Effect of crop establishment methods and fertility management on growth parameters 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 parameters *viz*. plant height (cm), number of tillers m^{-2}, dry matter accumulation (m^{-2}) and leaf area index 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, leaf area index, CGR, RGR, NAR, AGR and LAR, 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, leaf area index, CGR, RGR, NAR, AGR and LAR.

Introduction

"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" **(Anonymous, 2020-21).** "Rice is one of the most significant cereal crop, with more than 70 % of world's population" **(Yadav and Singh, 2006)**. "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).** 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 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%" **(Nainwal *et al*., 2013)**. "System of Rice Intensification (SRI) could improve rice plants as morphology and physiology and what would be theirimpact on resulting crop performance, compared with currently recommended scientific management practices (SMP) with SRI practices,grain yield was increased by 48% in these trials at the same time, significant improvements were observed in the morphology of SRI plants in terms of tiller number per hill, leaf area index" (LAI). **Thakur *et al.* (2014)**

"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" **(Carter *et al.* 2004)**. 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 **(Sutaliya and Singh, 2005). "**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" **(Bejbaruha *et al.* 2009)**. "All nutrients in vermin-compost are in readily available form, thereby, enhancing nutrients uptake by plants" **(Banik and Sharma 2009).**

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 spacing of 20×10cm spacing (M_3) and System of Rice Intensification (M_4) in spacing of 25×25cm spacing and four nitrogen levels *viz*, 100% RDF (150: 60:40 npk kg ha $^{-1)}$ (N_1), 75% RDF +25% RDN through FYM (N_2), 75 % RDF + 25% RDN through V.C (N_3) and 50 % RDF + 25 % RDN through V.C. + 25% RDN through FYM (N_4). Sowing of seed as DSR by drum seeder in puddled soil and DSR in line sowing, a seed rate of 30 kg/ha and 100 kg/ha was used for drum seeded and line sowing methods, respectively. Seeds are shown on 5thJuly, 2021. In this mathods, 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 the sowing 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. In transplanting method 21 days old seeding were transplanted as per the treatment and in SRI method 12 days old seedling was transplanted**.** To maintiained the fetility of soil inorganic and organic fertilizers were applied as per the treatments**.** The sources of fertilizers were urea for N, DAP for P and MOP for K.

Leaf area index (LAI):

The leaf area index was recorded at 30, 60 and 90 DSA/DAT. Plants were taken by placing a quadrate (50 cm×50 cm) randomly in each plot. The land area covered by the total leaves was measured with the help of automatic leaf area meter. After calculating total leaf area it was divided by the ground area in order to get leaf area index as per formula mentioned below:

$$\text{Leaf area index} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Ground area (cm}^2\text{)}}$$

Crop growth rate (CGR) (g m^{-2} day^{-1}):

Crop growth rate was computed with the help of following formula as suggested by (Blackman and black, 1955).

$$CGR = \frac{w2 - w1}{t2 - t1} \times \frac{1}{P}$$

Where,

W_1 = Total dry matter of crop plant at time interval t^1

W_2 = Total dry matter of crop plant at time interval t^2

Relative growth rate (g g^{-1}day $^{-1}$)

The relative growth rate (RGR) is termed as increase in the dry weight during a time span over its weight expressed is g g^{-1} day^{-1} formula suggested by Radford, 1967 used to work out the RGR is given below.

Relative growth rate (g g^{-1}day $^{-1}$) $= \frac{\log e\ W2 - \log e\ W1}{t2 - t1}$ (g g^{-1}day $^{-1}$)

Where,

$Log_e\ w^2$ and $log_e\ w^1$ were natural log dry matter produced at time t^2 and t^1 times respectively.

Net assimilation rate (g m^{-2} day^{-1})

It indirectly indicates the rate of net photosynthesis. It is expressed as g of dry matter produced per m2 of leaf area in a day. For calculating NAR, the total leaf area of crop has to be used but not the leaf area index. It was calculated at 30, 60 and 90 DAS intervals as per the formula given by Beadle (1987) and expressed in g m-1 day-1.

$$\text{Net assimilation rate (g } m^{-2} \text{ } day^{-1}) = \frac{(w2-w1)\times \log e\ L2 - \log eL1}{(t2-t1)\times L2-L1}$$

Where,

$L^1$and W^2 are leaf area and dry weight off plants at time t^1, and L^2 and W^2 are leaf area and dry weight off plants at ime t^2.

