

Original Research Article

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Impact of System of Rice Intensification (SRI) Components on Nutrient Content, Nutrient Uptake, Soil Parameters and Economics over Conventional Puddled Transplanted Rice

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ABSTRACT

Keywords

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An experiment was conducted at research farm of Bihar Agricultural University, Sabour, Bhagalpur, India during *Kharif* 2019 to study the impact of system of rice intensification (SRI) components on nutrient content and uptake, soil parameters and economics over conventional puddled transplanted rice. The experiment was laid out in completely randomized block design with eight treatments replicated thrice. The first treatment was conventional puddle transplanted rice (CPTR), thereafter six treatments were CPTR with an addition component of SRI in each treatment and the last treatment was sole SRI. Results revealed that the highest gross return (Rs 122650 ha⁻¹) was recorded in the SRI, which was statistically at par with CPTR with 12 days seedling. The highest net return (Rs 78975 ha⁻¹) was recorded in the CPTR with 12 days seedling, and highest B:C ratio obtained (2.12) in CPTR with 12 days seedling. Among all the treatments the N, P and K content in grain was recorded no significant difference. The highest N, P and K uptake in grain and straw were recorded with SRI over other treatments.

Introduction

Globally rice spread in an area of about 216 million hectares (mha) with the production and productivity of 655 million tonnes (mt) and 3004 kg ha⁻¹ respectively. Rice stands second position in area and production in world (FAOSTAT 2015). In India rice is grown in an area of about 43.19 mha having 110.15 mt production of and 2550 kg ha⁻¹ productivity (Annual report of Ministry of Agriculture and Farmers' Welfare, 2017-18).

It is a great challenge to the farmers and researchers to achieve the Country's needs i.e. 140 mt of rice requirement (Dinesh *et al.*, 2017) in the year 2025 under the worsening condition of water scarcity and reduction in cultivable land (Shobharani *et al.*, 2010).

Rice is generally grown in traditional transplanted system where continuous water stagnation is present which leads to water losses through percolation, evaporation, seepage and results in poor water use

efficiency. Excess water, transplanting shock, use of older seedlings and inappropriate spacing are the major concerns of traditional transplanted system which leads to low productivity of rice. To sustain the productivity of rice, we have to practice cultivation methods in which all these challenges will be resolved. System of rice intensification (SRI) has the potential to meet these challenges because it has the capacity to increase the productivity with less water requirement. The technique, SRI was firstly used by the farmer of Madagascar in 1984. In India, SRI technology was spread with a goal of increasing the productivity of irrigated rice with profuse tillering, higher fertile gains, greater root growth and the soil microbial abundance and diversity (Kumar and Shivay, 2004).

The SRI system is found to be an efficient alternative to increase the rice production as it requires less water, less seed, reducing cost of cultivation and saving labour over time. Basically under SRI technique the six components are very important *viz.* early transplanting (8-12 days), carefully transplanting with 1 seedling hill⁻¹, wider spacing (25cm × 25cm), weeding and aeration (mechanical rotating hoe/cono weeder), water management (alternate wetting and drying) and application of farm yard manure (FYM). The SRI system improves the productivity of rice in a sustainable way. Yield obtained in SRI system is generally high because of less competition faced by plants as well as better root development thanks to organized spacing, more sunlight interception, enhanced soil microbial population, high organic matter content and better nutrient & water availability. The weeds are also controlled easily with the help of mechanical hand weeder which helps in soil aeration, reduces the green house gases emissions and increases the productivity of rice in sustainable way. In SRI system the implementation of alternate

wetting and drying (AWD) enhances the water use efficiencies and may reduces 30-40 % of water wastages from traditional methods (Latif, 2010). But the researchers faced still difficulties in acute implementation of all the techniques and trying to search the most important component among the six components of SRI. Based on the water table, depth and soil type, the AWD was found very complicated for the farmers as the water level lower down to about 5-10 cm and 5-15 cm from soil surface during before flowering and grain filling of rice, respectively (Bouman *et al.*, 2007; Kishore *et al.*, 2017). So, partial implementation of SRI technique in conventional practice may found to be beneficial in transplanted *kharif* rice (Palanisami *et al.*, 2013; Reuben *et al.*, 2016).

