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Effect of Crop Establishment Methods and Fertility Management on Growth, Yield and Economics of Rice (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India during *Kharif* 2021 and 2022. The study aims to determine the effect of crop establishment methods under fertility

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management on growth parameters of rice. The experiment was laid out in split plot design with three replications. The treatment consisted of four crop establishment methods *i.e.,* (M_1) Transplanting rice (Conventional) (M_2) Direct seeded rice by line sowing (Conventional) (M_3) Drum seeded method under puddled condition,(M_4) System of Rice Intensification (SRI) method kept in main plots .However, four nitrogen levels *viz,* (N_1) 100% RDF (150: 60:40 kg N:P:K ha $^{-1)}$, (N_2) 75% RDF +25% RDN through FYM, (N_3) 75 % RDF + 25% RDN through vermi-compost (VC), (N_4) 50 % RDF + 25 % RDN through V.C. + 25% RDN through FYM allotted the in sub plots. This way there was made 16 treatment combinations. As per the results the values of growth, yield and economics *viz*. plant height (cm), number of tillers m^{-2}, dry matter accumulation (m^{-2}), grain yield (q ha^{-1}) , straw yield (q ha^{-1}), biological yield (q ha^{-1}) , harvest index % and economics of rice were increased significantly with system of rice intensification (SRI) method followed by transplanting method. However, in fertility management the application of 100% RDF [150: 60:40 N: P: K kg ha^{-1}] recorded the maximum plant height, dry matter accumulation, no of tillers, grain yield (q ha^{-1}) , straw yield (q ha^{-1}), biological yield (q ha^{-1}) , harvest index % and economics, which was at par with the application of 75 % RDF + 25% RDN through Vermi- compost and significantly superior over rest of the treatments.

Keywords: Crop establishment methods; fertility management; plant height; no of tillers; grain yield; straw yield; biological yield; harvest index; economics.

1. INTRUDUCTION

"Rice belongs to the family Poaceae (Gramineae) and it is C_3 plant, self-pollinated crop and having diploid chromosome number *i.e.,* 2n= 24. The word *Oryza* is most likely of Indian origin ('Vrihi'= Sanskrit, and 'arise'= Tamil)" [Nene, 2005]. "Rice (*Oryza sativa* L.) mostly grown in India and South East Asia. Around 90 of the world's rice is cultivated and consumed in the Asian region. In crop year 2021, there were around 165.25 million hectares of rice-cultivated area worldwide, yielding 756.7 million tonnes" [1]. "Rice is one of the most significant cereal crop, with more than 70 %of world's population" [2]. "Among the rice growing countries, India has the largest area followed by china and Indonesia. In respect to production, India ranks second after china. India accounts 20% of all world rice production. Rice is pre-eminent crop and is the staple foods of the people of the eastern and southern parts of the country" [3]. The area under rice crop in our country is about 47 m ha with a total production 132 million tonnes USDA, 2023.

"There are different methods of crop establishment namely; Direct seeded rice, Transplanting and SRI are adopted for the cultivation of rice. Among these methods transplanting method most commonly used in different areas, while direct seeding method is used in the area where less water available and frequent irrigation at proper intervals is generally given to avoid yield losses" [4]. "Direct seeded rice (DSR) being a cost effective, consumes less water and labour-saving crop establishment method is becoming popular. Direct seeded method can be categorized as wet seeding (pre-germinated seeds) and dry seeded. In wet seeded, pre-germinated seeds are sown into puddled and leveled field which are free from standing water and in dry seeded; dry rice seeds are drilled or broadcast on unpadded soil either after dry tillage or zero tillage or on a raised bed. DSR is efficient resource conservation technology which saves the labour to the extent of about 40% and water up to 60%" [5,6].

