Original Research Article

Evaluation of Crop Establishment Methods and Nano Urea Versus Conventional Urea on Growth Indices in Rice Crop (*Oryza sativa* L.)

ABSTRACT:

The present study aimed to evaluate Crop Establishment Methods and Nano Urea Versus Conventional Urea on Growth Indices in Rice Crop (*Oryza sativa* L.). Method of crop establishment influences the performance of rice through its effect on growth and development. Although, system of rice intensification has been reported to be the best establishment method. In traditional fertilizers, there is a huge loss of fertilizers by various manners like drift, leaching, runoff, microbial degradation, hydrolysis and photolysis. Bio accessibility of nutrients to plant is much lower relative to the rate of conventional fertilizers applied. The experiment was conducted during two consecutive seasons of *Kharif* 2022 and 2023 at the Agronomy Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.), India. The nitrogen level had significantly affected on crop growth rate, relative growth rate and net assimilation rate at all the stages of crop growth during both the years of investigations. The maximum Net assimilation rate at 30-60 and 60-90 DAS/DAT and crop growth rate, relative growth rate at 30-60, 60-90 and 90 to harvest DAS/DAT was recorded under 60% RDN through conventional Urea + 40% RDN through Nano Urea which was at par with 40% RDN through conventional Urea + 60% RDN through Nano Urea treatment, while significant over rest of the treatment during both the years of investigations.

Keywords: Nano urea, Conventional Urea, Crop Establishment Methods, Bio accessibility Rice Crop.

1. INTRODUCTION

"Rice (*Oryza sativa* L.) is one of the most important cereal crops of the Poaceae family, it is said to have come from South-East Asia. In both regions of the temperate region and the tropics. A variety of agricultural ecologies, including irrigated uplands, rain-fed lowlands, and rice habitats that are vulnerable to flooding are used to grow rice. In terms of area and output, India is the second-largest producer of rice in the world after China. Rice is cultivated World-wide over an area of about 167.24 million ha with an annual production of about 756.74 million tonnes and productivity 4.60 tone ha^{-1} in 2020-2021" (FAO,2021). "Rice is the most important staple food in Asia, providing on an average 32 % of total calorie uptake because of growing population, the demand for rice is expected to increase in the coming decades". Pingali *et al.* (1997).

"Method of crop establishment influences the performance of rice through its effect on growth and development"[15-17]. "Although, transplanting has been reported to be the best establishment method but due to high water and labour requirement, some alternatives like dry and wet direct seeding are being explored to ensure optimum yield at a lower cost. The results revealed that both transplanted and direct seeded method needed nearly equal investment on cultivation, but transplanted rice required more initial expenditure as compared to direct seeded rice". (Singh et al., 1997) Nanotechnology is one of the cornerstone technologies in the 21st century. In traditional fertilizers, there is a huge loss of fertilizers by various manners like drift, leaching, runoff, microbial degradation, hydrolysis and photolysis. Bio accessibility of nutrients to plant is much lower relative to the rate of conventional fertilizers applied. It also gives rise to air and water adulteration. Nutrient use efficiency for standard fertilizers rarely surpasses 30-40% i.e., NUE of conventional nitrogen (30-35%), phosphorus (18-20%), and potassium (35-40%). Shang *et al.* (2019). Nano fertilizer nutrient use efficiency (NUE) is high as it is delivered to the site according to the crop demand. Nano fertilizer nutrient release character is according to the crop absorption rate, unlike conventional fertilizer in which nutrient release rate is substantial than crop absorption rate, causing low fertilizer use efficiency and environmental jeopardy (Shang *et al.,* 2019).

2. MATERIALS AND METHODS

The experiment was conducted during two consecutive seasons of *Kharif* 2022 and 2023 at the Agronomy Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) which is situated on Ayodhya-Raebareli Road at the distance of 42 km from Ayodhya district head quarter. The experimental site falls under sub- tropical conditions with remarkable humidity and lies between 24.40 North latitude and 82.12^0 East longitudes with an altitude 113 meters above mean sea level. The experimental field was well leveled having good irrigation and drainage facilities. The source of irrigation was tube well. The experiment was layout in split plot design (SPD) with three replications taking three crop establishment methods direct seeded rice (DSR), System of Rice Intensification (SRI), transplanting rice in main plot and seven nitrogen level N_1: Control, N_2: 100% RDN through conventional Urea, N_3: 100% RDN through Nano Urea, N_4: 80% RDN through conventional Urea + 20% RDN through Nano Urea, N_5: 60% RDN through conventional Urea + 40% through Nano Urea, N_6: 40% RDN through conventional Urea + 60% through Nano Urea and N_7: 20% RDN through conventional Urea + 80% through Nano Urea in sub plot. Soil was sampled before sowing and after harvest of the crop to know the fertility status of the experiment field. The growth analysis was done as per standard procedures

2.1 Crop Growth Rate

It represents the dry weight gained by a unit area of crop in unit time. The crop growth rate (CGR) was estimated by using the formula suggested by Watson (1956) and expressed as g m^{-2} day^{-1}.

$$\mathrm{CGR} = \frac{1}{\mathrm{A}} + \frac{\mathrm{W}_2 - \mathrm{W}_1}{\mathrm{T}_2 - \mathrm{T}_1}$$

Where,

A is area, W_1 and W_2 Whole plant dry weight at T_1 and T_2 time, respectively.