Materials and Methods

The investigation was conducted at the research farm of Bihar Agricultural University, Sabour, Bhagalpur, India during 2019*kharif* season. Bhagalpur stationed south of the river Ganges and representing of Agro-climatic Zone III-A which is situated at latitude of 25°15'40" N and 87°2'42"E longitude with altitude of 52.73 meter above mean sea level. The soil of the experimental plot was sandy clay loam in nature (50.9% sand, 21.1% silt and 28.3% clay) (International pipette Method, Piper (1950) having low in fertility status (192.5 kg available N ha⁻¹, 17.8 kg available P ha⁻¹ and 123.8 kg available K ha⁻¹), neutral condition in nature (pH = 7.4). The initial soil sample was collected before the experimentation at 0-15 cm soil depth to get the soil fertility status.

The experiment was laid out in completely randomized block design with eight treatments replicated thrice. The details of treatments are given in table 1. The size of individual plot was 6m × 3m. The first treatment was conventional puddled

transplanted rice (CPTR), thereafter six treatments were also CPTR with an addition component of SRI in each treatment and the last treatment was sole SRI. The recommended dose of fertilizer was 120:60:40 kg N:P₂O₅:K₂O ha⁻¹ and the sources were Urea, Di Ammonium Phosphate, Muriate of Potash and vermi-compost. In CPTR the 22 days old seedlings were used with general spacing was maintained as 20cm × 15cm. In treatments T₅ and T₈ the 50% N (60 kg N ha⁻¹) was mitigated with vermi-compost having 1.75% N and those plots were received @ 3.4 t vermi-compost ha⁻¹ during final land preparation. All the treatments received full dose of P₂O₅ and K₂O as basal dose i.e. one day before transplanting. The N fertilizer was applied in three split i.e. 40% as basal and remaining was applied in two equal split (30%) at active tillering (25 DAT) and panicle initiation (45 DAT) stages. As the treatment T₅ and T₈ received vermi-compost as basal, here the N was applied in split as 25% in both the active tillering and panicle initiation stages. In the treatment T₇ and T₈, the mechanical rotating hoe was used twice for weed management and the others received one hand weeding and herbicide application as post emergence during the course of investigation. The details treatment combinations are given below.

Crop variety

The crop variety 'Sabour Shree' was released from Bihar Agricultural University, Sabour. It is generally recommended for long duration (145-150 days) with an average potential yield about 45-55 q ha⁻¹.

Statistical Analysis

The data were analyzed statistically by applying "Analysis of Variance" (ANOVA) technique of completely randomized block design. The significance of different sources

of variations was tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05. Standard error of mean (SEm±) and least significant difference (LSD) at 5% level of significance were worked out for each character and provided in the summary tables of the results to compare the difference between the treatment means (Table 1-5).

Results and Discussion

Soil Parameters

Among all the treatments, there were no significant differences in available N, P and K in soil after harvest of crop.

From the one year experimental findings the soil chemical properties did not differ significantly among the treatments. However CPTR with N-Organic:inorganic::50:50 (T₅) has obtained highest available N in soil (241kg ha⁻¹), available P₂O₅(32.8 kg ha⁻¹), available K₂O(141.4 kg ha⁻¹) and organic carbon(0.51%) at harvest. The inorganic (NPK) + Organic (vermi-compost) 50:50 has improved the soil fertility status because it may release the nutrients slowly. These statements are supported by Dass *et al.*, (2015), Jat *et al.*, (2015) and Mohanty *et al.*, (2014) who found that application of inorganic + organic(50% R.D.F. + 50% R.D.F based on nitrogen requirement) in rice improved the nutrient content of the soil.

Plant parameters

Nutrient content

Among all the treatments the N content in grain was recorded no significant difference. However, the highest and lowest N content in grain was recorded (1.17 %) in T₅ (CPTR with N-Organic: inorganic:: 50:50) and(1.13 %) in T₃ (CPTR with spacing of 25 cm x 25 cm) treatments respectively. Similarly, N content

in straw after harvest recorded no significant difference among all the treatments. However, treatment T₈ (Full component of SRI) and T₁ (Conventional PTR) were given maximum and minimum content in straw that is (0.76 %) and (0.68 %) respectively.