"Fertility management form application of organic and inorganic sources of nutrients used for maintaining the plant nutrients in soil and improves nutrients-use efficiency that is essential in sustainable crop production. Organic matter acts as a source and a sink for plant nutrients as well as provides energy substrate for soil microorganisms. Thus, it enhances activities of soil, flora and fauna as well as intrinsic soil properties, soil nutrient capital, water-holding capacity and soil structure in turn makes soilless susceptible to leaching and erosion. Therefore, these practices are essential to maintained and enhanced the soil quality and sustainability of an agro-ecosystem" [7]. FYM is nutrient-rich and contains 0.5 percent nitrogen, 0.2 percent phosphorus, and 0.5 percent potassium. Regular use of FYM as organic manure has demonstrated its effectiveness in increasing crop output by improving the physiochemical characteristics of the soil (such as bulk density, water holding capacity, and organic carbon content). Additionally, it affected the soil's phosphorus and potassium leftovers. Farmyard manure (FYM), which gives plants all the nutrients they need and increases soil microbial activity, is a crucial source of organic manure for field crops [8]. “Farm Yard Manure (FYM) is the most important sources of organic matter and a key factor in conserving soil moisture to crop with drought as well as improving and sustaining soil fertility and productivity. Vermi-compost can be utilized in crop production as a component of Integrated nutrient management (INM) and as a single source of all essential crop nutrients” [9]. “All nutrients in vermin-compost are in readily available form, thereby, enhancing nutrients uptake by plants” [10].

2. MATERIALS AND METHODS

The experiment was set up at the Acharya Narendra Deva University of Agriculture & Technology's Agronomy Research Farm in Kumarganj, Ayodhya (Uttar Pradesh), during the kharif seasons of 2021 and 2022. Geographically, Ayodhya (Kumarganj) is located at 26.470 North, 82.120 East, and has an elevation of 113 metres above mean sea level. It has a subtropical climate. The experimental location is located 42 km from the Ayodhya district headquarters on the main campus of the university, on the left side of the Ayodhya-Raebareli road. The experimental plot had adequate irrigation and other infrastructure, and it had uniform fertility. The district has a semi-arid climate with hot, dry summers and freezing winters; it is located in the subtropical zone of the Indo-Genetic Plains. A critically scattered average annual rainfall of 1200 mm falls over this region. Rainfall is more frequently limited to the months of July to September. The period from the middle of June to the end of September sees about 90% of the total rainfall. According to the study of the experimental field, the soil had a pH of 8.1 and a conductivity of 0.34 dSm-1, indicating that it was somewhat alkaline in reaction. The information makes it clear. The soil had a low level of organic carbon (0.34%), a high level of potassium (265.0 kg ha-1), a medium level of available phosphorous (16.5 kg ha-1), and a low level of available nitrogen (180.0 kg ha-1). Three replications were used in the split plot design of the experiment. The treatment included four crop establishment techniques, including transplanting rice (conventional) at a 20x10 cm spacing (M1), direct seeded rice by line sowing (conventional) at a 2010 cm spacing (M2), drum seeding under puddled conditions at a 2010 cm spacing (M3), and system of rice intensification (M4) at a 2525 cm spacing, as well as four nitrogen levels, including 100% RDF (150: 60: 40 NPK) The seed rates employed for the drum seeder method of DSR sowing in puddled soil and the line sowing method of DSR sowing were 30 kg/ha and 100 kg/ha, respectively. Seeds The seeds were immersed in water for 24 hours in this method to sprout the seeds. After being incubated for 8–10 hours, the seeds were then sown on puddled soil using a drum seeder. Before seeds were sowed, drum seeded plots were puddled by giving them two cross-plows with a desi plough, followed by planking in pounded water, and then sprouted rice seeds were sown with a drum seeder. Seeds were manually seeded in lines using the DSR by line sowing technique. In the transplanting approach, seedlings were transplanted after 21 days in accordance with the treatment, while in the SRI method, seedlings were transplanted after 12 days. Inorganic and organic fertilisers were applied in accordance with the treatments to maintain the soil's fertility. For N, P, and K fertilisers, the supplies were urea, DAP, and MOP, respectively.

2.1 Growth

2.1.1 Plant height (cm)

The plant height was recorded at 30, 60, 90 DAS and at harvest stage . Five plants were selected randomly in each plot and tagged for observation. The height was measured from base near ground to top most tip of the plant. The measurement of all five plants was averaged to express the plant height (cm).

2.1.2 Number of tillers (m^{-2})

The number of tillers (m^{-2}) was counted at 30, 60 and 90 DAS/DAT and at harvest from randomly selected 0.25 m^{-2} areas at four locations in net plot area with the sum of the four observations; the final value was computed and expressed in terms of mean value of four observations that is number of tillers per square meter.

2.2 Yield Attributing

2.2.1 Grain yield (q ha^{-1})

After taking the bundle weight of the harvested produce of each net plot, their grains were threshed by beating them on wooden platform and cleaned. The grains thus obtained were sun dried to about 14-15% moisture content. The weight of dried grains was recorded in kg plot^{-1} which was further multiplied with conversion factor in order to get grain yield in q ha^{-1}.

