PERFORMANCE OF LANDRACE AND IMPROVED RICE VARIETIES UNDER THE SYSTEM OF RICE INTENSIFICATION MANAGEMENT IN BAJHANG DISTRICT OF NEPAL

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ABSTRACT

Participatory action research was conducted in Luinyata VDC of Bajhang district during main rice-growing season of 2012 to evaluate the effects of cultivation practices in rice varieties. The experiment was in factorial randomized complete block design, where two methods of cultivations: System of rice intensification (SRI) and conventional transplanting (CT) and 3 different varieties: Khumal-4, Thapachini and Hansaraj Basmati were evaluated. Data were collected on grain yield, number of tillers, panicle length and number of filled and unfilled grains per panicle. Results averaged across the three varieties showed significantly better crop performance with SRI practices: higher number of tillers per hill, panicles per hill, tillers per m2, panicles per m2, and grain yield. The values of these parameters comparing SRI with conventional practice were, respectively, 24.5 vs. 11.3, 21.5 vs. 9.5, 305 vs. 273, 273.5 vs. 233.8, and 7.6 vs. 4.46 tha-1. Among the varieties evaluated, the highest yield was achieved with the Thapachini (8.11tha-1) using SRI methods. Average yield increase across the three varieties with SRI practice was 70% compared CT. These results indicate the practical relevance of SRI principles for increasing rice production in mountainous regions of Nepal.

Key words: Grain yield, Landraces, Participatory Action Research, System of rice intensification (SRI).

INTRODUCTION

The System of Rice Intensification (SRI) is a set of ideas and insights that emphasizes the use of younger seedlings, 15-day old and individually planted with wide spacing, together with the adoption of intermittent irrigation, organic fertilization, and active soil aeration (Stoop et al., 2002; Uphoff, 2007). It is based on known scientific principles for enhancing the growth and performance of both plant roots and soil biota, to produce more healthy and productive plant phenotypes (phenomena) from any genotype (initial genetic potential) (Uphoff, 2012). It has emerged as a set of guiding principle that can help to produce higher yield through stronger and healthier plants establishment while building better soils and reducing reliance on external inputs. In dozens of countries, SRI

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techniques is found to be productive, resource-saving, and environmentally benign when compared to conventional rice production system (Namara et al., 2008; Sato and Uphoff 2007; Sinha and Talati, 2007).

In Nepal, SRI was initiated in 1999 in Khumaltar under a joint project of the Nepal Agricultural Research Council (NARC) and Cornell University. The National Wheat Research Program at Bhairahawa then conducted SRI trials in 2001 and 2002 to understand what was involved in this system(Neupane, 2003). Reports have indicated that SRI method of rice cultivation could have great scope for benefiting Nepali farmers if well understood and managed properly. Steps in this process are archived at. http://sri.ciifad.cornell.edu/countries/nepal/NepalArchives.html

An action-oriented research on SRI carried out by Khadka, (2010) in the low- plain (Tarai) area, gave yields on farmers' more than double what they produced with conventional transplanting methods (Khadka 2010).The SRI rice yields on farmers' fields, ranging from 6.0 to 8.4 t ha^{-1}, which is an increase of 48 to 153% over other methods of rice productions. With low cost of production, farmers' average net income from SRI was increased by 84%. A family of five with a rice area of just 0.15 ha could achieve annual food-grain security by getting a yield of 7 t ha^{-1} with SRI method (EU-FAO, 2012). These results sparked interest in what SRI management could accomplish under the multiple constrained conditions of Nepal's Far Western Region, where poverty and food insecurity are particularly entrenched.

It remained to be determined, however, how applicable SRI methods could be in the northern parts of the Far Western Region, with elevations up to 7,000 m, mostly poor soils, and short growing season. Bajhang district is one of the most economically-disadvantaged and geographically-remote districts of the country. Farming is conducted between 820 and 2457 m above sea level and usually on small landholdings, averaging just 0.37 ha (data from District Agricultural Development Office, Bajhang, 2011) as compared to national average land holding of 0.80 ha (CBS, 2010). A majority of the households grow rice for their food security using age-old practices. Accordingly, rice productivity in the district is very low, just 1.7 t ha^{-1} compared to average productivity in the Far Western Region of 2.5 t ha^{-1} and national rice productivity of 2.9 t ha^{-1} (CBS 2010).

