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*season 2021 -22 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.*, (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, (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.

Comment [TTS1]: Introduce the research gap, followed by aims, objectives and methodology. Then results, discussions and conclusions.

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

Formatted: Font: Italic

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 (*Oryzasativa* L.)mostlygrownin 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, 2020-21).[2] "Rice is one of the most significant cereal crop, with more than 70 %of world's population" (Yadav and Singh, 2006).[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 thecountry" (Anonymous,2009).[3] The area under rice crop in our country is about 47 m ha with a total production 132 million tonnesUSDA, 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 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%"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 soilless susceptible to leaching and erosion. Therefore, these practices are essential to maintained 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 itprovides 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]

Comment [TTS2]: Choose one type of referencing either Harvard or numeric

Materials and Methods

The experiment was laid out during *kharif*season 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^{0} North latitudes, 82.12^{0} 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 (M_1), Direct seeded rice by line sowing (Conventional) at 20×10cm spacing(M_2), Drum seeded under Puddled condition in fo gnicaps 20×10cm spacing(M_3) and System of Rice Intensification)M_4) fo gnicaps ni 25×25cm spacing and four nitrogen levels ,ziv100% RDF (150: 60:40 kpn kg ha -1) (N_1), 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 fo sa deesDSR by drum seeder lios 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 nIthe 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 ehtsowing of seeds by giving two cross ploughing with desi plough followed by planking in pounded water, after that sprouted seeds of rice were sown with drum seeder. In DSR by line sowing method seeds were hand sown in lines. nItransplanting dohtem 21 days old seeding were transplanted ni dna tnemtaert eht rep sa SRI method 12 days old seedling detnalpsnart saw .

stnemtaert eht rep sa deilppa erew srezilitref cinagro dna cinagroni lios fo ytilitef eht deniaitniam oT. The sources of fertilizers were urea for N, PADfor P and MOP for K.

Result and Discussion

Growth:

Plant height (cm):

The plant height was recorded at 30, 60, 90 DAS and at harveststage . 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 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.

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 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}.

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.

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

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]

IncaseIn case of fertility management, the maximum value of plant height were 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 Vermi-compost (V.C) and recorded significantly higher value of plant height over rest of the treatments at 30 to 60 DAS/DAT, 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 increasedatthe successivestagesof crop growthasinfluence effect of crop establishment methods and fertility management on rice. It clearly reveals that the rate ofgrowthofthetillerswasinitiallylowandmaximumnumberoftillerswasobservedduring 60to90DAS.Thedatashowingtheprogressiveincreaseofnumberoftiller(m^{-2})continued till 90 DAS after that reduced of number of tiller (m^{-2}) till maturity. The increasein number of tiller (m^{-2}) was rapidly during early crop growth period up to 90 DAS andafter that a reduced rate of increase in number of tiller (m^{-2}) was registered in all thetreatmentduringboth theyears of experimentation.

The maximum number of tillers was noted when rice seedling transplanted in (M_4) system of rice intensification (SRI) method, which was at par with the (M_1) 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 ofcrop growth. But at 30 DAS, there was non-significant difference in number of tiller (m^{-2}).However,maximumnumberoftiller(m^{-2})(222.04and228.29),(280.85and292.10),(312.05and324.50)and(308.96and321.30)at30,60,90DASandatharvestwasfound 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_4treatment during the boththe bothyears. 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) 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 (1998).

Biologicalyield(q/ha):

Total dry matter accumulation (Grain + straw) by crop is an important indexindicatingthephotosyntheticefficiencyofcropandphotosyntheticleftbehindafterrespiration which ultimately influences the crop yield. The data have been presented inTable-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 .~~method. The maximum biological yield (q ha^{-1}) 131.54 and 134.01 (q ha^{-1}) was recorded under the system of rice intensification (SRI) method. Followed by transplanting method~~ 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 byKumar *et al.* (2019).