Absolute growth rate (AGR) :

It expresses the dry weight increase per unit time and is expressed in g/plant /day.

$$\text{Absolute growth rate (AGR)} = \frac{W2-W1}{t2-t1}$$

Where,

W^2 and W^1 are the total dry weights per plant at time t^2 and t^1 respectively.

Leaf area ratio (LAR) (gm^{-2} day^{-1}):

Leaf area ratio (gm^{-2} day^{-1}) is the ratio off assimilatory area per unit plant material (dry matter). It was calculated as per following formula

$$\text{Leaf area ratio} = \frac{\text{Leaf area}}{\text{Plant dry matter}}$$

Results and discussion

Leaf area index (LAI)

The leaf area index was influenced significantly by eaffect of crop establishment methods and fertility management at successive growth stages of crop have been presented in Table 1. In general, leaf area index was increased at higher rate from 30-60 DAS and then increased at slowest rate up to 90 DAS during the course of investigation. Leaf area index was significantly influenced by effect of crop establishment methods and fertility management of rice at all the successive growth stages of rice crop during both the years of experimentation. The maximum value of leaf area index was noted when rice seedling transplanted in system of rice intensification 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, exept 30 DAS/DAT during both the years of experimentaiton of crop. This might be due to increased rate of light absorption, high photosynthetic activities and increased absorption of nutrients from the soil. which results crop obtained higher number of tillers m^{-2} in SRI method causes increased the leaf area index . the similar trend was found Thakur *et al.* (2011) also observed that SRI improves soil health by providing a good amount of nutrients to crop which augment higher leaf area. Under SRI system there are single seedling per hill, no competition for nutrients between plant to plant and enough exposure for leaves to sunlight for photosynthesis, might be the reason for higher leaf area index.

incase of fertility management, the maximum value of leaf area index were recorded wtih the application of 100% RDF (150:60:40 kg npk ha^{-1}), which was at par with the applicationof 75% RDF + 25% N through V.C and recorded significantly higher value of leaf area index over rest of the treatments at 30, 60 and 90 DAS/DAT during both the years of experimentation. The lowest LAI was obtained when nitrogen was applied at the rate of 50 % RDF + 25 % RDN through V.C. + 25 % RDN through FYM at all growth stages of rice crop mainly due poor nutrient supply system from the organic sources. These findings were also supported by Pandey (1997). It was most likely related to the plant's short height, fewer leaves, low rate of light absorption, low photosynthetic activities, and low soil nutrient absorption (Uddin *et al.* (2013).

Crop growth rate (CGR) g m^{-2} day^{-1}

The crop growth rate was influenced significantly by crop establishment methods 30- 60 DAS/DAT, 60- 90 DAS/DAT except 90 at harvest DAS/DAT. While the fertility management was affected significantly between all the stages have been presented in Table -2. In general, Crop growth rate (CGR) was increased at higher rate from 30-60 DAS, 60- 90 DAS and then decreased at slowest rate up to 90 at harvest DAS during the course of investigation. The maximum value of crop growth rate was noted with system of rice intensification method, which was at par with the transplanting method and was significantly superior over rest of the treatment during both the years of experimentation. This was because of early vegetative growth due to planting of young seedlings raised in SRI and with better interception of solar radiation and greater net photosynthesis capacity might have contributed for higher crop growth rate. The similar trend was found (Afrina Rahman *et al.*, 2020).

Among the fertility management practices, the maximum value of crop growth rate were recorded wtih 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 V.C and found significantly higher over rest of the treatments at 30-60 DAS/DAT, 60-90 DAS/DAT and 90 at harvest DAS/DAT during the course of investigation. This might be due to inorganic nutrients easily available in the root zone resulting in absorption of more water, nutrient uptake and utilization by plant, which increased the metabolic process and performed better mobilization of synthesized carbohydrate into amino acid and proteins, which in turn stimulated rapid cell division and cell elongation and facilitated faster growth. The similar results reported by (Afrina Rahman *et al.*,2020)

Relative growth rate (g g^{-1}day $^{-1}$)

The relative growth rates between 30-60 DAS/DAT, 60- 90 DAS/DAT and 90- at harvest DAS/DAT were affected significantly by crop establishment methods and fertility management practiced are presented in Table-3. The relative growth rate (RGR) was increased at faster rate from 30-60 DAS/DAT, 60 90 DAS/DAT and then decrease between 90- at harvest DAS/DAT. The maximum value of crop growth rate was observed in system of rice intensification method, which was at par with the transplanting method and was significantly superior over rest of the treatment during both the years of experimentation. This might be due to early vegetative growth resulting planting of young seedlings raised in SRI and with better interception of solar radiation and greater net photosynthesis capacity might have contributed for higher relative growth rate. The similar results reported by (Preetam biswas *et al.*2023*)*