Lack of appropriate improved varieties and little access to quality seeds, fertilizers and plant protection have been main factors behind low productivity of rice in the district. Under such circumstances, SRI could be an alternative option for small landholding farmers to increase their rice production from limited land area because it does not require them to purchase of external inputs. The experimental results reported here are based on participatory action research conducted to evaluate the performance of SRI vs. conventional practices under Bajhang condition, considering landraces and an improved variety of rice.

METHODOLOGY

The experiment was conducted in the main rice-growing season of 2012 (May to September) at Luinyata VDC of Bajhang on the fields of seven progressive farmers through participatory action research and demonstration. The same trials were conducted with 25 farmers in the VDC, as the main purpose was to have widespread demonstrations for farmers to see results for themselves. But data were collected from the fields of a smaller number of farmers (7 farmers) randomly selected for examination and comparisons.

The research site is located 1450 meters above mean sea level. Three rice varieties were used in the experiment, one improved (Khumal-4) and two landraces (Hansaraj Basmati, an aromatic rice with good export possibilities, and Thapachini, also very popular locally).

The factorial experiment was conducted using randomized complete block design where methods of cultivation were taken as the first factor and varieties as the second. Conducting the same experiments on individual farmers' fields provided replications relevant for statistical analysis. The size of the action research plots varied from 200 to 400 m^2 according to the size of the field that the respective farmers make available. In each farmer's fields, measurements were made from five randomly-selected 1 m^2 quadrates.

SRI practice consisted of : (a) single or at most two seedlings per hill; (b) 12-day-old seedlings;(c) plant spacing of 25- x 25-cm; (d) intermittent wetting and drying during the vegetative phase, with no standing water on the field, applying 3-cm irrigation after surface drying to keep the soil moist, and then 2–3 cm of standing water during the reproductive phase; (e) farmyard manure application at a rate of 3.2 t ha^{-1} along with chemical fertilizer (urea, diammonium phosphate, and muriate of potash) at respective rates of 30 kg N ha^{-1}, 30 kg P ha^{-1}, and 35 kg ha^{-1};and (f) two weedings by rotary weeders at 20 and 45 days after transplanting. P and K were applied at the time of final land preparation, while N was applied in three equal splits: 15, 45 and 55 days after transplanting.

Under the conventional method, 21-day-old seedlings were transplanted with three seedlings per hill at a spacing of 15-x10-cm, in the puddle field having 5–6 cm of pounded water. The water level was maintained 2–3 cm of standing water in the entire crop period however, it was drained 15 days before harvest. A single hand weeding was done at 25 DAT, with nutrient management the same as what was applied in SRI practices.

Data collection and analysis: Phenological data were gathered from five 1 m^2 areas randomly demarcated within each plot. Observation were madeontillers per hill, effective tillers (panicles) per hill, tillers per m^2, effective tillers per m^2, average panicle length, and number of filled and unfilled grains per panicle. For the measurement of yield, whole crop area was harvested, and yield was calculated afteradjusting grains at 14% moisture. Data analysis was done with

Microsoft Excel (2007) and MSTAT-C (1986). When significant differences were found after analysis of variance (ANOVA), means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSIONS

The results averaged across the three varieties showed that SRI practice significantly produced higher tillers per hill (24.5), panicles per hill (21.5), tillers per m^2 (305.19), panicles per m^2 (273.5) than conventional transplanting (Table 1). As expected (why such expectation), with conventional practice there were significantly higher numbers of hills $^{-2}$ compared to SRI (37.04 vs. 16.00). Despite the reduced number of plant population and wider spacing between plants with SRI practice, there were higher numbers of tillers m^{-2}. There was thus a significant SRI advantage on an area basis as well per hill. The percentage of effective tillers was higher with SRI method (87.9%) compared to conventional management (84.5%).