Among all the treatments the P content in grain was recorded no significant difference. However, the highest and lowest P content in grain was recorded (0.29%) in T₅ (CPTR with N-Organic: inorganic:: 50:50) and (0.23 %) in T₇ (CPTR with weed management through Cono-weeder / mechanical rotating hoe) treatments respectively. Similarly, among all the treatments the P content in straw was recorded no significant difference. However, the highest and lowest P content in straw was recorded (0.157 %) in T₈(Full component of SRI) and (0.133 %) in T₇ (CPTR with weed management through Cono-weeder/ mechanical rotating hoe) treatments respectively.

Similarly, K content in grain after harvest recorded, no significant difference was found among all the treatments. However, treatment T₈ (Full component of SRI) and T₆ (CPTR with Saturation water management) were given maximum and minimum content in grain that is (0.31 %) and (0.23 %) respectively. Similarly, recorded K content in straw after harvest recorded, no significant difference was found among all the treatments. However, treatment T₈ (Full component of SRI) and T₆ (CPTR with Saturation water management) were given maximum and minimum content in straw that is (1.38 %) and (1.27 %) respectively.

Among all the treatments the N content in grain was recorded no significant difference. However, the highest and lowest N content in grain was recorded (1.17 %) in T₅ (CPTR with N-Organic: inorganic:: 50:50) and (1.13 %) in T₃ (CPTR with spacing of 25cm×25cm)

treatments respectively. Similarly, recorded N content in straw after harvest observed no significant difference was found among all the treatments. However, treatment T₈ (Full component of SRI) and T₁ (Conventional PTR) were given maximum and minimum content in straw that is (0.76 %) and (0.68 %), respectively. Among all the treatments the P content in grain was recorded no significant difference. However, the highest and lowest P content in grain was recorded (0.29%) in T₅ (CPTR with N-Organic: inorganic:: 50:50) and (0.23 %) in T₇ (CPTR with weed management through mechanical rotating hoe) treatments respectively. Similarly, among all the treatments the P content in straw was recorded no significant difference. However, the highest and lowest P content in straw was recorded (0.157 %) in T₈ (Full component of SRI) and (0.133 %) in T₇ (CPTR with weed management through mechanical rotating hoe) treatments respectively. Similarly, K content in grain after harvest recorded, no significant difference was found among all the treatments. However, treatment T₈ (Full component of SRI) and T₆ (CPTR with Saturation water management) were given maximum and minimum content in grain that is (0.31 %) and (0.23 %), respectively. Similarly, recorded K content in straw after harvest recorded, no significant difference was found among all the treatments. However, treatment T₈ (Full component of SRI) and T₆ (CPTR with Saturation water management) were given maximum and minimum content in straw that is (1.38 %) and (1.27 %), respectively.

Nutrient uptake

The highest N uptake in grain (70 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (64.7 kg ha⁻¹) and CPTR with 1 seedling/hill (61.7 kg ha⁻¹). The lowest N uptake in grain (50.8 kg

ha⁻¹) was recorded with CPTR with Saturation water management (AWD).The highest N uptake in straw (50.5 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (46.9 kg ha⁻¹) and CPTR with 1 seedling/hill (45 kg ha⁻¹). The lowest N uptake in straw (38 kg ha⁻¹) was recorded with CPTR with Saturation water management (AWD).The highest total N uptake (120.5 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (111.6 kg ha⁻¹).