2.2.2 Straw yield (q ha^{-1})

Straw yield was determined from the net plot area of each plot. After separating of grains, the sub-samples were oven dried to a constant weigh for obtaining straw yield. The straw yield (kg plot^{-1}) was recorded by subtracting the weight of grains from the weight of total harvested produce of each net plot. The straw yield thus obtained in kg plot^{-1} was further multiplied with conversion factor for achieving the straw yield in q ha^{-1}.

2.2.3 Biological yield (q ha^{-1})

After harvesting the crop, produce was left for dried for 4-5 days in the plot and then weight of total produce was harvested from net area of each plot recorded into kg plot^{-1} and expressed as q ha^{-1}.

2.2.4 Harvest index (%)

The recovery of grains (economic yield) in total produce was considered as ‘Harvest Index’ which is expressed in percentage. It denotes the ratio of economic yield (grain yield) to biological yield and was calculated with following formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

2.3 Economics Studies

2.3.1 Cost of cultivation [Rs ha^{-1}]

Cost of cultivation of different treatment was worked out by considering all the expenses incurred. The cost of input and prices of produce prevalent at the Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj (Ayodhya) Uttar Pradesh were taken into consideration for calculating economics of different treatment. It is expressed in rupees per hectare.

2.3.2 Gross return [Rs ha^{-1}]

Gross return was worked out by multiplying grain and straw yield separately under various treatment combinations with their existing market price. The money value of both grain and straw was added together in order to achieve gross return. It is expressed in rupees per hectare.

2.3.3 Net return [Rs ha^{-1}]

Net return was calculated by deducting the cost of cultivation from the gross return of the individual treatment combination. Net return (Rs ha^{-1}) = Gross return (Rs ha^{-1}) – Cost of cultivation (Rs ha^{-1})

2.3.4 Benefit-cost ratio

Benefit cost ratio was worked out by dividing the net return to the cost of cultivation of the individual treatment combination:

$$\text{C ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

In Table 1, data on plant height at various growth phases of the crop are shown as being significantly influenced by the effects of crop setup techniques and fertility management. It is evident that the plant first grew slowly, reaching its highest rate of growth between 30 and 60 DAS/DAT. The data demonstrates that plant height continued to rise gradually till maturity. Up until 90 DAS/DAT, the early stages of crop growth saw a quick increase in plant height, but after that, all treatments experienced a steady uptick in plant height over the course of the two experimentation years. The system of rice intensification (SRI) method, which was on par with the transplanting method and significantly better than the other methods of crop establishment in rice at successive growth stages of rice, except for 30 DAS/DAT during both years of crop experimentation, produced the highest value of plant height when rice seedlings were transplanted. According to Shekar et al. [11], one explanation for the tallest plants in the SRI method is that they have enough room to develop both above and below the ground (branch and root) in addition to having greater light transmission in the canopy. When the SRI method of transplanting was utilised, this situation increases cell proliferation, resulting in increased stem elongation and possibly enhanced plant height [5,6].

In terms of fertility management, the application of 100% RDF (150:60:40 kg NPK ha-1) produced the highest value of plant height, which was comparable to the application of 75% RDF + 25% N through vermicompost (V.C). This treatment also produced a significantly higher value of plant height than the other treatments at 30 to 60, 90 DAS/DAT, and at harvest during both years of the experiment. Due to an adequate supply of nutrients from both inorganic and organic sources, plant height increased. As a result of strong root development, various metabolic processes, and better mobilization of carbohydrates that had been synthesized into amino acids and protein. Finally, it caused the plant to develop quicker than the other treatments. The fact that nitrogen is the main growth promoter element and aids in greater food production, which results in enhanced cell division and cell enlargement, explains why nitrogen plays a role in boosting plant height. Meena et al. [12] found that nitrogen has a similar impact on the height of rice plants.

3.2 Number of Tillers (m^{-2})

Table 2 provides information on the number of tillers affected considerably by crop establishment techniques and fertility management at various growth stages of the crop. The number of tiller (m^{-2}) progressively increased at the successive stages of crop growth as influence effect of crop establishment methods and fertility management on rice. It clearly reveals that the rate of growth of the tillers was initially low and maximum number of tillers was observed during 60 to 90 DAS. The data showing the progressive increase of number of tiller (m^{-2}) continued till 90 DAS after that reduced of number of tiller (m^{-2}) till maturity. The increase in number of tiller (m^{-2}) was rapidly during early crop growth period up to 90 DAS and after that a reduced rate of increase in number of tiller (m^{-2}) was registered in all the treatment during both the years of experimentation.

