

“Effect of crop establishment methods and fertility management on growth, yield and economics of Rice (*Oryza sativa* L.)”

ABSTRACT

An experiment was conducted at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (Uttar Pradesh) during *Kharif* 2021 and 2022 in order to study the effect of crop establishment methods under fertility 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.*, (M₁) Transplanting rice (Conventional) (M₂) Direct seeded rice by line sowing (Conventional) (M₃) Drum seeded method under puddled condition, (M₄) System of Rice Intensification (SRI) method kept in main plots. However, four nitrogen levels *viz.* (N₁) 100% RDF (150: 60:40 kg N:P:K ha⁻¹), (N₂) 75% RDF +25% RDN through FYM, (N₃) 75 % RDF + 25% RDN through vermi-compost (VC), (N₄) 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 Vermicompost 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, and economics.]

INTRUCTION

“Rice belongs to the family Poaceae (Gramineae) and it is C₃ 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” [Anonymous, 2020-22].[2] “Rice is one of the most significant cereal crop, with more than 70 %of world’s population” [Yadav and Singh, 200].[1] “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” [Anonymous,2009].[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. 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 unpudded 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%” [Tomar *et al.* (2018).[5]

“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 soil susceptible to leaching and erosion. Therefore, these practices are essential to maintain and enhanced the soil quality and sustainability of an agro-ecosystem” [Kumar *et al.* (2008)] [23] FYM is rich in nutrients and contains 0.5% Nitrogen, 0.2% Phosphorus and 0.5% Potassium. FYM is used regularly as organic manure and it’s proved its ability in enhancing crop production due to improve the physiochemical properties of the soil (like- bulk density, water holding capacity and organic carbon content). It also had effect on residual phosphorus and potassium in soil. Farmyard manure (FYM) is an important source of organic manure in field crops because it provides all required plant nutrient and boosts soil microbial activity[Kumar *et al.* (2021)]. [4] “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” [Tripathi *et al.* (2013)] [7]. “All nutrients in vermin-compost are in readily available form, thereby, enhancing nutrients uptake by plants” [Banik and Sharma 2009].[6]

Materials and Methods

The experiment was laid out during *kharif* in 2021 and 2022 at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (Uttar Pradesh). Geographically, Ayodhya (Kumarganj) falls in sub-tropical climate and it is situated at 26.47° North latitudes, 82.12° East longitudes with an altitude of 113 meters above mean sea level. The experimental site is situated in main campus of university on left side of Ayodhya -Raebareli road at the distance of 42 km from Ayodhya district headquarter. The experimental plot was homogenous in fertility having assured irrigation and other required facilities. The climate of the district is semi arid with hot and dry summer and cold winter and falls under subtropical zone in Indo-Genetic Plains. This region receives an average annual rainfall of about 1200 mm, which is critically distributed. Rain is more often confined to the period from July to September. About 90% of the total rainfall is received from mid June to end of September. It appears from the analysis of the experimental field that the soil was slightly alkaline in reaction having pH (8.1) with electrical conductivity (0.34 dSm⁻¹). It is obvious from the data. The soil was low in organic carbon (0.34%), available nitrogen (180.0 kg ha⁻¹), medium in available phosphorous (16.5 kg ha⁻¹) and high in potassium (265.0 kg ha⁻¹). The experiment was laid out in split plot design with three replications. The treatment consisted of four crop establishment methods *i.e.*, Transplanting rice (Conventional) at 20x10 cm (M₁), Direct seeded rice by line sowing (Conventional) at 20x10cm spacing (M₂), Drum seeded under Puddled condition in forgnicaps 20x10cm spacing (M₃) and System of Rice Intensification (M₄) forgnicaps ni 25x25cm spacing and four nitrogen levels ,ziv100% RDF (150: 60:40 NPK kg ha⁻¹) (N₁), 75% RDF +25% RDN through FYM (2N), 75 % RDF + 25% RDN through V.C (3N) and 50 % RDF + 25 % RDN through V.C. + 25% RDN through FYM (4N). Sowing for sa deesDSR by drum seederlios delddup ni and DSR in line sowing, a seed rate of 30 kg/ha and 100 kg/ha was used for drum seeded and line sowing sdohtem, respectively. Seeds are shown on 5thJuly, 2021. ,sdohtam siht ni the seeds