Among the fertility management practices, the maximum value of relative growth rate 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 V.C and found significantly higher over rest of the treatments at 30-60 DAS/DAT, 60-90 DAS/DAT and 90 at harvest DAS/DAT during the course of investigation. Relative growth rate (RGR) was high in the early stages and it started declining progressively with the aging of the crop. The reason of declining in relative growth rate (RGR) at the final stage can be associated to increasing of the dead and woody tissues than the alive and active tissues and decrease of leaf area index. Similar result was given by (Afrina Rahman *et al.*,2020).

Net assimilation rate (g m^{-2} day^{-1})

The net assimilation rate was affected significantly by crop establishment methods and fertility management at successive growth stages which are presented in Table-4. In general, net assimilation rate was increased at higher rate to up 30-60 DAS interval and then decreased at slowest rate to up 60-90 DAS/DAT during the course of investigation. Net assimilation rate was significantly affected by crop establishment methods and fertility management of rice at all the successive growth stages of rice crop during both the years. Net assimilation rate was significantly recorded higher under transplanting method (M_1) which was significant superior over with system of rice intensification method (M_4) ,DSR by drum seeder (M_3) and DSR by line sowing(M_2) methods at 30-60 DAS, 60-90 DAS. The maximum relative growth rate (0.447 and 0.460), (0.316 and 0.307) and (1.51 and 1.52) at 30-60 DAS/DAT and 60-90 DAS/DAT stage was recorded under the transplanting method (M_1) followed by system of rice intensification method (M_4), DSR by drum seeder (M_3) and DSR by line sowing(M_2) methods of rice crop, respectively both year data.

Net assimilation rate was significantly recorded higher under 100% RDF (150:60:40 kg npk ha^{-1}), which was significant superior over with 75% RDF + 25% N through V.C, 75% RDF + 25% RDN through FYM (N_2)and 50% RDF + 25% RDN through VC RDF + 25% through FYM (N_1). The maximum net assimilation rate (0.431 and 0.444) and (0.313 and 0.304) at 30-60 DAS/DAT and 60-90 DAS/DAT stage was recorded under the (M_1). While the lowest net assimilation rate was recorded with (M_4) treatment both year data. These results was reported by (Afrina Rahman *et al.*,2020). It was due to favorable environment in the root zone resulting in absorption of more water, optimum uptake and utilization of nutrient by plant, which increased the metabolic process and performed bettermobilization of synthesized carbohydrate into amino acid and proteins, which in turn stimulated rapid cell division and cell elongation and facilitated faster growth. The similar results reported by (Preetam biswas *et al.*,2023*)*.

Absolute growth rate (AGR):

The absolute growth rate was influenced by eaffect of crop establishment methods and fertility management at 30- 60 and-60 90 DAS been presented in Table-5. In general, absolute growth rate (AGR) was increased at higher rate from 30-60 DAS and then increased at slowest rate up to -60 90 DAS during the course of investigation. Absolute growth rate (AGR) was significantly influenced by effect of crop establishment methods and fertility management of rice at all the successive growth stages of rice crop during both theyears of experimentation. The maximum value of absolute growth rate was noted when rice seedling transplanted in system of rice intensification method, which was at par with the transplanting method and was significantly superior over rest of the methods of crop establishment in rice during both the years of experimentation of crop. SRI registered significantly higher absolute growth rate between 30-60 DAS over other establishment practices. This was because of early vegetative growth due to planting of young seedlings raised in SRI and with better interception of solar radiation and greater net photosynthesis capacity might have contributed for higher absolute growth rate. The similar results reported by (Afrina Rahman *et al.* 2020) and (Preetam biswas *et al.*2023*)*

incase offertility management the maximum value of ,absolute growth ratewere recorded wtih which was at par with the applicationof ,($^{1-}$kg npk ha 150:60:40)RDF %100the application of C and recorded significantly higher value of.N through V %25 +RDF %75absolute growth rate 30of the treatments at r restove-.he years of experimentationduring both t 60 The decline in AGR was possibly due to the raise of metabolically active tissue, which contributed less to the plant growth. The trend of AGR for fertility management was relatively equal but the higher AGR was observed in 60-90 DAS after that it reduced in all the treatments. It can be due to decrease in photosynthetic efficiency. The similar results reported by (Watson, 1958; Ghasal *et al.,* 2014)