When rice seedlings were transplanted using the (M4) system of rice intensification (SRI) method, the maximum number of tillers was observed. This method was comparable to the (M1) transplanting method and significantly better than the other methods of crop establishment successive growth stages of rice, with the exception of 30 DAS/DAT during both years of experimentation. The higher number of tillers m^{-2} in SRI method might be due to sufficient spacing, earlier transplanting and better water management, resulting increased nutrients availability which lead to better root development, ultimately produced a greater number of tillers m^{-2} [13].

The fertility management practices significantly affected the number of tiller (m^{-2}) at all stages of crop growth. But at 30 DAS, there was non-significant difference in number of tiller (m^{-2}). However, maximum number of tiller (m^{-2}) (222.04 and 228.29), (280.85 and 292.10),(312.05 and 324.50) and (308.96 and 321.30) at 30, 60, 90 DAS and at harvest was found to be superior under 100% RDF (150:60:40 kg npk ha^{-1}) (N_1), which was at par with75% RDF + 25% N through V.C, and followed by 75% RDF +25% RDN through FYM (N_2), 50 % RDF + 25 % RDN through V.C. + 25 % RDN through FYM (N_4). While the lowest number of tiller (m^{-2}) was recorded with N_4 treatment during the both years. This fact that nitrogen appears to play a crucial part in the creation of new tissues that are dependent on protoplasmic structure, cell division, and cell elongation may explain the rising number of tillers with increasing nitrogen levels. The results are in agreement with those of [11,12].

3.3 Grain Yield (q ha^{-1})

According to data on rice grain yield as influenced by crop establishment methods and fertility management shown in Table.3, the system of rice intensification (SRI) method recorded the highest grain yield of 55.80 and 56.96 (q ha-1). which, in both study years, was determined to be much better than the remaining two treatments and comparable to the transplanting procedure. In the SRI approach, the yield increased by 1.6%, 7.70%, and 12.90%, respectively. The outcomes concur with those reported by Husain et al. [14] Jnanesha et al. [15]. According to reports, the SRI planting method's maximum grain output was mostly the result of a larger total number of tillers hill-1, the longest panicle length, and the highest number of grains panicle-1.

The data for grain yield (q ha-1) showed that 100% RDF (150:60:40 kg npk ha-1) significantly outperformed applications of 75% RDF + 25% N via V.C and FYM, as well as applications of 75% RDF + 25% RDN. 50% RDF plus 25% RDN via [V.C.] plus 25% RDN via FYM. According to statistics from both years, treatment with 50% RDF + 25% RDN through [V.C.] + 25% RDN through FYM resulted in the lowest grain yield [16] as well as [17] discovered that higher yields might be ascribed to the combination application of the recommended dose of inorganic fertiliser, which promoted better nutrient availability along with higher nutrient digestion and ultimately increased grain output.

3.4 Straw Yield (q ha^{-1})

Data pertaining to straw yield of rice as affected by effect of crop establishment methods and fertility management have been presented in Table 3. The variations in straw yield due to crop establishment methods and fertility management were found statistically significant during both the year of extermination SIR method of rice was recorded maximum value of straw yield (75.74 and 77.04 qh^{-1}) which was at par with transplanting method which was significantly superior over rest of two treatment. The maximum straw yield 75.74 and 77.04 (q ha^{-1}) was recorded under the system of rice intensification (SRI) method There was an increase in straw yield (1.56% and 1.38%), (12.3% and 12.15%) and (6.48% and 6.33%) in SRI method of crop establishment over transplanting , DSR by line sowing and drum seeder, respectively during both the years. This might be due to maximum growth parameters and yield attributes were obtained under SRI method and offered higher straw yield of rice. This statement is also supported by [18,19].

Straw yield data showed that 100% RDF (150:60:40 kg npk ha-1) produced the highest yield, followed by 75% RDF + 25% N through V.C, 75% RDF + 25% RDN through FYM, and 50% RDF + 25% RDN through [V.C.] + 25% RDN through FYM.While over both years of data, the lowest straw production was noted with 50% RDF + 25% RDN through [V.C.] + 25% RDN through FYM treatment. This may be brought on by taller plants, a denser tiller population, and a greater rate of dry matter production. [7] obtained similar results.