The lowest total N uptake (88.8 kg ha⁻¹) was recorded with CPTR with Saturation water management (AWD).Similarly, the highest P uptake in grain (15.3 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (15.3 kg ha⁻¹), CPTR with 1 seedling/hill (13.6 kg ha⁻¹), CPTR with N-Organic: inorganic(13.5 kg ha⁻¹),CPTR with spacing of 25 cm x 25 cm (12.5kg ha⁻¹) and conventional PTR (12.2 kg ha⁻¹). The lowest P uptake in grain (10.4 kg ha⁻¹) was recorded with CPTR with Saturation water management. The highest P uptake in straw (10.5 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (9.3 kg ha⁻¹), CPTR with 1 seedling/hill (8.8 kg ha⁻¹) and CPTR with N-

Organic:inorganic::50:50 (9.2kg ha⁻¹). The lowest P uptake in straw (7.3 kg ha⁻¹) was recorded with CPTR with weed management through Conoweeder / mechanical rotating hoe. The highest total P uptake(25.8 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (24.7 kg ha⁻¹),CPTR with 1 seedling/hill (22.3kg ha⁻¹) and CPTR with N-Organic: inorganic::50:50 (22.7kg ha⁻¹).

The lowest total P uptake (17.8 kg ha⁻¹) was recorded with CPTR with Saturation water management (AWD).The highest K uptake in grain (18.7 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (15.7 kg ha⁻¹). The lowest K uptake in grain (10.3 kg ha⁻¹) was recorded with CPTR with Saturation water management (AWD).Similarly, the highest K uptake in straw (92.5 kg ha⁻¹) was recorded with SRI, which was found at par with CPTR with 12 days seedling (86.3 kg ha⁻¹), CPTR with 1 seedling/hill (88.3 kg ha⁻¹), Conventional PTR (83.8 kg ha⁻¹) and CPTR with N-Organic: inorganic::50:50 (80.6 kg ha⁻¹). The lowest K uptake in straw (67.9 kg ha⁻¹) was recorded with CPTR with Saturation water management (AWD).

Table.1 Treatment Details

T₁	Conventional puddled transplanted rice (CPTR)
T₂	CPTR using 12 days old seedlings (First component of SRI)
T₃	CPTR with spacing of 25cm × 25cm (Second component of SRI)
T₄	CPTR with single seedling/hill (Third component of SRI)
T₅	CPTR with N-Organic:inorganic::50:50 (Fourth component of SRI)
T₆	CPTR with Saturation water management i.e. alternating wetting and drying (Fifth component of SRI)
T₇	CPTR with weed management through Conoweeder / mechanical rotating hoe(Sixth component of SRI)
T₈	SRI (Spacing: 25cm× 25 cm), single seedling/hill, 12 days old seedling, N-Organic: Inorganic (50:50), Saturation water management, weed management through conoweeder/ mechanical rotating hoe)

Table.2 Effect of different crop establishment method on the soil chemical properties of the rice crop

Treatments	Soil chemical properties at harvest			
	Available N, (kg ha ⁻¹)	Available P ₂ O ₅ (kg ha ⁻¹)	Available K ₂ O (kg ha ⁻¹)	Organic carbon, (%)
T1: Conventional PTR (CPTR)	237	29.3	128.3	0.46
T2: CPTR with 12 days seedling	228	28.9	126.6	0.43
T3: CPTR with spacing of 25cm×25cm	224	28.1	131.6	0.48
T4: CPTR with 1 seedling/hill	221	28.5	123.7	0.45
T5: CPTR with N-Organic:inorganic::50:50	241	32.8	141.4	0.51
T6: CPTR with Saturation water management (AWD)	236	29.9	127.8	0.48
T7: CPTR with weed management through mechanical rotating hoe	224	31.8	123.4	0.46
T8: SRI	230	29.2	129.9	0.51
SEm(±)	8	3	10.32	0.03
LSD (p= 0.05)	NS	NS	NS	NS

PTR = Puddled transplanted rice; CPTR = Conventional puddle transplanted rice; AWD = Alternate wetting and drying; SRI = System of rice intensification; SEm(±) = Standard error of mean; LSD = Least significant difference

Table.3 Effect of different crop establishment method on the nutrient content by grain and straw in rice crop