Table 1. Effect of method of cultivation on variety and tillers/hill and panicles/hill

Treatment	Tillers/hill	Panicles/hill	Hill /m^2	Tillers/ m^2	Panicles/ m^2
Methods of Cultivation					
SRI	24.52	21.55	16^b	305.19	273.52
Conventional	11.30	9.55	37.04^a	273.23	233.81
$F_{0.05}$	*	*	**	*	*
		Varieties			
Thapachini	18.57	15.77	25.79	338.40^a	295.30^a
Khumal-4	18.43	16.11	27.50	299.10^a	265.60^a
Hansraj Basmati	16.74	14.77	26.29	230.20^b	200.10^b
SEm±	0.49	0.54	0.89	8.47	8.03
LSD value $_{(0.05)}$	3.7	3.3	5.4	51.5	48.1
$F_{0.05}$	Ns	Ns	Ns	*	*
Interaction Effects (you just present factors interaction, this is not a good way to present interaction terms					
SRI×Thapachini	23.40^a	20.03^a	16.00^b	358.00^a	321.00^a
SRI×Khumal-4	26.54^a	23.00^a	16.00^b	312.00^{ab}	279.40^{ab}
SRI×Hansraj	23.63^a	21.63^a	16.00^b	245.60^{bc}	220.10^{bc}
Conventional ×Thapachini	13.74^b	11.51^b	35.57^a	318.70^a	269.60^{ab}
Conventional ×Khumar-4	10.31^b	9.22^b	39.00^a	286.10^{abc}	251.70^b
Conventional ×Hansraj	9.86^b	7.91^b	36.57^a	214.90^c	180.10^c
LSD value $_{(0.05)}$	5.2	4.7	7.7	72.9	69.2
SEm±	0.85	0.76	1.26	378.8	11.37
$F_{0.05}$	*	*	*	*	*

$^{\Psi}$Figures in column with the same letter are not significantly different (p = 0.05) according to DMRT, LSD = Least significance difference, SEM = Standard error of mean difference, * = significant (at p = 0.05), ** = highly significant (at p = 0.01), ns = not significant.

Comparing SRI with available best cultivation practices across varieties, there were 117% more tillers per hill and 126% more panicles per hill, while tillers per m^2 were increased by 12%, and panicles per m^2 by 17%. No significant differences were seen among the three varieties for numbers of tillers per hill and effective tillers per hill. Tillers m^{-2} and panicles m^{-2} were the highest with Thapachini (338 and 295), but this was not significantly different with of Khumal-4 (299 and 266). Hansaraj Basmati (230 and 200) was the lowest for these two parameters.

The highest number of tillers per hill was recorded in Thapachini variety cultivated through SRI method (23.4), whereas the highest number of effective tillers per hill was recorded in Khumal-4 under SRI practice (23.0), although this difference was not statistically significant with other varieties. The lowest value for both of these parameters (number of tillers per hill and effective tillers per hill) were recorded in Hansaraj Basmati cultivated with conventional method (9.85 and 7.91).

The highest percentage of effective tillers per hill was recorded in Hansaraj variety cultivated in SRI method (91.4%), followed by Khumal-4 (86.7%). The lowest percent was with Hansaraj Basmati when cultivated through conventional transplanting (80.2%). No significant difference in tillers m^{-2} was observed in interaction effects, but significantly more effective tillers m^{-2} were recorded in Thapachini when cultivated through SRI method (321), which was statistically on par with Khumal-4 under SRI cultivation (279). Significantly lower numbers of effective tillers m^{-2} were found with hansraj Basmati when it was cultivated with conventional transplanting (180).

The SRI effects on enhanced tillering are consistent with the findings of Udaykumar (2005), Vijayakumar et al. (2006) and Krishna et al. (2008), who documented higher tillering and greater yields under SRI management compared to conventional methods. The favorable effects of SRI management could be due to more efficient utilization of resources as a result of less inter-plant and intra-hill competition. SRI promotes more vigorous growth as seen from plant height, leaf area index, and dry matter production than the normal planting (Zhenget al. 2004). Rice plants grow more vigorously with SRI method and produce more tillers and leaves as well as roots, ensuring better resources utilization and resulting in higher grain production compared to conventional method.