3.5 Biological Yield (q/ha)

The amount of total dry matter accumulated by a crop (grain plus straw) is a significant indicator of the crop's photosynthetic efficiency and the amount of photosynthetic material left over after respiration, both of which have an impact on crop output. Table 3 contains a presentation of the data. Maximum biological yield (q ha-1) data were obtained using the system of rice intensification (SRI) approach, which was equivalent to transplanting. Under the system of rice intensification (SRI) approach, the highest biological yields of 131.54 and 134.01 (q ha-1) were noted. Then the rice crop was transplanted, using data from the respective years. The biological yield (q ha-1) increased for the SRI mode of crop establishment over transplanting, DSR by line sowing, and drum seeder for both years by 0.04 and 0.14 percent, 1.24 and 1.3 percent, and 1% and 1.0 percent, respectively. This might be because there was enough water available, which helped to increase the accumulation of dry materials. The strength of the vegetative growth, development, and yield attribute work together to define the productivity of biological yield of a crop. Kumar et al. [20] reported findings that were similar.

The biological yield data (q ha-1) showed that under 100% RDF (150:60:40 kg npk ha-1), it was much higher than under 75% RDF + 25% N via V.C, 75% RDF +25% RDN through FYM, and 50% RDF + 25% RDN through [V.C.] + 25% RDN through FYM. The N4 treatment produced the lowest biological yield (q ha-1) in both years of data. This may be as a result of an increase in yield contributing traits and crop growth at harvest stage compared to other fertility levels. Similar results were found by Kumar et al. [8] and Tomar et al. [5,6], respectively.

3.6 Harvest Index (%)

Data pertaining the harvest index (%) are presented in Table 3 that effect of crop establishment methods and fertility management had not significantly influenced on harvest index (%).However, for both years of data, the system of rice intensification (SRI) method and the transplanting method of rice crop both recorded the highest harvest indexes (42.42 and 42.50%). The relationship between grain yield and total biological yield (grain plus straw) is called the harvest index. Harvest index is essentially a supplementary statistic that depends on the crop's economic and biological yield. However, the greater harvest index was noted using the SRI approach as a result of the higher rice grain yield per unit biological production. Stoop [21] and Husain et al. [14] both reported findings that were similar.

The data for harvest index (%) indicated that 100% RDF (150:60:40 kg npk ha-1) had the highest level of significance, followed by 75% RDF + 25% N via V.C, 75% RDF +25% RDN through FYM, and 50% RDF + 25% RDN through [V.C.] + 25% RDN through FYM.The combination of 50% RDF + 25% RDN through [V.C.] + 25% RDN through FYM treatment resulted in the lowest harvest index (%) in the data from the two years. Practises for fertility management also had a negligible impact on the rice harvest index. The higher grain yield of rice per unit biological yield was the cause of the better harvest index with the application of 100% RDF N by inorganic fertiliser. The findings of [22] also support this.

3.7 Economics Studies

The data pertaining on economics studies viz. Cost of cultivation (₹ ha^{-1}), Gross return (₹ ha^{-1}), Net return (₹ ha^{-1}), Benefit : cost ratio (₹ ha^{-1}) as influenced significantly by establishment methods and fertility management practices in Table 4.

3.8 Cost of Cultivation (₹ ha^{-1})

The highest pooled data of cost of cultivation (₹48453.06 ha^{-1}) was recorded under the DSR (M_1) ratio along with (N4) 50% RDF +25% RDN through VC RDF + 25% through FYM (M_4N_1) treatment and the lowest pooled data of cost of cultivation (₹34285.97 ha^{-1}) under establishment methods SRI (M_4) along with (N_1)100% RDF (M_4N_1) pooled data of during both the years of experimentation. The similar finding was reported by [23,24].

3.9 Gross Return (₹ ha^{-1})

The highest pooled data of gross return (₹132300.6 ha^{-1}) was recorded under the SRI (M_4) ratio along with (N_1)100% RDF (M_4N_1) treatment and the lowest pooled data of gross return (₹112849.2 ha^{-1}) under establishment methods DSR (M_2) along with (N4) 50% RDF +25% RDN through VC RDF + 25% through FYM (M_2N_4) pooled data of during both the years of experimentation. The similar finding was reported by [25,26].

3.10 Net Return (₹ ha^{-1})

The highest pooled data of net return (₹98014.62 ha^{-1}) was recorded under the SRI (M_4) ratio along with (N_1)100% RDF (M_4N_1) treatment and the lowest pooled data of net return (₹64461.55 ha^{-1}) under establishment methods DSR (M_2) along with (N4) 50% RDF +25% RDN through VC + 25 % RDF through FYM (M_2N_4) pooled data during both the years of experimentation. The similar finding was reported by [23,27].

