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Performance of Rice with Varied Age of Seedlings and Planting Geometry under System of Rice Intensification (SRI) in Farmer's Field in Western Terai, Nepal

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Abstract

Numbers of on-farm experiments were conducted to assess the performance of rice (var. *Sabitri*) cultivated using System of Rice Intensification (SRI) with varied age of seedlings and planting geometry in four VDCs of Kailali, far western Nepal, under the aegis of Farmers' Field School (FFS) during the rainy season of 2010. The experiment consisted of the seedlings of four age groups; 8, 15, 22 and 29-days and four planting geometry; 15x15cm^2, 20x20cm^2, 25x25cm^2 and 30x30 cm^2 planted in four FFSs. Parameters such as number of tillers per hill, effective tillers /m^2, 1000 seed weight (TGW) and grain yield were recorded. The results showed that 8-days-old seedlings produced significantly higher number of tillers per hill (40) and effective tiller per m^2 (373), higher 1000 seed weight (21.10 g), grain yield (7.8ton/ha), net return (Rs.71900/ha) and B:C ratio (1.594). Similarly, crop planted in the geometry of 25x25 cm^2 produced significantly higher number of tillers per hill(36), effective tiller per m^2 (328), higher 1000 grain weight (21.50 g), grain yield (8.54mt/ha), net return (Rs.83350/ha) and B:C ratio (1.84).

Key words: farmers field school, western Terai, grain yield, B : C ratio, tillers/ m^2

Introduction

Rice (*Oryza sativa* L. var. *Indica*) is the most important cereal crop in agriculture and economy of Nepal. It shares about 20% to the agricultural gross domestic product (AGDP) and accounts about 53% of the total food grain production and covering more than 50% of the agricultural land area (NARC 2007). Rice is grown in 1.55 million ha of cultivable land with 71% in Terai and 24.9% in Inner-Terai, and 4.1% in Hills and Mountains (MOAC 2008) amounting 4.30 million ton of rice grain with an average productivity of 2.9 t ha^{-1} (FAO 2010). It is the main diet of Nepalese people and meets more than 50% of their total calorific requirements (NARC 2007). Rice is considered to be on the front line to fight against the world's hunger and poverty and it is pertinent in case of Nepal as well. Increasing rice production can solve the country's food problem and save millions of Rupees now spent by the Government every year for importing food grains. Productivity of rice in Nepal is very low 2.9 mt/ha, as compared to the neighboring country (India 3.1 mt ha^{-1}) and the world 4.1 mt ha^{-1} (FAO 2010). This indicates an urgent need to increase the productivity and the production of rice to feed the population.

Recently, a new approach, widely known as system of rice intensification (SRI), has attracted attention of scientists as well of farmers because of its success in increasing rice yield. The performance of SRI raises the hope among policy makers, development workers and farmers for solving the problems of low productivity and to enhance food security in remote areas where modern inputs are costly and not easily available. Claims have been made that SRI method of rice cultivation could produce 15–20 mt ha^{-1} (Uphoff 2002). SRI is a civil society innovation which occurred outside the formal research system, that was first developed accidentally in Madagascar by Father Henri de Laulanié, who combined field observations of rice plant performance with a series of experiments over a decade (Laulanié 1993). The new set of practices greatly improved the growing environment for rice plants, evoking more productive phenotypes from all rice genotypes on which the practices were used. The five major components of the SRI are: (1) the use of young seedlings at the two-leaf stage (8–15 days with one seedling per hill), (2) wide plant spacing of 25 cm x 25 cm to as much as 50 cm - 50 cm, (3) use of rotator weeder, (4) the addition of organic matter (manure and/or compost) to supply adequate nutrients, and (5) intermittent drainage and dryingof soil for it's aeration during the vegetative stage (Stoop *et al.* 2002). However, these claims have recently been questioned in general by some of the scientists (Dobermann 2003, Sheehy *et al.* 2004). In this context, the study of the performance of different components of SRI in increasing productivity of rice in wide range of environment seems imperative. Far-western Nepal is one of the poorest development regions of Nepal where no or few agricultural research works have been undertaken. Therefore, on-farm experiments were conducted at four farmers' field schools in Kailali district, Nepal during 2010 rainy season for evaluating the performance of rice using the seedlings of different ages with varied planting geometry under the SRI.