The varietal responses to different methods of cultivation have been observed by different researchers in the past. Varieties which have high tillering ability perform better as compared to low-tillering varieties under SRI method, due to wider spacing (Sarath and Thilak 2004; Thakur et al. 2011b). Chapagain and Yamaji (2010) and Thakur et al. (2010a) have also reported that SRI management promotes better root growth, greater number of effective tillers per hill, longer panicles, and greater number of filled grains per panicle over conventional management.

Table 2. Effect of variety and method of cultivation in panicle length, filled grains per panicle, unfilled grains per panicles and total grains per panicle and panicle per m2

Treatments	Length of panicle, cm	Filled grains, n	Unfilled grains, n	Total Grains, n	Grain yield t ha-1
Methods of Cultivation					
SRI	28.43	184.21	13.90	195.72	7.60
Conventional	22.49	113.73	11.61	125.07	4.46
F0.05	*	*	Ns	**	**
Varieties					
Thapachini	24.97a	108.10c	4.92bc	113.10b	6.18a
Khumal-4	24.61a	206.90a	21.65a	226.97a	6.40a
Hansraj Basmati	26.81a	131.90b	11.68b	141.12b	5.51a
F0.05	Ns	*	*	**	**
SEm±	1.92	3.32	1.41	3.614	0.24
LSD value	11.69	20.24	8.59	64.94	1.47
Interaction Effects					
SRI×Thapachini	30.74a	135.90b	4.97c	140.65cd	8.11a
SRI×Khumar-4	26.09a	255.40a	23.11a	272.54a	7.87a
SRI×Hansraj	28.49a	161.30b	13.63abc	173.97bc	6.81ab
Conv.×Thapachini	19.20a	80.37c	4.88c	85.54e	4.25c
Conv.×Khumar-4	23.14a	158.4b	20.20ab	181.40b	4.93bc
Conv.×Hansraj	25.14a	102.40c	9.74bc	108.28de	4.21c
F0.05	Ns	*	*	**	*
SEm±	2.71	4.70	1.99	6.268	0.34
LSD value	16.53	28.62	12.15	38.09	2.08

ΨFigures in column with the same letter are not significantly different (p = 0.05) according to DMRT, LSD = Least significance difference, SEM = Standard error of mean difference, * = significant (at p = 0.05), ** = highly significant (at p = 0.01), ns = not significant.

The panicle length, number of filled grains per panicle, and total number of grains per panicle were all found to be significantly higher with SRI technique (28.4 cm, 184.2 and 195.7) compared to conventional method of transplanting (22.5 cm, 113.7 and125.1). However the number of unfilled grains was not significantly different between the two methods of cultivation. No effect of cultivation practices were observed in number of filled and unfilled grains.

Among the tested varieties the number of filled grains, unfilled grains, and total number of grains was the highest with the improved variety Khumal-4 (206.9, 21.6 and 227.0, respectively) and the lowest with Thapachini (108.1, 4.9 and 113.1, respectively). No significant differences in panicle length were recorded among the tested varieties.

In terms of interaction effects between cultivation method and varieties, the highest numbers of filled grains, unfilled grains and total numbers of grains were recorded on Khumal-4 variety when cultivated with SRI methods (255.4, 23.1, 272.5, respectively), whereas all these parameter were the lowest in Thapachini when cultivated through conventional method (80.4, 4.9, 85.5), practically on par with Hansraj Basmati when similarly cultivated (Table 2).

Significantly higher grain yield was obtained from SRI method (7.6 t ha^{-1}) as compared to conventional transplanting (4.46 t ha^{-1}), which is 70% more yield from SRI than conventional transplanting. However, no significant difference in grain yield was seen between SRI and conventional management among the three varieties tested when their yields were averaged.

Considering average grain yield for the two management systems, the highest yield was recorded in Khumal-4 (6.4 t ha^{-1}) and the lowest was with Hansraj Basmati (5.5 t ha^{-1}), with Thapachina in between (6.2 t ha^{-1}). Khumal-4, developed from crossing IR28 and Pokhreli Mashino, was released in 1987 for warm temperate ecological domains in Nepal (Gautam and Shrestha, 2012). NARC has reported that the yield potential of this variety is 6.3 t ha^{-1} under optimum condition, but with SRI management it produces 25% more (7.87 t ha^{-1}).

