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RESEARCH REVIEW

OPTIMIZING RICE YIELDS: INFLUENCE OF SEEDLING AGE AND CROP SPACING IN SRI

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ABSTRACT

This study evaluates the impact of seedling age and crop spacing in the System of Rice Intensification (SRI) on rice yields in Nepal. Given the country's dependency on rice, optimizing SRI techniques is crucial for higher productivity. Late planting of older seedlings and narrow spacing are key challenges leading to reduced rice production, resulting in higher imports. SRI offers a sustainable solution. The research focuses on seedling age and crop layout as critical factors for yield and economic returns within the SRI framework. Conducted in Sharadanagar Chitwan, Nepal, the study employed a randomized complete block design, testing seedling ages (8, 15, 22, and 29 days) and crop arrangements (20×20, 25×25, and 30×30 cm^2). Findings emphasize the benefits of early transplantation of younger seedlings (around 15 days old) and wider spacing (25×25 cm) for superior vegetative growth, productive tillers, and overall grain yield. The study highlights the importance of optimizing seedling age and crop layout for enhanced rice cultivation, suggesting that younger seedlings and appropriate spacing under the SRI model can significantly improve both vegetative and reproductive growth, thereby increasing grain yield and economic benefits. Implementing these refined parameters can strengthen Nepal's agricultural resilience, enhance food security, and reduce rice imports.

KEYWORDS

System of Rice Intensification, Seedling Age, Crop Spacing, Economic Returns, Agriculture Resilience.

1. INTRODUCTION

The prevalence of malnutrition and other diseases in developing Rice (*Oryza sativa L.*) is a staple in Nepal, integral to food security, nutrition, employment, and the economy. It constitutes 67% of cereal consumption and 23% of protein intake, contributing 20% to the Agricultural Gross Domestic Product (AGDP) and 7% to the overall GDP (Gauchan et al., 2022; MoALD 2020). In 2019, rice cultivation covered 1.49 million hectares with an average yield of 3.76 metric tons per hectare (MoALD 2019). Rice is grown across diverse agroclimatic regions, from the lowland terai plains to high hills, adapting to various topographies and climates (NARC, 2007). Despite its significance, domestic rice production has not met the increasing demand, leading to more imports (Tripathi et al., 2018). Achieving rice self-sufficiency is crucial for national food security and reducing import reliance (Bishwajit et al., 2013; Arnon, 1972). Late transplanting of older seedlings with narrow spacing has hindered rice production in many areas (Dhital and Thakur, 1995). SRI offers a promising alternative, enhancing productivity and aligning with sustainability goals like water conservation, soil health, and reduced methane emissions (Shamshiri et al., 2018; Faruk et al., 2009). Within SRI, seedling age and crop geometry are key determinants of yield and economic returns. Early transplanting of young seedlings maximizes tillering potential by transplanting before the fourth phyllochron begins (Dwipa et al., 2018). This strategic approach promotes higher tiller numbers during early growth phases. The study assesses the effects of seedling age and crop spacing on rice yield and economic returns under SRI (Gani et al., 2002; Jayawardena and Abeysekera, 2002; Krishna, 2000).

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment took place during the rainy season at a farmers' field in Sharadanagar, near the Institute of Agriculture and Animal Science (IAAS) in Rampur, Chitwan. The soil had a sandy loam texture and was moderately acidic.

2.2 Experimental Design

The study used a two-factor Randomized Complete Block Design (RCBD) with three replications and twelve treatments. Treatments included varying seedling ages (8, 15, 22, and 29 days) and crop geometries (20×20 cm^2, 25×25 cm^2, and 30×30 cm^2).

2.3 Experimental Area

The experimental area covered 914.5 m^2 (15.5 m x 59 m). Each plot measured 18 m^2 (6 m x 3 m), with net plot sizes for harvesting at 8.4 m^2 for 20×20 cm^2, 9 m^2 for 25×25 cm^2, and 9 m^2 for 30×30 cm^2. Plots were spaced 1 m apart.

2.4 Planting Material

The rice variety 'Ramdhan', with an average yield potential of 4.845 t/ha, was chosen for cultivation. Released by NARC in 2006, this variety was suited for upland conditions.