Treatments	Nutrient content (%) at harvest					
	Grain			Straw		
	N, %	P, %	K, %	N, %	P, %	K, %
T1: Conventional PTR (CPTR)	1.16	0.23	0.24	0.68	0.137	1.36
T2: CPTR with 12 days seedling	1.14	0.27	0.28	0.72	0.144	1.33
T3:CPTR with spacing of 25cm×25cm	1.13	0.24	0.26	0.69	0.135	1.30
T4: CPTR with 1 seedling/hill	1.16	0.25	0.24	0.70	0.137	1.37
T5: CPTR with N-Organic:inorganic::50:50	1.17	0.29	0.25	0.67	0.156	1.37
T6: CPTR with Saturation water management (AWD)	1.15	0.24	0.23	0.71	0.140	1.27
T7: CPTR with weed management through mechanical rotating hoe	1.14	0.23	0.27	0.69	0.133	1.32
T8: SRI	1.16	0.25	0.31	0.76	0.157	1.38
SEm(±)	0.01	0.02	0.02	0.024	0.008	0.04
LSD (p= 0.05)	NS	NS	NS	NS	NS	NS

PTR = Puddled transplanted rice; CPTR = Conventional puddle transplanted rice; AWD = Alternate wetting and drying; SRI = System of rice intensification; SEm(±) = Standard error of mean; LSD = Least significant difference

Table.4 Effect of different crop establishment method on the nutrient uptake by grain and straw in rice crop

Treatments	Nutrient uptake, kg ha ⁻¹								
	N uptake			P uptake			K uptake		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T1: Conventional PTR (CPTR)	61.4	42.2	103.6	12.2	8.4	20.6	12.5	83.8	96.3
T2: CPTR with 12 days seedling	64.7	46.9	111.6	15.3	9.3	24.7	15.7	86.3	102.0
T3: CPTR with spacing of 25cm×25cm	58.8	40.9	99.7	12.5	8.1	20.6	13.6	77.3	90.9
T4: CPTR with 1 seedling/hill	61.7	45.0	106.7	13.6	8.8	22.3	13.0	88.3	101.2
T5: CPTR with N-Organic:inorganic::50:50	54.5	39.5	93.9	13.5	9.2	22.7	11.7	80.6	92.2
T6: CPTR with Saturation water management (AWD)	50.8	38.0	88.8	10.4	7.5	17.8	10.3	67.9	78.1
T7: CPTR with weed management through mechanical rotating hoe	52.1	38.8	90.9	10.5	7.3	17.8	12.4	73.7	86.1
T8: All component of SRI	70.0	50.5	120.5	15.3	10.5	25.8	18.7	92.5	111.3
SEm(±)	2.8	2.4	4.1	1.1	0.6	1.4	1.3	4.6	5.1
LSD (P=0.05)	8.4	7.4	12.3	3.2	1.9	4.4	4.0	13.9	15.5

PTR = Puddled transplanted rice; CPTR = Conventional puddle transplanted rice; AWD = Alternate wetting and drying; SRI = System of rice intensification; SEm(±) = Standard error of mean; LSD = Least significant difference

Table.5 Effect of different crop establishment method on the economics of the rice crop

Treatments	Gross Return (Rs/ha)	Net Return (Rs/ha)	Return per Rs invested
T1: Conventional PTR (CPTR)	108172	70866	1.90
T2: CPTR with 12 days seedling	116281	78975	2.12
T3: CPTR with spacing of 25cm×25cm	106146	68840	1.85
T4: CPTR with 1 seedling/hill	109330	72024	1.93
T5: CPTR with N-Organic:inorganic::50:50	96326	35020	0.57
T6: CPTR with Saturation water management (AWD)	90775	53469	1.43
T7: CPTR with weed management through mechanical rotating hoe	94173	59737	1.73
T8: All component of SRI	122650	64214	1.10
SEm(±)	4477	4477	0.11
LSD (p= 0.05)	13579	13579	0.34

PTR = Puddled transplanted rice; CPTR = Conventional puddle transplanted rice; AWD = Alternate wetting and drying; SRI = System of rice intensification; SEm(±) = Standard error of mean; LSD = Least significant difference

Similarly, the highest total K uptake (113.3 kg ha^{-1}) was recorded with SRI, which was found at par with CPTR with 12 days seedling (102 kg ha^{-1}), CPTR with 1 seedling/hill (101.2 kg ha^{-1}), and Conventional PTR (96.3 kg ha^{-1}). The lowest total K uptake (78.1 kg ha^{-1}) was recorded with CPTR with Saturation water management (AWD).