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~~yield attributing character and growth of crop at harvest stage in comparison to other fertility levels. The similar finding reported byKumar *et al.* (2021)[4] and Tomar *et al.* (2018).[5]

Harvestindex (%)

Data pertaining the harvest index (%) are presented in Table.-3that 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 (₹ 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.

Costofcultivation (₹ ha^{-1})

The highest ~~pooleddata~~pooleddata of cost of cultivation (₹ 48453.06 ha^{-1}) was recorded under the DSR (M_1)ratioalongwith(N4)50% RDF +25% RDN through VC RDF + 25% through FYM (M_4N_1)treatment and the lowestpooled 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 duringboth the years of experimentation. The similar finding was reported by (Mohanty*et al.*2014 [8]and Jnanesha*et al.* (2017).[9]

Grossreturn (₹ ha^{-1})

The highest pooleddata of gross return (₹ 132300.6 ha^{-1}) was recorded under the SRI (M_4) ratioalongwith(N_1)100% RDF (M_4N_1) treatment and the lowestpooled 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 duringboth the years of experimentation. The similar finding was reported by Kumar *et al*. (2018)[23] and Sinde*et al.* (2017).[24]

Netreturn (₹ ha^{-1})

The highest pooled data of netreturn(₹ 98014.62 ha^{-1}) was recorded under the SRI (M_4) ratioalongwith(N_1)100% RDF (M_4N_1) treatment and the lowestpooled data of netreturn(₹ 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 duringboth the years of experimentation. The similar finding was reported by Hugar*et al*. (2009) and Mohanty*et al.* (2014).[25]

Benefit cost ratio (B:C)

The highest pooled data of benefit cost ratio(2.86ha^{-1}) was recorded under the SRI (M_4) ratioalongwith(N_1)100% RDF (M_4N_1) treatment and the lowestpooled 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 duringboth the years of experimentation. The similar finding was reported by Jnanesha*et al.* (2017)[9]andMohanty*et al.* (2014).[25]

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 (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 sativaL*).

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 theeconomicsofricecrop.

Treatments	Costof cultivation (₹ ha^{-1})	Grossreturn (₹ ha^{-1})	Netreturn (₹ 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

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.

Comment [TTS3]: You cannot conclude in a point form. Write a paragraph. Refer to aims and objectives of the research. Conclude based on results obtained

REFRENCES

1. Yadav, V. and Singh, B. 2006 Effect of crop establishment methods and weed- management practices on rice (Oryza sativa L.) and associated weeds. *Indian J. Agron.* 51(4):301-303.
2. Anonymous,(2020-21) Annual-Report .Indian Council of Agricultural Research (Ministry of Agriculture and Farmers Welfare.
3. Anonymous,(2009) Annual-Report .Indian Council of Agricultural Research (Ministry of Agriculture and Farmers Welfare.
4. Kumar, G. N., Singh, P. K., Naresh, R. K., Chandra, M. S., & Kumar, A. (2021) 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: http://www. ijcmas. com*, ***10*** (01).
5. Tomar, R., Singh, N. B., Singh, V., & Kumar, D. (2018). Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. *J. Pharmacogn. Phytochem*, ***7*** (2), 520-527.
6. Banik and Sharma 2009 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"
7. Tripathi, M. K., Majumdar, B., Bhandari, H. R., Chaudhary, B., Saha, A. R., &Mahapatra, B. S. (2013). Integrated nutrient management in sunnhemp (*Crotalaria juncea*)-Rice cropping sequence in eastern Uttar Pradesh, India. *Indian Journal of Agricultural Research*, ***47***(3), 253-257.
8. Mohanty, T. R., Maity, S. K. and Roul, P. K. 2014. Response of rice to establishment methods and nutrient management practices in medium land 51 (2): 136-142.
9. Jnanesha A.C. and Kumar, 2017. Effect of Crop Establishment Methods on Growth Yield And Water Productivity of Rice. *International Journal on Agricultural Sciences* **8** (1) : 40-45.
10. Hugar, A. Y., Chandrappa, H., Jayadeva, H. M., Sathish, A., &Mallikarjun, G. B. (2009). Influence of different establishment methods on yield and economics of rice. *Agricultural Science Digest*, ***29*** (3), 202-205.
11. Stoop WA, Uphoff N, Kassam A. (2002) 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.* 71:249-274.
12. Husain, M. M., Haque, M. A., Khan, M. A. I., Rashid, M. M., & Islam, M. F. (2003). Direct wet-seeded method of establishment of rice under irrigated condition. *The Agriculturists*, **1**(1), 106-113.
13. Kumar, G. N., Singh, P. K., Naresh, R. K., Chandra, M. S., & Kumar, A. (2021) 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: http://www. ijcmas. com*, ***10*** (01).
14. Tomar, R., Singh, N. B., Singh, V., & Kumar, D. (2018). Effect of planting methods and integrated nutrient management on growth parameters, yield and economics of rice. *J. Pharmacogn. Phytochem*, ***7*** (2), 520-527.
15. Sowmya, C., &Ramana, M. V. (2012). Performance of hybrids/high yielding varieties and nutrient management in system of rice intensification-a review. *Agricultural Reviews*, *33*(1):1-15.
16. Anuradha, S., & Vijay, B. (2010). Effect of different crop establishment methods on growth, yield and economics of rice (Oryza sativa L.). *Environment and Ecology*, ***28***(1), 519-522.
17. Babu, S., Marimuthu, R., Manivannan, V., &Rameshkumar, S. (2001). Effect of organic and inorganic manures on growth and yield of rice. *Agricultural Science Digest*, ***21*** (4), 232-234