Leaf area ratio (LAR) (gm^{-2} day^{-1}):

The leaf area ratio (LAR) was influenced significantly by crop establishment methods 30- 60 DAS/DAT, except 60- 90 DAS/DAT. While the fertility management was affected significantly between all the stages have been presented in Table-5. In general, leaf area ratio (LAR) was increased at higher rate from 30-60 DAS/DAT and then decreased at slowest rate up to 60- 90 DAS/DAT during the course of investigation. The maximum value of leaf area ratio (LAR) was noted with system of rice intensification method (SRI), which was at par with the transplanting method and was significantly superior over rest of the treatment during both the years of experimentation. This was because of early vegetative growth due to planting of young seedlings raised in SRI and with better interception of solar radiation and greater net photosynthesis capacity might have contributed for higher crop growth rate. The similar trend was found (Afrina Rahman *et al*., 2020).

Among the fertility management practices, the maximum value of leaf area ratio (LAR) 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 V.C and found significantly higher over rest of the treatments at 30-60 DAS/DAT and 60-90 DAS/DAT during the course of investigation. This might be due to inorganic nutrients easily available in the root zone resulting in absorption of more water, nutrient uptake and utilization by plant, which increased the metabolic process and performed better mobilization of synthesized carbohydrate into amino acid and proteins, which in turn stimulated rapid cell division and cell elongation and facilitated faster growth. The similar results reported by (Afrina Rahman *et al.*,2020)

Table-1: Effect of crop establishment methods and fertility management on leaf area index of rice.

	Leaf area index

Treatments	30 DAS		60 DAS		90 DAS	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**
Methods of establishment						
Transplanting (M_1)	2.38	2.42	4.89	5.06	5.25	5.42
DSR (M_2)	2.22	2.28	3.91	4.04	4.19	4.59
Drum seeder (M_3)	2.28	2.33	4.16	4.30	4.46	4.61
SRI (M_4)	2.39	2.44	4.94	5.10	5.30	5.47
SEm±	0.05	0.05	0.10	0.10	0.10	0.11
CD 5%	NS	NS	0.35	0.35	0.36	0.38
Fertility levels						
100% RDF (N_1)	2.43	2.53	4.89	5.08	5.28	5.48
75% RDF + 25% RDN through FYM (N_2)	2.24	2.30	4.45	4.55	4.76	5.12
75% RDF + 25% RDN through VC (N_3)	2.40	2.36	4.73	4.90	5.11	5.29
50% RDF + 25% RDN through VC RDF + 25% through FYM (N4)	2.20	2.28	3.83	3.97	4.06	4.20
SEm±	**0.04**	**0.04**	**0.07**	**0.09**	**0.09**	**0.10**
CD 5%	**0.13**	**0.13**	**0.23**	**0.27**	**0.29**	**0.30**

Table-2: Effect of crop establishment methods and fertility management on crop growth rate of rice.

Treatments	CGR (g m^{-2} day^{-1})		
	30-60	**60-90**	**90 At harvest**

	2021	2022	2021	2022	2021	2022
Methods of establishment						
Transplanting (M_1)	14.57	15.35	14.98	14.91	7.02	7.88
DSR (M_2)	10.62	11.28	11.75	11.86	5.42	6.26
Drum seeder (M_3)	11.64	12.16	12.55	12.60	5.96	6.70
SRI (M_4)	14.86	15.47	15.29	15.18	7.46	8.12
SEm±	**0.29**	**0.31**	**0.30**	**0.30**	**0.14**	**0.16**
CD 5%	**1.03**	**1.10**	**1.04**	**1.04**	**0.49**	**0.55**
Fertility levels						
100% RDF (N_1)	14.47	15.22	15.23	15.19	7.62	8.34
75% RDF + 25% RDN through FYM (N_2)	12.89	13.50	13.35	13.43	6.19	7.04
75% RDF + 25% RDN through VC (N_3)	13.87	14.68	14.58	14.52	7.10	7.88
50% RDF + 25% RDN through VC RDF + 25% through FYM (N_4)	10.46	10.86	11.42	11.40	4.95	5.69
SEm±	**0.23**	**0.22**	**0.26**	**0.27**	**0.12**	**0.14**
CD 5%	**0.71**	**0.68**	**0.82**	**0.85**	**0.38**	**0.45**

Table-3: Effect of crop establishment methods and fertility management on relative growth rate of rice.