Table 1. Effect of crop establishment methods and fertility management on plant height at successive growth stages of rice

Treatments	Plant height (cm)							
	30 DAS		60 DAS		90 DAS		At harvest	
	2021	2022	2021	2022	2021	2022	2021	2022
Crop establishment Methods								
Transplanting	34.88	35.90	78.85	78.75	93.98	93.93	98.45	101.48
DSR	34.03	35.08	66.20	68.25	79.30	81.75	82.45	84.90
Drum seeder	34.53	35.55	70.48	72.63	84.80	87.38	87.38	90.03
SRI	35.35	36.38	80.15	82.68	96.35	99.40	100.00	102.88
SEm±	**0.77**	**0.79**	**1.67**	**1.73**	**1.96**	**1.99**	**2.09**	**2.18**
CD at 5%	**NS**	**NS**	**5.79**	**5.99**	**6.80**	**6.89**	**7.23**	**7.56**
Fertility levels								
100% RDF	36.40	37.43	79.68	82.10	95.73	98.63	99.45	102.48
75% RDF + 25% RDN through FYM	33.65	34.65	73.25	72.98	87.23	86.98	90.85	93.50
75% RDF + 25% RDN through VC	35.70	36.78	78.03	80.50	93.85	96.83	97.28	100.15
50% RDF + 25% RDN through VC RDF + 25% through FYM	33.03	34.05	64.73	66.73	77.63	80.03	80.70	83.15
SEm±	**0.64**	**0.65**	**1.34**	**1.29**	**1.77**	**1.79**	**1.66**	**1.60**
CD at 5%	**1.97**	**2.03**	**4.15**	**3.97**	**5.17**	**5.53**	**5.13**	**4.95**

Table 2. Effect of crop establishment methods and fertility management on number of tillers at successive growth stages of rice

Treatments	Number of tillers (m²)							
	30 DAS		60 DAS		90 DAS		At harvest	
	2021	2022	2021	2022	2021	2022	2021	2022
Methods of establishment								
Transplanting	212.74	218.99	273.45	284.40	303.85	315.95	300.83	312.85
DSR	207.55	213.96	242.00	251.70	268.85	279.70	266.23	276.89
Drum seeder	210.60	216.68	256.45	266.70	284.95	296.30	282.14	293.37
SRI	215.64	221.89	277.95	288.95	308.85	321.05	305.76	317.84
SEm±	**4.73**	**4.86**	**5.91**	**6.24**	**6.48**	**6.74**	**6.46**	**6.72**
CD at 5%	**NS**	**NS**	**20.48**	**21.62**	**22.**42	**23. 34**	**22.37**	**23.26**
Fertility levels								
100% RDF	222.04	228.29	280.85	292.10	312.05	324.50	308.96	321.30
75% RDF + 25% RDN through FYM	205.27	211.37	256.95	267.35	285.55	297.05	282.71	294.11
75% RDF + 25% RDN through VC	217.77	224.33	278.50	289.45	309.40	321.70	306.34	318.47
50% RDF + 25% RDN through VC RDF + 25% through FYM	201.45	207.71	233.55	242.85	259.50	269.75	256.94	267.07
SEm±	**3.85**	**4.86**	**4.81**	**4.74**	**5.58**	**5.85**	**5.54**	**5.76**
CD at 5%	**11.86**	**16.82**	**14.82**	**14. 61**	**17.19**	**18.05**	**17.07**	**17.76**

Table 3. Effect of crop establishment methods and fertility management on grain & Straw yield, biological yield and harvest index (%) of Rice (*Oryza sativa L*)

