - 1200 mm of rainfall in a year. Table 1 presents additional information on soil texture and pH, and altitude of the study sites.

Figure 1: Location of study sites

Table 1: Soil types, pH and altitude of study sites

Site	Altitude (masl)	Soil texture	pH
I (Khangma)	2000	Loam	4.40
II (Thragom)	1850	Loamy to sandy clay	4.47
III (Pangthang)	1600	Sandy loam to sandy clay loam	5.99

Experimental Design

The experimental design was a simple randomized block design (RBD) with three replications and five treatments at each site. Plot size was 5 x 4 m^2, and there were a total of 15 plots in each site. The treatments are:

1. 20 x 20 cm spacing, 3 - leaf stage seedling
2. 20 x 20 cm spacing, 4 - leaf stage seedling

3. 30 x 30 cm spacing, 3 - leaf stage seedling
4. 30 x 30 cm spacing, 4 - leaf stage seedling
5. Control (farmers' normal practice, > 7 leaf stage)

For control, farmers' normal practices of rice cultivation was followed such as transplanting of older seedlings having three to four tillers at close spacing of less than 15 cm in a bunch of two to three seedlings; application of pre-emergence selective herbicide (Butachlor) at three days after transplanting at the rate of 40 gm per plot; maintaining about 7 cm water level from transplantation to two weeks before harvest; and weeding for two to three times.

Rice Variety and Seedling Transplanting

Each site was planted with a different variety of rice: Paropa and Verna (two local varieties) at Sites II and III respectively, while a released variety Khangma maap was used at Site I. Selection of variety for this study was based on popular cultivar grown by farmers at each site.

Seeds were pre-soaked in water for 24 hours before sowing in the solarized nursery bed (Culman et al., 2006). Seedlings were transplanted at three and four leaf stage, following a square pattern of 30 x 30 cm and 20 x 20 cm spacing, attainable at about 22 – 25 days at the given altitude. For control plots, 50 - 60 day-old seedlings or greater than 7 leaf stages were transplanted. The total numbers of seedlings transplanted per plot were 222, 500 and 900 for 30 x 30 cm and 20 x 20 cm spacing, and control plot respectively.

Water Management and Weeding

After the transplantation of seedlings at shallow depth (2 - 3 cm) slightly in a slanting position in well-puddled soil, moist soil condition was maintained for about two weeks in all the experimental plots except the control, which was flooded. Then, a cycle of alternate wetting (up to 2 cm water level) and drying (about to crack) was executed during the vegetative phase. Initially, the duration of wetting was kept about two to three days more than that of drying, due to high summer heat. About 5 - 7 cm water levels were maintained during the entire reproductive phase and the water was removed about 15 - 20 days before the harvest.

A total of three weeding were done by hand, aided by small tools. The first weeding was carried out at about two weeks after transplantation, and the subsequent weedings at an interval of two weeks. There was no active soil aeration with hoe, and rotary weeder is usually recommended with SRI.

Application of Fertilizer

A small quantity of urea (46:0:0) at the rate of 173.8 gm per plot, equivalent to 40 kg/ha, was applied at 55 days after transplantation in all the plots due to yellowing of the tips of leaves. Normally, SRI practice involves provision of organic manure.

RESULTS AND DISCUSION

The main results of the evaluation trials on SRI are summarized in Table 2. The 3 - leaf stage seedlings spaced at 30 x 30 cm gave the best results for yield contributing parameters and yield measurement, which were consistent with SRI theory and expectations. The prevalence of diseases was negligible, which showed the effect of soil solarization on nursery bed. However, a few insect pests (stem borers) were observed in all plots.

Yield-contributing Parameters

The yield contributing parameters such as total numbers of productive or fertile tillers (panicles) per hill, length of panicle, and number of filled grains per panicle were found more in SRI plots than the conventional plots (Table 2). The highest numbers of productive tillers, 34, 32 and 30 were found in plots with wider spacing (30 x 30 cm) in three sites as compared to 16, 15 and 14 of control plots (Figure 2). The difference in fertile tillers is 53% at site I and II, and 50% at site III, as compared to percent of fertile tillers in conventional plots. Similarly, the difference in average number of filled grains per panicle is 22% at site I, 37% at site II and 29% at site III for plots with wider spacing (30 x 30 cm) in all the sites as compared to control plots. Both of these parameters appear important factors in determining the rice yield presented in Table 2.

However, the percentage of difference in fertile tillers and filled grains is slightly less by about 10% of fertile tillers and 3% of filled grains compared to the difference seen in individual 30 x 30 cm spacing plot, when all the SRI plots with different spacing and leaf stage of seedlings combined at each site. This indicates that maintaining wider spacing, one plant per hill, and transplanting younger seedling induces more robust root growth, profuse tillering, longer panicles and consequently more grains per panicle than closer spacing and transplanting older seedlings.