In terms of interaction effects between method of cultivation and varieties, the highest grain yield was produced by Thapachini grown under SRI method (8.11 t ha^{-1}), followed by Khumal-4 (7.87 t ha^{-1}) and then Hansraj Basmati (6.81 t ha^{-1}). Grain yield with SRI method was increased over conventional transplanting by 91% for Thapachini, by 60% for Khumal-4, and by 62% for Hansraj Basmati.

The lowest grain yield per hectare was recorded with Hansraj Basmati under conventional transplanting (4.21 t ha^{-1}). However, this yield was not, statistically speaking, significantly lower than from Thapachini and Khumal-4 varieties when these were cultivated with conventional method.

The trials indicated that there is considerable unexploited yield potentiality of Hansraj Basmati as the production from this landrace can be significantly increased by using SRI principles. This variety is a fine, aromatic rice very popular in the locality due to its unique flavor and aroma, marketed under the brand name of Jorayal Basmati. This is one of the most demanded and unique varieties of rice in Nepal, not produced elsewhere.

In the past in Kailali district, significantly higher grain yield had been achieved from various varieties when grown with SRI practices (Dahal and Khadka, 2012). Farmers' field trials conducted with six improved varieties (Sarju-52, Sunaulo Suganandha, Radha-4, Jaya, Mithila and Sabitri) showed yield, respectively, 114%, 109%, 116%, 114% and 89% higher with SRI management than with conventional transplanting (Khadka and Dahal 2013).

Kumar et al. (2005) had previously observed in India that hybrids such as KRH2, HRI 126, PHB-71 and DRRH2 performed better, with a 40-42% yield advantage, under SRI management A number of other reports on SRI performance have showed similar increments in rice yield (Ceesay et al. 2006; Kabir and Uphoff 2007; Namara et al. 2008; Satyanarayana et al. 2007; Sato and Uphoff 2007; Senthilkumar et al. 2008; Sinha and Talati 2007;Zhao et al. 2009). Thakur et al.

(2010b) documented 42% increase in grain yield with SRI management practice, from 4.49 t ha^{-1} to 6.38 t ha^{-1}, as compared to conventional transplanting, while reductions were made in both seeds and water.

Young, single seedling per hill has been shown to produce more dry matter and higher grain yield in part as a result of their more open canopy structure which enhances light interception concurrent with root growth, slower leaf senescence, and greater photosynthesis during the ripening stage as compared with conventional transplanting practice (Thakur et al. 2010a). Wider spacing with SRI helps to slow the natural decrease in rice plant leaves' chlorophyll content, in their fluorescence, and in the rate of photosynthesis during later stages of ripening, and all this contributes to greater dry matter production of individual hills (San-oh et al. 2004).

Similarly, SRI water management, keeping soil mostly aerobic by wetting and drying, also helps in improving root systems. Continuous flooding creating anaerobic soil conditions causes degeneration of rice plants' roots (Kar et al. 1974). Use of a rotary weeder contributes for active aeration of the top soil and thereby enhances root system growth; simultaneously the weeder incorporates weed biomass into soil, further enhancing soil fertility. As a convergent effect of all these practices, SRI management increases the yield and yield-contributing characteristics in rice.

CONCLUSIONS

The yield of a very popular indigenous rice variety Hansraj Basmati was increased by 62% with SRI management practice over conventional transplanting method. Another favored local variety Thapachini had its yield increment by 91% with SRIThe yield of an improved variety Khumal-4 was raised by 60%, a non-trivial increase.

These results indicate that improving the food security of small landholding households in the Far West Nepal, quickly and at low cost, is very feasible even in remote areas such as Bajhang district, where poverty and hunger are major issues. It can be concluded that SRI method is similarly applicable in remote, high-altitude rice fields as in the more favorable lowlands of the Tarai. The method is beneficial for both local and improved varieties.

The scope for utilizing SRI technique may be greater in remote districts of Nepal where transportation facilities and access to inputs like improved seed and chemical fertilizers are greatly constrained, and where food needs and food insecurity are the greatest. As there is high demand for fine, aromatic rice in local as well as overseas markets, if surplus rice production can be achieved with SRI management, there could be a positive impact on reducing poverty as well as on food insecurity by utilizing Nepal's cache of rice biodiversity together with SRI management practice.

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