Treatments	Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Biological yield(q ha^{-1})		Harvest index (%)	
	2021	2022	2021	2022	2021	2022	2021	2022
Methods of establishment								
Transplanting	54.90	56.05	74.57	75.99	129.47	132.04	42.40	42.44
DSR	48.60	49.63	67.39	68.69	115.99	118.32	41.90	41.94
Drum seeder	51.50	52.58	71.13	72.46	122.63	125.04	42.00	42.05
SRI	55.80	56.96	75.74	77.04	131.54	134.01	42.42	42.50
SEm±	**1.17**	**1.19**	**1.62**	**1.67**	**2.77**	**2.83**	**0.93**	**0.94**
CD at 5%	**4.05**	**4.14**	**5.62**	**5.80**	**9.63**	**9.81**	**NS**	**NS**
Fertility levels								
100% RDF	56.40	57.58	77.09	78.52	133.49	136.10	42.24	42.30
75% RDF + 25% RDN through FYM	51.61	52.68	70.77	72.07	122.38	124.75	42.16	42.21
75% RDF + 25% RDN through VC	55.91	57.08	76.48	77.92	132.39	135.00	42.22	42.27
50% RDF + 25% RDN through VC RDF + 25% through FYM	46.90	47.88	64.47	65.68	111.37	113.56	42.10	42.15
SEm±	**0.99**	**1.03**	**1.32**	**1.29**	**2.34**	**2.44**	**0.77**	**0.76**
CD at 5%	**3.05**	**3.20**	**4.09**	**3.97**	**7.22**	**7.54**	**NS**	**NS**

Table 4. Effect of crop establishment methods and fertility management on the economics of rice crop

Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit cost ratio (B:C)
M_1N_1	36069.98	131254.9	95184.88	2.64
M_1N_2	39063.07	125622.3	86559.24	2.22
M_1N_3	45363.07	130680.4	85317.29	1.89
M_1N_4	48453.06	120093.1	71640	1.48
M_2N_1	36004.57	124011	88006.43	2.45
M_2N_2	38997.66	118337.7	79339.99	2.04
M_2N_3	45297.66	123436.5	78138.84	1.73
M_2N_4	48387.65	112849.2	64461.55	1.34
M_3N_1	35319.07	127401.9	92082.78	2.61
M_3N_2	38312.16	121768	83455.84	2.18
M_3N_3	44612.16	126827.4	82215.19	1.85
M_3N_4	47702.15	116240.1	68537.9	1.44
M_4N_1	34285.97	132300.6	98014.62	2.86
M_4N_2	37279.06	126666.8	89387.75	2.40
M_4N_3	43579.06	131727.4	88148.3	2.02
M_4N_4	46669.05	121138.8	74469.76	1.60

3.11 Benefit Cost Ratio (B:C)

The highest pooled data of benefit cost ratio(2.86 ha^{-1}) was recorded under the SRI (M_4) ratio along with (N_1)100% RDF (M_4N_1) treatment and the lowest pooled data of benefit cost ratio (1.34 ha^{-1}) under establishment methods DSR (M_2) along with (N4) 50% RDF +25% RDN through VC + 25% RDF through FYM (M_2N_4) pooled data during both the years of experimentation. The similar finding was reported by [15,23].

4. CONCLUSIONS

The following conclusions can be made based on the results mentioned previously:

- The System of Rice Intensification (SRI), among crop establishment methods, obtained the highest growth yield attributes and rice yield.

- The use of 100% RDF, which was deemed an acceptable fertility management method to improve rice's growth, yield attributes, and yield, was comparable to the use of 75% RDF+25% N through V.C at all phases of rice crop development.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous, Annual-Report. Indian Council of Agricultural Research (Ministry of Agriculture and Farmers Welfare; 2020-21.
2. Yadav V, Singh B. Effect of crop establishment methods and weed-management practices on rice (*Oryza sativa* L.) and associated weeds. Indian J. Agron. 2006;51(4):301-303.
3. Anonymous, Annual-Report. Indian Council of Agricultural Research (Ministry of Agriculture and Farmers Welfare; 2009.
4. Baboo K, Nand V. Effect of Crop Establishment Methods and Fertility Management on Growth Parameters of Rice (*Oryza sativa* L.). International Journal of Plant & Soil Science. Jun 19 2023;35(16):24-32.
5. Tomar R, Singh NB, Singh V, Kumar D. Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. J. Pharmacogn. Phytochem, 2018;7(2):520-527.
6. Tomar R, Singh NB, Singh V, Kumar D. Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. J. Pharmacogn. Phytochem, 2018;7(2):520-527.
7. Kumar Balwinder. Gupta RK, Bhandari AL. Soil Fertility Changes after Long-Term

Application of Organic Manures and Crop Residues under Rice-Wheat System. J. Indian Society of Soil Science. 2008;56(1): 80-85.