According to the grain yield of rice crop the nutrient uptake was also varied among the treatments. The highest N, P and K uptake were recorded in the SRI treatment where the maximum productivity was noticed. The SRI recorded significantly higher P and K uptake for grain, straw and total than the other treatments. However, the total N uptake was found statistically similar in SRI (T8) and CPTR with 12 days old seedlings (T2). This might be due to increase in grain and straw yield which resulted in the increase in N uptake (Vishwakarma *et al.*, 2016). The Highest nutrient uptake in SRI was due to water management in SRI through AWD, enhanced the microbial solubilisation of phosphorous which resulted in the highest P uptake (Vishwakarma *et al.*, 2016). Jana *et al.*, (2015) reported that the nutrient uptake was highest in the SRI as compared to the transplanted rice because of the better soil conditions in SRI practice.

Economics

The highest Gross Return ($\text{Rs. } 122650 \text{ ha}^{-1}$) was recorded with SRI, which was found at par with CPTR with 12 days seedling ($\text{Rs. } 116281 \text{ ha}^{-1}$) and CPTR with single seedling/hill (109330). The lowest Gross Return (90775) was recorded with CPTR with Saturation water management (AWD).

Similarly, the highest Net Return ($\text{Rs. } 78975 \text{ ha}^{-1}$) was recorded with CPTR with 12 days seedling, which was found at par with Conventional PTR (70866), CPTR with 1

seedling/hill (72024) and CPTR with spacing of $25\text{cm} \times 25\text{cm}$ ($\text{Rs. } 68840 \text{ ha}^{-1}$). The lowest Net Return ($\text{Rs. } 35020 \text{ ha}^{-1}$) was recorded with CPTR with N organic: inorganic:: 50:50. Similarly, the highest Return per Rs. invested (2.12) was recorded with CPTR with 12 days seedling, which was found at par with conventional PTR (1.90), CPTR with single seedling/hill (1.93), and CPTR with spacing of $25\text{cm} \times 25\text{cm}$ (1.85). The lowest Return per Rs invested (0.57) was recorded with CPTR with N organic: inorganic:: 50:50. Gross Returns ($\text{Rs. } 122650/\text{ha}$) were obtained highest in the SRI, which was statistically at par with CPTR with 12 days seedling ($\text{Rs. } 116281/\text{ha}$) and CPTR with 1 seedling/hill ($\text{Rs. } 109330/\text{ha}$). SRI has produced highest grain yield which has resulted in the highest gross returns. These results are in conformity with Sudhakar *et al.*, (2017). The highest Net Returns ($\text{Rs. } 78975/\text{ha}$) was recorded with CPTR with 12 days seedling, which was statistically at par with Conventional PTR ($\text{Rs. } 70866/\text{ha}$), CPTR with 1 seedling/hill ($\text{Rs. } 72024/\text{ha}$) and CPTR with spacing of $25 \text{ cm} \times 25 \text{ cm}$ ($\text{Rs. } 68840/\text{ha}$) and the highest Return per Rupee invested (2.12) was recorded with CPTR with 12 days seedling, which was found at par with Conventional PTR (1.90), CPTR with 1 seedling/hill (1.93), and CPTR with spacing of $25 \text{ cm} \times 25 \text{ cm}$ (1.85). This is because of less cost of cultivation in CPTR, CPTR with 1 seedling/hill, CPTR with spacing of $25 \text{ cm} \times 25 \text{ cm}$ and CPTR with 12 days seedling and higher gross returns which has resulted in the highest net returns as well as Return per Rs invested. These results are conformity with the findings of Kumar and Kumar (2018), Sudhakar *et al.*, (2017) and Mohandas *et al.*, (2015).

In conclusion the Based on these finding we can suggest the farmer in our country to go for partial implementation of SRI i.e., 12 days old seedling with single seedling/hill in

transplanted kharif rice if practicing all principles of SRI is not possible. But the highest gross return (Rs 122650 ha⁻¹) was recorded in the SRI, which was statistically at par with CPTR with 12 days seedling. However, the highest net return and B:C ratio were recorded Rs 78975 ha⁻¹ and 2.12 respectively in the CPTR with 12 days seedling.

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