2.5 Seedling Preparation

Four raised dry nursery beds were prepared for seedlings of different ages on various dates. Seeds were soaked for 14 hours and incubated in a moist gunny bag for 34 hours. Pre-germinated seeds were broadcasted on nursery beds and covered with a thin soil-vermicompost layer (Krishna and Biradarpatil, 2009; Makarim et al., 2002). Beds received daily irrigation. Before lifting, the nursery beds were thoroughly irrigated.

2.6 Transplantation

Single seedlings were transplanted per hill, with different ages (8, 15, 22, and 29 days) and spacings (20×20 cm, 25×25 cm, and 30×30 cm) in a square pattern. Transplanting occurred on June 28, 2008, following government guidelines. Gap filling was done a week after transplanting. Conventional land preparation was performed using a tractor.

2.7 Manure and Fertilizer Application

Farmyard manure was applied at 6 t/ha, and chemical fertilizer at 50:45:45 kg NPK/ha was used during final land preparation. The remaining half was split and applied at the tillering and panicle initiation stages (Manomani and Jacqulin, 1995). Zinc sulfate was applied at 20 kg/ha during transplanting to address zinc deficiency.

2.8 Weeding and Irrigation

Weeding was conducted thrice at 15, 30, and 45-day intervals. Water was applied to maintain soil moisture without saturation, with periodic drying periods during the growing phase (McHugh, 2002). After tillering, standing water at 2.5 cm height was maintained.

2.9 Harvesting and Yield Estimation

Crops were harvested following traditional practices, with yield estimated at 12% moisture. Vegetative and reproductive parameters were recorded, and economic analysis conducted.

2.10 Data Analysis

Data were compiled using the MSTATC package, with means separated by Duncan's Multiple Range Test (DMRT). SPSS was used for regression analysis, and ANOVA tested significance at a 5% level.

3. Results and Discussion

3.1 Vegetative growth influence in SRI cultivation

Plant height was not significantly affected by seedling age and crop spacing. However, younger seedlings (8 and 15 days) attained higher plant heights (99.45 cm and 98.33 cm, respectively). Wider spacing (30×30 cm^2) also resulted in higher plant height (99.04 cm), possibly due to less competition for nutrients and light (Singh, 2004; Uphoff, 2000; Uphoff and Fernandes, 2002; Watson, 1947). Significant differences were observed in tiller numbers, with 15-day seedlings producing the highest tillers per plant (38.11), followed by 8-day seedlings (32.27) (Menete et al., 2008). The wider spacing of 25×25 cm^2 produced the highest tillers per plant (32.48).

15-day seedlings and 25×25 cm^2 spacing yielded the highest LAI (2.76 and 2.78, respectively), attributed to higher tiller and leaf numbers. Dry matter production was highest in 15-day seedlings (177.60 g) and 25×25 cm^2 spacing (149.10 g), indicating better resource utilization.

Table 1: Effect of Seedling Age and Crop Spacing on Vegetative Characters of Rice under SRI

Treatments	Plant height (cm)	Number of tillers/plant	Number of leaves/plant	Leaf area index (LAI)	Dry matter production/plant
Age of seedlings					
8 days seedlings	99.45	32.27^b	125.00	2.16^b	141.30^b
15 days seedlings	98.33	38.11^a	134.10	2.76^a	177.60^a
22 days seedlings	94.05	27.89^c	119.60	1.92^b	123.60^c
29 days seedlings	95.57	23.29^d	114.80	2.04^b	107.90^d
CD (P = 0.05)	**NS**	**2.931**	**NS**	**0.2713**	**14.44**
Sem ±	**1.685**	**0.9993**	**4.769**	**0.09250**	**4.924**
Spacing					
20 cm × 20 cm	94.74	30.60^{ab}	123.80	2.49^b	136.40^b
25 cm × 25 cm	96.78	32.48^a	127.50	2.78^a	149.10^a
30 cm × 30 cm	99.04	28.08^b	118.80	1.41^c	127.40^b
CD (P = 0.05)	NS	2.538	NS	0.2349	12.51
Sem ±	**1.459**	**0.8654**	**4.130**	**0.08010**	**4.265**
CV %	**5.22**	**9.86**	**11.59**	**12.45**	**10.73**
Grand mean	**96.85**	**30.39**	**123.39**	**2.22**	**137.63**

Figures in the same column followed by same letter (s) are not significantly at P<0.05 by DMRT

3.2 Grain Yield Dynamics: Seedling Age and Crop Spacing

Effective tillers per m^2 were highest in 15-day seedlings (264.90) and 25×25 cm^2 spacing (266.10). The highest number of grains per panicle was also observed in 15-day seedlings (149.30) and 25×25 cm^2 spacing (140.10). These parameters influenced grain yield significantly.