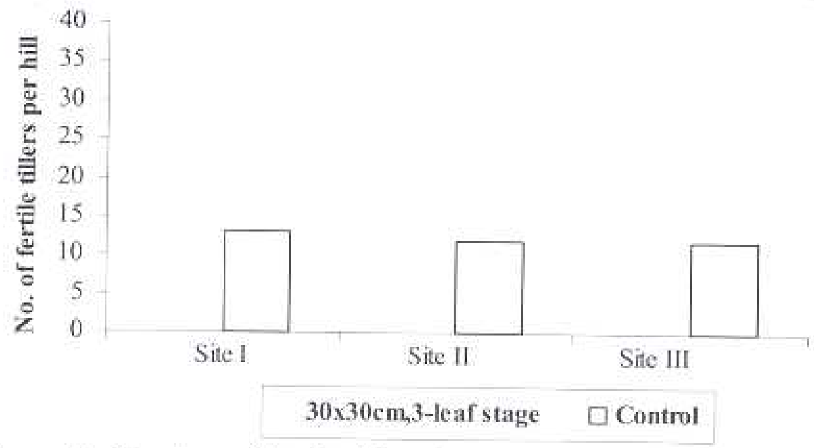

Figure 2: Number of fertile tillers in 30 x 30 cm spacing (3 - leaf stage seedling) and control plot in three sites.

Yield

In all the three sites, on average, SRI plots showed better yield performance compared to plots with conventional methods (Table 2). This finding is in line with the evaluation conducted by Anthofer (2004) that SRI method had better yield performance than conventional methods in Cambodia. Among these sites, better yield performance was observed at Site I as compared to Site II and III for both SRI as well as control plots. This may be attributed to the type of variety planted (Wang et al., 2002), or to the soil types and differences in nutrient status (Amiri, 2006; BIND, 2003) found among study sites.

Table 2: Yield and yield-contributing parameters of trials at three different sites

Sl.No	Parameters	Site I (Khangma)	Site II (Thragom)	Site III (Pangthang)
1	Rice variety	Khangma maap	Paropa	Verna
2	Average fertile tiller/hill			
2.1	20 x 20 cm, 3 - leaf stage	25	27	21
2.2	20 x 20 cm, 4 - leaf stage	21	22	18
2.3	30 x 30 cm, 3 - leaf stage	34	32	30
2.4	30 x 30 cm, 4 - leaf stage	29	27	26
2.5	Control	16	15	14
3	Plant height (cm)			
3.1	20 x 20 cm, 3 - leaf stage	142	134	142
3.2	20 x 20 cm, 4 - leaf stage	141	138	141
3.3	30 x 30 cm, 3 - leaf stage	144	146	144
3.4	30 x 30 cm, 4 - leaf stage	143	135	143
3.5	Control	136	121	133

4	Average filled grains/panicle			
4.1	20 x 20 cm, 3 - leaf stage	163	160	163
4.2	20 x 20 cm, 4 - leaf stage	170	170	170
4.3	30 x 30 cm, 3 - leaf stage	174	176	174
4.4	30 x 30 cm, 4 - leaf stage	155	165	155
4.5	Control	135	111	124
5	Yield ton/ha*			
5.1	20 x 20 cm, 3 - leaf stage	5.7	3.9	3.8
5.2	20 x 20 cm, 4 - leaf stage	5.2	3.8	3.3
5.3	30 x 30 cm, 3 - leaf stage	6.0	4.2	4.2
5.4	30 x 30 cm, 4 - leaf stage	5.3	3.8	3.6
5.5	Control	5.2	3.6	3.6

* Mean yield from 66, 150, and above 200 seedlings for 30 x 30 cm spacing, 20 x 20 cm spacing, and control plot respectively, in 6 m^2 crop-cut area at 14 % moisture content.

As seen in Table 2, among the treatments, SRI plot with 30 x 30 cm spacing (3 - leaf stage seedling) obtained higher mean yield of 6.0 ton/ha at site I and 4.2 ton/ha at site II and III, followed closely by 20 x 20 cm spacing (3 - leaf stage seedling) with 5.7 ton/ha, 3.9 ton/ha and 3.8 ton/ha respectively in three sites. The mean yield for the control plots are 5.2 ton/ha at site I and 3.6 ton/ha at site II and III. For SRI plot with 30 x 30 cm spacing (3 - leaf stage seedling) against control plots, the mean yield achieved is higher by 13% at site I and 14% at site II and III. Considering the smaller number of seedlings used with 30 x 30 cm spacing (66) compared with control plots (Table 4), the difference in mean yield obtained seems considerably higher for SRI plots. So, in this study, lesser the number of seedlings used with wider spacing, higher is the yield obtained. With SRI methods, there is a potential to save seed use by about 78% (considering average use of 22.5 kg seeds per acre for conventional methods against maximum 5 kg seeds for SRI methods).

Table 4: Number of seedlings or hills in 6 m^2 crop-cut area.