Methodology

Experiments were conducted at farmers' field schools namely Khailad, Lalbojhi, Ramsikhrajhala and Pahalmanpur villages with clay loam soil (pH 6.4) in Kailali district during the 2010 rainy season (June–September) following the principles of SRI using randomized complete block design taking individual farmer's field school as replications. Farm yard manure @1.5 mt ha^{-1} along with chemical fertilizers (urea, diamonium pospahte and Murate of potash) to supply NPK@ 60:40:40 kg/ha^{-1},and zinc sulfate @ 8 kg Zn /ha for Zn supplement were applied. Seedlings of 8, 15, 22 and 29- days old were planted with four spacing, 15x15, 20x20, 25x25 and 30x30 cm. Each individual plot had the size of 4 m x 3 m^2. Water management was done as per the SRI principle: intermittent wetting and drying during the vegetative phase. The plots received 3 cm of irrigation water to keep the soil moist followed by surface drying throughout the vegetative phase and 2–3 cm of standing water during the reproductive phase. Data on number of tillers per hill, effective tillers per m^2, 1000 seed weight (TGW) and grain yield were recorded from five hills randomly selected from each plot before harvesting. For the measurement of grain yield, an area of 10 m^2 was taken from inside the plot, excluding the border rows, as net harvest plot. After the harvest the crop was sun dried for four days, threshed with wooden stick and cleaned. The grains were weighed and recorded after adjusting to 14% moisture level. All the inputs and their costs were recorded during the growing season and an economic analysis was also done. The data were analyzed using statistical package MSTATC and mean separation was done by Duncan's multiple range test (DMRT).

Results and Discussion

Yield and yield attributes as affected by the spacing

Analyzed data (Table 1) showed that the number of tillers per hill was highest in the plots planted with 30x30 cm spacing which was at par with that obtained in 25x 25cm spacing, which was significantly different from the rest of the treatments. In contrast, significantly higher number of effective tillers/m^2 was obtained in 25x25cm^2 spacing, whereas 30x30 cm^2 spacing produced the lowest (253.00) number of effective tiller . The result corroborates with the finding of Uphoff and Fernandes (2002) who found significantly higher number of effective tillers/m^2 in 25x25cm spacing and advised the farmers to use this spacing for higher yield. Menete *et al*. (2008) reported that wider plant spacing (0.3 m) in SRI decreased grain yields by 11.5% (6.2–5.5 t/ha) than at closer spacing (0.2 m) and added that increasing plant spacing readily results in decreased yields, although rice plants can compensate to a considerable extent by increasing per plant productivity. Still, a factor increase in plant spacing results in a square factor decrease in plant density, and therefore necessitates very high gains in per plant productivity. Similarly, significantly higher 1000 seed weight was obtained from the same spacing although it was only different from 15x15cm spacing, and at par with the other spacing treatments. In the same way, significantly higher grain yield (8.54 t ha^{-1}) was obtained in spacing 25x 25 cm. The optimum level of plant population coupled with better yield parameters might have resulted in higher seed yield/ha under 25 x 25 cm spacing. Karki *et.al*. (2009) also has similar finding.

Table 1. Yield and yield attributing characters of rice crop as affected by the planting geometry in Kailali, 2010

Spacing	Tiller per hill	Effective tiller per m^2	Thousand grain weight TGW (g)	Yield (MT/ha)
15x15	12.00 ^{c}	277.00 ^{c}	20.10 ^{b}	6.00^{c}
20x20	22.00 ^{b}	286.00^{b}	20.50^{ab}	6.84^{b}
25x25	36.00 ^{a}	328.00^{a}	21.50^{a}	8.54^{a}
30x30	38.00 ^{a}	253.00 ^{d}	21.20 ^{a}	6.55^{b}
LSD value	3.06	8.24	0.76	0.51
s	1.01	2.73	0.25	0.17

Yield and yield attributing characters of rice as affected by the age of seedlings

The analyzed data showed that significantly higher grain yield (7.8 mt ha^{-1}) was obtained from the treatment planted with 8-days-old seedlings and lowest yield (6.3 mt h^{-1}) was in 29-days-old seedlings, which, however, was not significantly different from the treatment with 22-days-old seedlings. Similarly tiller per hill, effective tiller per m^2 were also significantly higher in 8-days -old seedling than the rest, and the value was lowest in 29-days-old seedlings. However, no significant difference among the treatments was observed in TGW (Table 2).