18. Ram, S., Chauhan, R. P. S., Singh, B. B., & SINGH, V. P. (2000). Integrated use of organic and fertilizer nitrogen in rice (*Oryza sativa*) under partially reclaimed sodic soil. *The Indian Journal of Agricultural Sciences*, ***70***(2): 114-116.
19. Jnanesha A.C. and Kumar, 2017. Effect of Crop Establishment Methods on Growth Yield And Water Productivity of Rice. *International Journal on Agricultural Sciences* **8** (1) : 40-45.
20. Shekhar, J., Mankotia, B. S., & Dev, S. P. (2009). Productivity and economics of rice (*Oryza sativa*) in system of rice intensification in North-Western Himalayas. *Indian Journal of Agronomy*, *54* (4), 423-427.
21. Meena, R.N. Singh, S.P and Kalyan Singh. 2010. Effect of organic nitrogen nutrition on yield, quality, nutrient uptake and economics of rice (*Oryza sativa*) - table pea (*Pisumsativum var. hortense*)- onion (*Allium cepa*) cropping sequence. *Indian J. Agricultural Sciences*. **80** (1): 1003-6.
22. Choudhary, A.K. and Suri, V.K. 2009. Effect of organic manures and inorganic fertilizers on productivity, nutrient uptake and soil fertility in rice (*Oryza sativa* L.)-wheat (*Triticumaestivum*L.) crop sequence in western Himalayas. *Current Advances in Agricultural Sciences*, **1**(2): 65-69
23. Kumar, Balwinder. Gupta, R.K. and Bhandari, A.L. 2008. Soil Fertility Changes after Long-Term Application of Organic Manures and Crop Residues under Rice-Wheat System. *J. Indian Society of Soil Science*, **56** (1):80-85.
24. Kumar, P., Choudhary, S. K., & Singh, A. (2018). Effect of Nitrogen Scheduling on Growth, Yield and Economics of Rice under Different Establishment Methods. *International Journal of Current Microbiology and Applied Sciences*, ***7***, 5153-5160.
25. Shinde, S.E.; More, S.S. Gokhale, N.B. and Patil, K.D. 2017. 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*, **5** (6): 970-
26. Mohanty, T. R., Maity, S. K. and Roul, P. K. 2014. Response of rice to establishment methods and nutrient management practices in medium land 51 (2): 136-142.