Sl. No	Treatment	Seedling or hill in 6 m^2 crop-cut area
1	20 x 20 cm spacing, 3 - leaf stage	150
2	20 x 20 cm spacing, 4 - leaf stage	150
3	30 x 30 cm spacing, 3 - leaf stage	66
4	30 x 30 cm spacing, 4 - leaf stage	66
5	Control plot	> 200

Further, the estimated marginal means of yield with specific variety used in all the sites is highest for 30 x 30 cm spacing plot (Figure 3). This corresponds to the findings reported elsewhere which have shown that with SRI, optimally wider spacing gives better yield.

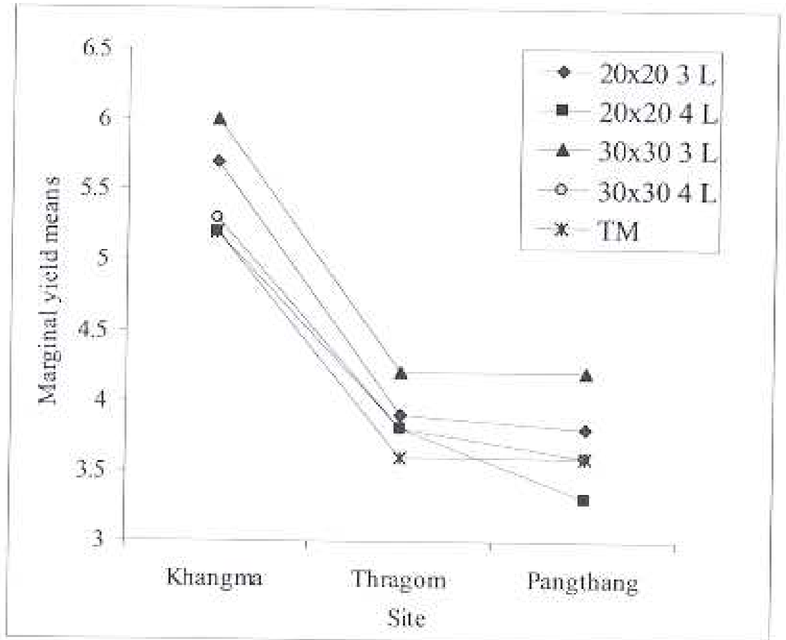

Figure 3: Estimated marginal means of yield in all the three sites.

The pair wise comparison between mean yields of the control and four treatments showed that there is a significance difference ($p<0.01$) in yield between 30 x 30 cm spacing (3 – leaf stage seedling) and control plot; 30 x 30 cm spacing (3 – leaf stage) and 20 x 20 cm spacing (3 - leaf stage) ($p<0.05$); 30 x 30 cm spacing (3 - leaf stage) and 20 x 20 cm spacing (4 - leaf stage) ($p<0.01$); 30 x 30 cm spacing (3 - leaf stage) and 30 x 30 cm spacing (4 - leaf stage) ($p<0.01$) at site I using Khangma map variety. Similar results were observed for other sites using specific variety.

Additionally, almost all the SRI plots had a large number of secondary tillers (more than in the control plots) with filled but some immature grains, which could have matured had the growth period been longer, which was not possible under the prevailing climatic conditions at this location. Further trials should be performed to assess the possibilities for proper growth of secondary tillers up to maturity using same variety at different locations with different management practices such as early sowing and transplanting, organic fertilization, and nursery beds.

CONCLUSION

The results of SRI study at Kanglung on yield and the yield contributing parameters showed a positive effect of SRI methods assessed in this study, as has been observed in many other countries. Higher mean yield of 6.0 ton/ha, above the nation's average yield of 2.9 ton/ha, was observed for Khangma maap variety at site I and 4.2 ton/ha with Paropa and Verna varieties at sites II and III respectively. Additionally, about 78% of seed use was saved compared to the conventional methods. From the SRI combination tested using seedling age and spacing, 30 x 30 cm spacing, 3 - leaf stage seedling provided better result. These SRI practices, diverging slightly from conventional practices, had a very clear impact on rice plant productivity and seed saving. There is a potential for subsistence farmers to eventually capitalize on higher yield with this SRI technique once skills are improved and recommended by research and extensions through further standard experimentation. These trials have already sparked some interest among farmers and researchers.

As reported in the June-December 2006 issue of the Himalayan Permaculture Group's *Newsletter and Progress Report*, a farmer working with the Group in the Humla region of Nepal was successful in using SRI methods at an elevation of 2500 masl. This further supports the proposition that SRI methods can be applied across a wide range of agro-climatic conditions. Further trials and demonstrations involving farmers and extension agents are required at various locations to demonstrate and consolidate the benefits of SRI technique, using recommended practices, under varied agro-ecological conditions comparing yields of SRI technique and conventional practices, thereby helping to build trust and confidence among farmers to adopt this methodology.

ACKNOWLEDGEMENT

The author wishes to acknowledge the help of Prof. Norman Uphoff, CIIFAD, Cornell University, Ithaca, New York, Dhan Bahadur Gurung, College of Natural Resources, Mamta Chhetri, RC Drala, Chukha, and many others for valuable inputs to this paper.

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