Table 2. Yield and yield attributing characters of rice as affected by the age of seedlings in Kailali, 2010

Age of the seedlings (day)	Tiller per hill	Effective tiller per m^2	TGW (g)	Yield (mt/ha)
8	40.00^{a}	373.00^{a}	21.10^{a}	7.80^{a}
15	34.00^{b}	346.60^{b}	20.80^{a}	7.40^{a}
22	10.00^{c}	123.00^{c}	21.05^{a}	6.50^{b}
29	8.00^{c}	93.60^{d}	21.00^{a}	6.30^{b}
LSD value	2.94**	13.32**	1.06	0.78**
s	0.975	4.41	0.35	0.25

Columns represented with same letter (s) are not significantly different among each other at 5% level of significance.

The findings were in conformity with the results of Krishna and Biradarpatil (2009), who also found seedling age and plating pattern significantly affecting the yield and yield attributing parameters. Similar findings are reported by (Singh *et al*. 2004) in which seedling age was known to influence the grain yield. Further, Pasuquin *et al*. (2008) reported that transplanting of young seedlings generated higher crop performance than transplanting old seedlings in SRI system. McHugh (2002) has reported that 8 to 15 days- old-seedlings transplanted produced the highest yield in Madagaskar, whereas in Sumatra the highest yields were obtained with 10-days -old seedlings. In north Sumatra, a crop planted with 15-days-old seedlings out yielded the 21- days- old one (Makarin *et al*. 2002). There were indications that the longer stay of seedlings in the nursery may have affected seedling growth pattern due to high seedling competition (Mandel *et al*. 1984).

Transplanting rice seedlings gives more yields at younger stage has been supported by many researchers (Ota 1975, Yamamoto *et al*. 1995, Horie *et al*. 2005). This practice captures the benefit of the early phyllochron stages (less than four leaves) having higher potential to produce more tillers per plant (Katayama 1951). SRI methods give highest yield when young seedlings are transplanted, less than 15- days-old and preferably only 8–12 days, i.e., before the start of the fourth phyllochron (Stoop *et al*. 2002). This preserves plants' potential for tillering and root growth that is compromised by later transplanting (Uphoff 2001, Randriamiharisoa & Uphoff 2002, Horie *et al*. 2005). In general, uprooting causes stress to the seedling which could be minimized when the endosperm remains attached (Sakai & Yosida 1957, Ota 1975). In conventional management, it has been reported that around 40-60% of the roots remain in the soil during pulling up from the nursery. Pruning of up to 60% of the seedling' roots during transplanting significantly decreased subsequent root and shoot dry matter accumulation (Ros *et al*. 1998). Therefore, it may be suggested that SRI practices lead to increased shoot and root dry matter accumulation by not disturbing the root system during transplanting.

Economic analysis

Gross return

The gross return per hectare was significantly affected by the age of seedlings. The analyzed data (Table 3) showed that the gross return among the treatments ranged from Rs 90.00 to 128.10 thousands/ha. The highest value (Rs. 117.60 thousands/ha) was obtained from the treatment with 8 –days-young seedlings, which was at par with the treatment where 15-days-old seedlings were planted, and significantly differed from the rest of the treatments. Likewise, the treatment with 29- days of seedlings produced the lowest gross return (Rs. 94.20 thousand/ha).

Table 3. Cost of cultivation, gross return, net return and B:C ratio of rice crop as affected by the age of seedlings in Kailali, 2010

Age of seedling (days)	Economic analysis			
	Cost of cultivation (Rs/ha ('000)	Gross return Rs/ha ('000)	Net return Rs/ha ('000)	B:C ratio
8	45.10	117.0[a]	71.90[a]	1.594[a]
15	45.10	111.0[a]	65.90[a]	1.461[a]
22	45.10	97.50 [b]	52.40[b]	1.162[b]
29	45.10	94.50[b]	49.40[b]	1.095[b]
LSD		11.70*	11.70*	0.26*
SEM ±		3.88	3.88	0.08

Columns represented with same letter (s) are not significantly different among each other at 5% level of significance

The higher gross return was obviously due to higher grain yield/ha in case of the treatment with 8-days-old and 15-days-old seedlings.

Similarly, it was observed that the effect of crop geometry on gross return was highly significant (table 4). Highest gross return (Rs. 128 thousands/ha) was obtained from the treatment with 25 cm × 25 cm geometry, which differed significantly from rest of the treatments. The treatments with 20 cm × 20 cm and 30 cm × 30 cm geometry produced the gross return statistically at par with each other. The lowest gross return (Rs. 90 thousands/ha) was obtained from 15 x 15 cm geometry, which was significantly different from all of the treatments. The highest gross returns in 25 cm × 25 cm geometry is also due to the highest yield/ ha in 25 cm × 25 cm geometry.