8. Kumar GN, Singh PK, Naresh RK, Chandra MS, Kumar A. Effect of Planting Techniques with Organic and Inorganic Nutrient Management on Growth, Yield Attributes and Productivity of Rice (*Oryza sativa* L.) under Rice-Wheat Cropping System. Journal homepage. 2021;10(01). Available:http://www. ijcmas. com
9. Tripathi MK, Majumdar B, Bhandari HR, Chaudhary B, Saha AR, Mahapatra BS. Integrated nutrient management in sunnhemp (*Crotalaria juncea*)-Rice cropping sequence in eastern Uttar Pradesh, India. Indian Journal of Agricultural Research. 2013;47(3):253-257.
10. Banik and Sharma All nutrients in vermin-compost are in readily available form, thereby, enhancing nutrients uptake by plants" All nutrients in vermin-compost are in readily available form, thereby, enhancing nutrients uptake by plants"; 2009.
11. Shekhar J, Mankotia BS, Dev SP. Productivity and economics of rice (*Oryza sativa*) in system of rice intensification in North-Western Himalayas. Indian Journal of Agronomy. 2009;54(4):423-427.
12. Meena RN, Singh SP, Kalyan Singh. Effect of organic nitrogen nutrition on yield, quality, nutrient uptake and economics of rice (*Oryza sativa*) - table pea (*Pisum sativum var. hortense*)- onion (*Allium cepa*) cropping sequence. Indian J. Agricultural Sciences. 2010;80(1):1003-6.
13. Choudhary AK, Suri VK. Effect of organic manures and inorganic fertilizers on productivity, nutrient uptake and soil fertility in rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) crop sequence in western Himalayas. Current Advances in Agricultural Sciences. 2009:1(2):65-69.
14. Husain MM, Haque MA, Khan MA I, Rashid MM, Islam MF. Direct wet-seeded method of establishment of rice under irrigated condition. The Agriculturists. 2003;1(1):106-113.
15. Jnanesha AC, Kumar. Effect of Crop Establishment Methods on Growth Yield And Water Productivity of Rice. International Journal on Agricultural Sciences. 2017;8(1):40-45.
16. Babu S, Marimuthu R, Manivannan V, Rameshkumar S. Effect of organic and inorganic manures on growth and yield of rice. Agricultural Science Digest, 2001;21(4):232-234.
17. Ram S, Chauhan RPS, Singh BB, SINGH, VP. Integrated use of organic and fertilizer nitrogen in rice (*Oryza sativa*) under partially reclaimed sodic soil. The Indian Journal of Agricultural Sciences. 2000; 70(2):114-116.
18. Sowmya C, Ramana MV. Performance of hybrids/high yielding varieties and nutrient management in system of rice intensification-a review. Agricultural Reviews. 2012*33*(1):1-15.
19. Anuradha S, Vijay B. Effect of different crop establishment methods on growth, yield and economics of rice (Oryza sativa L.). Environment and Ecology. 2010;28(1): 519-522.
20. Kumar V, Naresh RK, Tomar VK, Kumar R, Vivek KR, Yadav RB, Yadav OS. Growth, Yield and Water Productivity of Scented Rice (*Oryza sativa* L.) as Influenced by Planting Techniques and Integrated Nutrient Management Practice. International Journal of Current Microbiology and Applied Sciences. 2019; 8(06):2319-7706.
21. Stoop WA, Uphoff N, Kassam A. A review of agriculture research issue raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming system for resource-poor farmers. Agriculture system. 2002;71:249-274.
22. Mohanty TR, Maity SK, Roul PK. Response of rice to establishment methods and nutrient management practices in medium land 2014;51(2):136-142.
23. Mohanty TR, Maity SK, Roul PK. Response of rice to establishment methods and nutrient management practices in medium land. 2014;51(2):136-142.
24. Jnanesha AC, Kumar. Effect of Crop Establishment Methods on Growth Yield And Water Productivity of Rice. International Journal on Agricultural Sciences. 2017;8(1):40-45.
25. Kumar P, Choudhary SK, Singh A. Effect of Nitrogen Scheduling on Growth, Yield and Economics of Rice under Different Establishment Methods. International Journal of Current Microbiology and Applied Sciences. 2018;7:5153-5160.

26. Shinde SE, More SS. Gokhale NB, Patil KD. Evaluation of the rice hybrids grown under different INM practices for primary nutrients content and yield under lateritic soil of South Konkan. International J. Chemical Studies. 2017;5(6):970

27. Hugar AY, Chandrappa H, Jayadeva HM, Sathish A, Mallikarjun GB. Influence of different establishment methods on yield and economics of rice. Agricultural Science Digest. 2009; 29(3):202-205.

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