were soaked in water for 24 hours for sprouting the seeds. The seeds were then incubated for 8-10 hours prior to sowing by a drum seeder on puddled soil. Puddling in drum seeded plots was done just before sowing of seeds by giving two cross ploughing with desi plough followed by planking in ponded water, after that sprouted seeds of rice were sown with drum seeder. In DSR by line sowing method seeds were hand sown in lines. In transplanting method 21 days old seedlings were transplanted in the SRI method 12 days old seedlings were transplanted. The sources of fertilizers were urea for N, DAP for P and MOP for K.

Growth:

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).

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 m² 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.

Yield attributing:

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.

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 weight 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.

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.

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.

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

Economics studies:

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.

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.

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)

Benefit-cost ratio:

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

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

Results and Discussion:

Plant height (cm)

Data on plant height as influenced significantly by effect of crop establishment methods and fertility management at successive growth stages of crop have been presented in Table 1. It clearly reveals that the rate of growth of the plant was initially slow and maximum rate of growth was observed between 30 to 60 DAS/DAT. The data showing the progressive increase in plant height continued till maturity. The increase in plant height was rapid during early crop growth period up to 90 DAS/DAT, and thereafter, a slow rate of increase in plant height was registered in all the treatment during both the years of experimentation. The maximum value of plant height was noted when rice seedling transplanted in system of rice intensification (SRI) method, which was at par with the transplanting method and was significantly superior over rest of the methods of crop establishment in rice at successive growth stages of rice, except 30 DAS/DAT during both the years of experimentation of crop. The reason for the tallest plants in the SRI method may be that the plant has sufficient space above the ground (branch) and below the ground (root) to grow

well, as well as better light transmission in the canopy [Shekar *et al.* (2009)]. [20] This condition stimulates cell division, resulting in more stem elongation, and maybe enhanced plant height when the SRI method of transplanting was used. [Tomar *et al.* (2018)].[5]

In case of fertility management, the maximum value of plant height was recorded with the application of 100% RDF (150:60:40 kg NPK ha⁻¹), which was at par with the application of 75% RDF + 25% N through Vermicompost (V.C) and recorded significantly higher value of plant height over rest of the treatments at 30 to 60, 90 DAS/DAT and at harvest during both the years of experimentation. 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 role of nitrogen in increasing plant height can be explained by the fact that nitrogen is the primary growth promoter element, assisting in increased food synthesis, which leads to increased cell division and cell enlargement. Similar effects of nitrogen on rice plant height were discovered by [Meena *et al.* (2003)].[21]

Number of tillers (m⁻²):

Data on number of tillers as influenced significantly by effect of crop establishment methods and fertility management at successive growth stages of crop have been presented in Table 2. 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.

The maximum number of tillers was noted when rice seedling transplanted in (M₄) system of rice intensification (SRI) method, which was at par with the (M₁) transplanting method, and was significantly superior over rest of the methods of crop establishment successive growth stages of rice, except 30 DAS/DAT during both the 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. [Choudhury *et al.* (2009)].[22]

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) (N₁), which was at par with 75% RDF + 25% N through V.C, and followed by 75% RDF + 25% RDN through FYM (N₂), 50 % RDF + 25 % RDN through V.C. + 25 % RDN through FYM (N₄). While the lowest number of tiller (m⁻²) was recorded with N₄ 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 [Shekar *et al.* (2009)]. [20] and

[Meena *et al.* (2003)]. [21]

Grain yield (q ha⁻¹)

As per the data on grain yield of rice as affected by crop establishment methods and fertility management are given in the Table.3. The maximum grain yield (55.80 and 56.96 (q ha⁻¹) was recorded under the system of rice intensification (SRI) method. Which was at par with transplanting method and found significantly superior over rest of two treatment in both the years of experimentation. The yield was enhanced in SRI method by 1.6% 7.70% and 12.90% respectively. The results are in agreement with those of [Husain *et al.* (2003)].[12] and [Jnanesha *et al.* (2017)].[19] Reported that the highest grain yield of SRI planting method was mostly the outcome of higher total number of tillers hill⁻¹, highest panicle length and highest number of grains panicle⁻¹.