Table 4. Cost of cultivation, net returns and B:C ratio in rice farming as affected by the planting geometry in Kailali, 2010

Planting geometry (cm^2)	Economic analysis			
	Cost of cultivation (RS/ha ('000)	Gross return Rs/ha ('000)	Net return Rs./ha ('000)	B:C ratio
15x15	46.000	90.00[c]	59.71[c]	0.95[c]
20x20	45.000	102.60[b]	55.10[b]	1.28[b]
25x25	45.100	128.10[a]	83.35[a]	1.84[a]
30x30	44.000	98.25[b]	54.25[b]	1.23[b]
LSD		7.69*	7.69*	0.08*
SEM ±		2.55	2.55	0.02

Columns represented with same letter (s) are not significantly different among each other at 5% level of significance

The highest cost of cultivation was in 15x15 cm spacing (Rs 46,000 thousand/hac) and lowest in 30x30 cm (Rs 44,000 per hac.) however which is not significantly different. The highest cost of cultivation in 15x15 cm was due to the more labour requirement in transplanting since it required more number of seedlings and more number of transplanting rows and column in the field as compared to 30x30 cm^2.

The cost of cultivation was not different in age of seedlings (Rs 45100 per ha). This may be due to the same types of cultivation practices and no need of extra fertilizer, irrigation and plant protection measure due to the regular rainfall during seedling stage in 8 days and 29 days old seedlings.

Net return

The net return per hectare was significantly influenced by the planting geometry. The analyzed data (Table 3) showed that the highest net return (Rs 71.90 thousands/ha) was obtained from the treatment with 8-days of young seedlings, which was at par with the value (65.90 thousand/ha) obtained from 15-days old seedlings but differed significantly from that of the treatment with 22-days of seedlings (52.40 thousand/ ha) and 29-days of seedlings (49.40 thousand/ha). Higher net return per hectare in 8-days –old seedlings was due to higher grain yield.

Similarly, it was observed that the factor crop geometry significantly affected the net return among the treatments as well. The highest net return (83.35 thousands/ha) was obtained from the treatment with 25 cm × 25 cm which was significantly different from all the treatments. However, the treatments with 20 cm×20 cm and 30 cm × 30 cm spacing were statistically at par with each other. The lowest value (Rs.59.71 thousand/ha) was obtained from the narrower spacing that is 15 x 15 cm^2, which shows bad performance of SRI with close planting.

Benefit cost ratio

Benefit cost ratio is the ratio of gross returns to cost of cultivation which can also be expressed as return per rupee invested. Any value greater than 2.0 is considered safe as the farmers get Rs. 2.00 for every rupee invested (Reddy & Reddi 2002). On the other hand, minimum BC ratio of 1.5 for the agricultural sector has been fixed for any enterprises to be economically viable. Therefore, any crop enterprises must maintain at least the BC ratio of 1.5 to be economically sustainable (Bhandari 1993).

The analyzed data revealed that B:C ratio (BCR) was significantly influenced by age of seedlings and crop geometry (Table 3 & 4). The average benefit cost ratio ranged from 0.95 to 1.28. The highest BCR was observed in 8 days old seedlings (1.54), which was at par with 15 days old seedlings but different from 20 and 29- days- old seedlings respectively. The later two were not significantly different from each other. Significantly higher B:C in 8-days-old seedlings was due to high yield which ultimately caused both the high gross and net return per hectare .

Similarly, it was observed that the factor crop geometry was also highly significant to influence B:C ratio among the treatments. Significantly higher B:C ratio (1.84) was obtained from 25 cm × 25 cm crop geometry as compared to 20 cm×20 cm (1.28) and 30 cm × 30 cm (1.23). Higher B:C ratio in 25 cm × 25 cm was due to higher yield in this treatment. Thus, it is clear from the present investigation that, 8-days -old seedling with 25 x 25 cm spacing resulted in higher benefit cost ratio showing the economic efficiency of the treatment.

With the data from one season experiment on rice conducted in farmer’s field it can be concluded that younger seedlings aged 8-days, and transplanted in 25 cm × 25 cm geometry using SRI technique gave robust production of grain yield with good economic return. This technique can be extended to a larger rice growing area consisting of small landholding farmers and thereby increase rice production, and ultimately contribute to national food security.

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