15-day seedlings and 25×25 cm^2 spacing produced the highest grain yield (5.03 t/ha and 4.89 t/ha, respectively), indicating their suitability for SRI. Straw yield was also highest in these treatments (5.13 t/ha and 5.05 t/ha), reflecting balanced vegetative and reproductive growth (Nandisha and Mahadevappa, 1984). The harvest index was highest in 15-day seedlings (49.50%) and 25×25 cm^2 spacing (49.21%), underscoring efficient resource allocation for grain production.

Table 2: Effect of Seedling Age and Crop Spacing on Reproductive and Grain Yield Characteristics of Rice under SRI

Treatment	Effective tillers m^{-2}	Number of grains/ panicle	Sterility (%)	1000 grain wt(gm)	Grain yield (t/ha	Straw yield (t/ha)	Harvest index (%)
Age of seedlings							
8 days seedlings	261.00^a	142.4^b	11.80	22.48	6.08^b	6.43^b	48.53^a
15 days seedlings	264.90^a	157.7^a	11.30	22.84	6.59^a	7.05^a	48.50^a
22 days seedlings	243.60^{ab}	129.0^c	11.96	22.06	5.55^c	6.01^{bc}	47.75^a
29 days seedlings	217.70^b	116.5^d	12.13	21.93	4.42^d	5.74^c	42.54^b
CD (P = 0.05)	27.18	11.79	NS	NS	0.4648	0.5061	2.376
Sem ±	9.267	4.021	1.080	0.3221	0.1585	0.1726	0.8101
Spacing (cm^2)							
20 cm × 20 cm	263.80^a	135.8^b	11.98	22.56	5.57^b	6.33^{ab}	46.08

Table 2 (cont): Effect of Seedling Age and Crop Spacing on Reproductive and Grain Yield Characteristics of Rice under SRI

25 cm × 25 cm	266.10[a]	147.5[a]	10.36	22.35	6.04[a]	6.58[a]	47.66
30 cm × 30 cm	210.60[b]	125.9[b]	13.06	22.07	5.37[b]	6.02[b]	46.73
CD (P = 0.05)	23.54	10.21	NS	NS	0.4025	0.4383	NS
Sem ±	8.026	3.482	0.9351	0.2790	0.1372	0.1494	0.7015
CV %	11.27	8.84	27.45	4.33	8.41	8.20	5.19
Grand mean	246.79	136.41	11.80	22.33	5.66	6.31	46.83

Figures in the same column followed by same letter (s) are not significantly at P<0.05 by DMRT

3.3 Economic Viability: Analyzing Returns in SRI

Net returns were highest for 15-day seedlings (NRs. 36,900/ha) and 25×25 cm^2 spacing (NRs. 35,400/ha), indicating better profitability (Pasuquin et al., 2008; Reddy, 2002; Sarath and Thilak, 2004). Benefit-cost ratios were also favorable for these treatments (1.79 and 1.75, respectively), demonstrating their economic viability in SRI.

Table 3: Effect of age of seedlings and spacing on gross return, net return and B: C ratio under SRI

Treatments	Cost of cultivation (NRs/ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B: C ratio
8 days seedlings	29,600	63,400	33,800	1.74
15 days seedlings	29,600	66,500	36,900	1.79
22 days seedlings	29,600	62,400	32,800	1.72
29 days seedlings	29,600	57,000	27,400	1.63
20 cm × 20 cm	29,600	62,400	32,800	1.72
25 cm × 25 cm	29,600	65,000	35,400	1.75
30 cm × 30 cm	29,600	61,500	31,900	1.69

4. Conclusion

The study concludes that transplanting younger seedlings (around 15 days old) and using wider spacing (25×25 cm) within the SRI framework significantly enhances rice yield and economic returns. These practices improve vegetative growth, productive tillers, and overall grain yield. Implementing these parameters in SRI can strengthen Nepal's agricultural resilience, improve food security, and reduce rice imports. Adoption of early transplanting and optimal crop spacing should be promoted for sustainable rice cultivation.

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