Treatments	**RGR (g g^{-2} day^{-1}x10-^{3})**		
	30-60	**60-90**	**90 At harvest**

	2021	2022	2021	2022	2021	2022
Methods of establishment						
Transplanting (M_1)	16.24	16.64	7.63	7.37	2.57	2.78
DSR (M_2)	13.87	14.28	7.52	7.33	2.45	2.73
Drum seeder (M_3)	14.50	14.77	7.53	7.36	2.52	2.76
SRI (M_4)	16.51	16.90	7.68	7.40	2.63	2.82
SEm±	**0.34**	**0.35**	**0.04**	**0.01**	**0.03**	**0.02**
CD 5%	**1.19**	**1.23**	**0.01**	**0.05**	**0.10**	**0.08**
Fertility levels						
100% RDF (N_1)	15.95	16.46	7.71	7.50	2.74	2.92
75% RDF + 25% RDN through FYM (N_2)	15.62	15.82	7.56	7.34	2.49	2.74
75% RDF + 25% RDN through VC (N_3)	15.68	16.36	7.64	7.42	2.66	2.86
50% RDF + 25% RDN through VC RDF + 25% through FYM (N_4)	13.88	13.96	7.44	7.21	2.28	2.57
SEm±	**0.27**	**0.27**	**0.04**	**0.05**	**0.04**	**0.05**
CD 5%	**0.85**	**0.83**	**0.15**	**0.16**	**0.14**	**0.15**

Table-4: Effect of crop establishment methods and fertility management on net assimilation rate of rice.

Treatments	**NAR (mg cm^{-2} day^{-1}x10^{-3})**	
	30-60	**60-90**

	2021	2022	2021	2022
Methods of establishment				
Transplanting (M_1)	0.447	0.460	0.316	0.307
DSR (M_2)	0.385	0.400	0.315	0.306
Drum seeder (M_3)	0.401	0.412	0.313	0.305
SRI (M_4)	0.426	0.435	0.300	0.287
SEm±	**0.009**	**0.010**	**0.0007**	**0.001**
CD 5%	**0.032**	**0.034**	**0.002**	**0.003**
Fertility levels				
100% RDF (N_1)	0.431	0.444	0.313	0.304
75% RDF + 25% RDN through FYM (N_2)	0.424	0.436	0.311	0.301
75% RDF + 25% RDN through VC (N_3)	0.425	0.440	0.312	0.302
50% RDF + 25% RDN through VC RDF + 25% through FYM (N_4)	0.379	0.387	0.308	0.299
SEm±	**0.008**	**0.008**	**0.0003**	**0.0006**
CD 5%	**0.023**	**0.023**	**0.001**	**0.002**

Table-5: Effect of crop establishment methods and fertility management on absolute growth rate and leaf area ratio of rice.

Treatments	**AGR (g cm-^{2} day^{-1})**		**LAR (cm^{-1} g^{-1} day^{-1})**	
	30-60	60-90	30-60	60-90

	2021	2022	2021	2022	2021	2022	2021	2022
Methods of establishment								
Transplanting (M_1)	1.47	1.43	0.50	0.51	36.34	36.18	24.12	24.14
DSR (M_2)	1.07	1.11	0.44	0.45	35.96	35.69	23.85	23.88
Drum seeder (M_3)	1.20	1.24	0.48	0.49	36.13	35.84	24.02	23.93
SRI (M_4)	1.49	1.54	0.54	0.56	38.73	38.86	25.52	25.71
SEm±	**0.02**	**0.03**	**0.01**	**0.01**	**0.80**	**0.82**	**0.45**	**0.02**
CD 5%	**0.09**	**0.10**	**0.03**	**0.04**	**2.50**	**2.85**	**1.40**	**0.07**
Fertility levels								
100% RDF (N_1)	1.44	1.49	0.54	0.55	37.03	37.42	24.63	24.80
75% RDF + 25% RDN through FYM (N_2)	1.32	1.28	0.47	0.47	36.70	36.30	24.28	24.22
75% RDF + 25% RDN through VC (N_3)	1.41	1.46	0.53	0.54	36.90	36.83	24.50	24.56
50% RDF + 25% RDN through VC RDF + 25% through FYM (N_4)	1.06	1.09	0.43	0.44	36.53	36.01	24.11	24.08
SEm±	**0.02**	**0.02**	**0.008**	**0.009**	**0.10**	**0.20**	**0.10**	**0.16**
CD 5%	**0.08**	**0.07**	**0.026**	**0.027**	**0.31**	**0.59**	**0.34**	**0.50**

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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