The data pertaining to grain yield (q ha⁻¹) was significantly recorded under 100% RDF (150:60:40 kg npk ha⁻¹) which was at par with application 75% RDF + 25% N through V.C and followed by application 75% RDF +25% RDN through FYM . 50 % RDF + 25% RDN through [V.C.] + 25 % RDN through FYM. While the lowest grain yield was recorded with 50 % RDF + 25 % RDN through [V.C.] + 25 % RDN through FYM treatment both the years data. [Babu *et al.* (2001)].[17] and [Ram *et al.* (2000)].[18] found that higher yields under combined use of recommended dose of fertilizer inorganic NPK could be attributed, which favored better nutrient availability coupled with higher assimilation of nutrients and finally higher grain yield.

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 [Sowmya *et al.* (2012)]. [15] and [Anuradha *et al.* (2010)].[16]

The data pertaining straw yield was significantly maximum recorded under 100% RDF (150:60:40 kg npk ha⁻¹) which was at par with 75% RDF + 25% N through V.C followed by 75% RDF +25% RDN through FYM and 50 % RDF + 25 % RDN through [V.C.] + 25 % RDN through FYM .While the lowest straw yield was recorded with 50 % RDF + 25 % RDN through [V.C.] + 25 % RDN through FYM treatment during both year data. This may be probably due to higher plant height, density of tiller and increased rate of dry matter production. Similar findings were reported by [Kumar and Singh (2021)].[4]

Biological yield (q/ha):

Total dry matter accumulation (Grain + straw) by crop is an important index indicating the photosynthetic efficiency of crop and photosynthetic left behind after respiration which ultimately influences the crop yield. The data have been presented in Table-3. The data pertaining biological yield (q ha⁻¹)

was recorded maximum value under system of rice intensification (SRI) method, which was at par with transplanting method. The maximum biological yield 131.54 and 134.01 ($q\ ha^{-1}$) was recorded under the system of rice intensification (SRI) method. Followed by transplanting method of rice crop, respectively both year data. There was an increase in biological yield ($q\ ha^{-1}$) (0.04 and 0.14%), (1.24% and 1.33%) and (1% and 1.07%) on SRI method of crop establishment over transplanting, DSR by line sowing and drum seeder, during both the years, respectively. This might be due to adequate supply of water, which contributed to increasing in dry matter accumulation. Productivity of biological yield of a crop collectively determined by vigor of the vegetative growth, development as well as yield attribute. The similar findings were reported by [Kumar *et al.* (2019)]. [27]

The data pertaining biological yield ($q\ ha^{-1}$) was recorded significantly maximum under 100% RDF (150:60:40 kg npk ha^{-1}), which was at par with 75% RDF + 25% N through V.C and followed by 75% RDF +25% RDN through FYM and 50 % RDF + 25 % RDN through [V.C.] + 25 % RDN through FYM. While the lowest biological yield ($q\ ha^{-1}$) was recorded with N_4 treatment both year data. This might be due to improvement in yield attributing character and growth of crop at harvest stage in comparison to other fertility levels. The similar finding reported by [Kumar *et al.* (2021)]. [4] and [Tomar *et al.* (2018)]. [5]

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, the maximum harvest index (42.42 and 42.50 %) was recorded under the system of rice intensification (SRI) method, followed by transplanting method of rice crop, respectively during both year data. Harvest index is the function of grain yield to the total biological yield (grain+ straw). Basically, harvest index is a secondary data depends upon the crop's economic and biological yield. However, the higher harvest index was recorded with SRI method due to higher grain yield of rice per unit biological yield, led higher harvest index. Similar findings have also been reported by [Stoop (2005)] [11] and [Husain *et al.* (2003)]. [12]

The data pertaining harvest index (%) was recorded significant maximum under 100% RDF (150:60:40 kg npk ha^{-1}) which was at par with 75% RDF + 25% N through V.C and followed by 75% RDF +25% RDN through FYM and 50 % RDF + 25 % RDN through [V.C.] + 25 % RDN through FYM). While the lowest harvest index (%) was recorded with 50 % RDF + 25 % RDN through [V.C.] + 25 % RDN through FYM treatment during both year data. Fertility management practices also imposed a non-significant effect on harvest index of rice. The higher harvest index with the application of 100% RDF N by inorganic fertilizer was due to higher grain yield of rice per unit biological yield. This is also supported by the findings of [Mohanty *et al.* (2014)]. [8]

Economics studies

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

Cost of cultivation ($\text{₹}\ ha^{-1}$)

The highest pooled data of cost of cultivation ($\text{₹}\ 48453.06\ ha^{-1}$) was recorded under the DSR (M_1) ratio along with (N_4) 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 (M₄) along with (N₁)100% RDF (M₄N₁) pooled data of during both the years of experimentation. The similar finding was reported by [Mohanty *et al.*(2014)]. [8]and [Jnanesha *et al.* (2017).][9]

Gross return (₹ ha⁻¹)

The highest pooled data of gross return (₹ 132300.6 ha⁻¹) was recorded under the SRI (M₄) ratio along with (N₁)100% RDF (M₄N₁) treatment and the lowest pooled data of gross return (₹ 112849.2 ha⁻¹) under establishment methods DSR (M₂) along with (N₄) 50% RDF +25% RDN through VC RDF + 25% through FYM (M₂N₄) pooled data of during both the years of experimentation. The similar finding was reported by [Kumar *et al.* (2018)].[23] and [Sinde *et al.* (2017).][24]

Net return (₹ ha⁻¹)

The highest pooled data of net return (₹ 98014.62 ha⁻¹) was recorded under the SRI (M₄) ratio along with (N₁)100% RDF (M₄N₁) treatment and the lowest pooled data of net return (₹ 64461.55 ha⁻¹) under establishment methods DSR (M₂) along with (N₄) 50% RDF +25% RDN through VC + 25 % RDF through FYM (M₂N₄) pooled data during both the years of experimentation. The similar finding was reported by [Hugar *et al.* (2009)].[10] and [Mohanty *et al.* (2014).][25]

Benefit cost ratio (B:C)

The highest pooled data of benefit cost ratio (2.86 ha⁻¹) was recorded under the SRI (M₄) ratio along with (N₁)100% RDF (M₄N₁) treatment and the lowest pooled data of benefit cost ratio (1.34 ha⁻¹) under establishment methods DSR (M₂) along with (N₄) 50% RDF +25% RDN through VC + 25% RDF through FYM (M₂N₄) pooled data during both the years of experimentation. The similar finding was reported by [Jnanesha *et al.* (2017)]. [9] and [Mohanty *et al.* (2014).][25]

Table-2: 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 (m ²)							
	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 ₁ N ₁	36069.98	131254.9	95184.88	2.64
M ₁ N ₂	39063.07	125622.3	86559.24	2.22
M ₁ N ₃	45363.07	130680.4	85317.29	1.89
M ₁ N ₄	48453.06	120093.1	71640	1.48
M ₂ N ₁	36004.57	124011	88006.43	2.45
M ₂ N ₂	38997.66	118337.7	79339.99	2.04
M ₂ N ₃	45297.66	123436.5	78138.84	1.73
M ₂ N ₄	48387.65	112849.2	64461.55	1.34
M ₃ N ₁	35319.07	127401.9	92082.78	2.61
M ₃ N ₂	38312.16	121768	83455.84	2.18
M ₃ N ₃	44612.16	126827.4	82215.19	1.85
M ₃ N ₄	47702.15	116240.1	68537.9	1.44
M ₄ N ₁	34285.97	132300.6	98014.62	2.86
M ₄ N ₂	37279.06	126666.8	89387.75	2.40
M ₄ N ₃	43579.06	131727.4	88148.3	2.02
M ₄ N ₄	46669.05	121138.8	74469.76	1.60

CONCLUSIONS

On the basis of above results the following conclusions may be drawn:

- Among the crop establishment methods, the System of rice intensification (SRI) was achieved maximum growth yield attributes and yield of rice.
- The application of 100% RDF who found as suitable fertility management to enhanced the growth yield attributes and yield of rice which was at par with the application of 75% RDF+25% N through V.C at all the stages of rice crop.
- **COMPETING INTERESTS**
Authors have declared that no competing interests exist.

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