2.2 Relative growth rate

The parameter indicates rate of growth per unit dry mater. It is similar to compound interest wherein the increment in any interval adds to the capital for subsequent growth. This rate of increment is known as relative growth rate (Fisher, 1921):

$$RGR = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}$$

Where,

W_1 = Weight of dry matter (g) at time t_1

W_2 = Weight of dry matter (g) at time t_2

t_2-t_1 = The interval in days

loge = Natural logarithms (Logarithms to the base of 2.3026)

Relative growth rate is expressed in g/plant/day

2.2 Net Assimilation Raate

It is an indirect expression of net photosynthesis. It represents the dry matter produced per square meter of leaf area per day). NAR is calculated by using the formula as suggested by Gregory (1917) and expressed as mass unit-1 leaf area present per unit time (g cm^{-2} day^{-1}).

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{Log_e\, LA_2 - Log_e LA_1}{LA_2 - LA_1}$$

Where,

W_1 and W_2 is dry weight of whole plant at time t_1 and t_2 respectively. LA_1 & LA_2 is the leaf area at times T_1 and T_2 respectively.

3. RESULTS AND DISCUSSION

3.1 Crop Growth Rate

Crop Growth rate was significantly affected due to crop establishment methods and nitrogen level in table 1and depicted in fig 1a and 1b. Crop growth rate of rice increased with crop age up to 60-90 DAS/DAT and there after declined in the present investigation.

Data further revealed that maximum crop growth rate (18.58 and 18.82, at 30-60 DAS/DAT during 2022 and 2023 respectively) recorded under SRI method and (10.40 and 10.55, 6.35 and 6.17 at 60-90 and 90-120 DAS/DAT during 2022 and 2023 respectively) recorded under SRI method which was at par with transplanted rice and direct seeded rice at 60-90 and 90-120 DAS/DAT while significantly higher than rest of the treatments during both years.

The nitrogen level had significantly affected on crop growth rate at all the stages of crop growth during both the years of investigations. Higher crop growth rate (18.65 and 18.60, 11.12 and 11.63, 7.25 and 7.05, 17.58 and 17.71, 11.68 and 11.18, 6.53 and 6.49) was noted with 60% RDN through conventional Urea + 40% RDN through Nano Urea treatment, which was at par with 40% RDN through conventional Urea + 60% RDN through Nano Urea and significantly superior over rest of the treatment at various interval of crop growth during both the years of investigations. Although, lowest crop growth rate was observed under control treatment at all the stages during both the years of investigation. The reason for this is that nano-urea increases the formation of chlorophyll, and the rate of photosynthesis leads to overall growth in the plant, which may lead to the formation of a greater number of leaves). "might due to the increased in leaf area, leaf number and vegetative growth of plants which increasing the photosynthetic activity; consequently, the higher dry matter produced and increased crop growth rate (CGR). The increase in CGR ultimately increases the total dry matter". Gulser, (2005) and kumar *et al.* (2021)

3.2 Relative growth rate

The data on rice relative growth rate recorded at 30-60, 60-90 and 90-120 DAS/DAT for both the cropping seasons has been presented in tables 2 and depicted in fig 2a and 2b clearly indicated that establishment methods and nitrogen level had significant effect on relative growth rate at all stages of crop growth during both the years of experiment.

Data further revealed that maximum relative growth rate (39.85 and 39.81 at 30-60 DAS/DAT respectively) recorded under SRI method which was at par with transplanted rice during both years and (14.43 and 14.44, 8.41 and 8.23 at 60-90, 90-120 DAS/DAT during 2022 and 2023 respectively) recorded under DSR method which was significantly higher than rest of the treatments during both years.

The nitrogen level had significantly affected in respect of relative growth rate at various intervals of crop growth during both the years, except between 90-120 DAS/DAT. The maximum relative growth rate was recorded under control between 60-90, 90-120 DAS/DAT, which was at par with N_1, N_2 and N_3 between 60-90 DAS/DAT during both the years of investigation. While, between 30-60 DAS/DAT the maximum relative growth rate (39.70 and 39.33 g g-1 day-1) was recorded with SRI method which significantly superior over rest of treatments. This might be due to higher plant height, leaf area index with maximum number of tillers contributed to the growth parameters of rice resulted in higher relative growth rate. As the result of maximum number of leaves resulted in high Leaf area index which will harvest maximum solar radiation within the canopy resulting in production of high dry matter in crop. The results are in close conformity. Baloch *et al.* (2007 and Tripathi *et al.* (2018)

3.3 Net Assimilation rate

The data on rice net assimilation rate recorded at 30-60 and 60-90 DAS/DAT for both the cropping seasons has been presented in tables 3 and depicted in fig 3a and 3b clearly indicated that establishment methods and nitrogen level had significant effect on net assimilation rate at all stages of crop growth during both the years of experiment.

Data further revealed that maximum net assimilation rate (3.45 and 3.50, 2.21 and 2.14 at 30-60 and 60-90 DAS/DAT during 2022 and 2023 respectively) recorded under SRI method which was at par with transplanted rice (3.31 and 3.35, 2.11 and 2.07 at 30-60 and 60-90 DAS/DAT during 2022 and 2023 respectively) and was found significantly superior over direct seeded rice at 30- 60 and 60-90 DAS/DAT during both the years.

The nitrogen level had significantly affected on net assimilation rate at all the stages of crop growth during both the years of investigations. The maximum Net assimilation rate at 30-60 and 60-90 DAS/DAT was recorded under 60% RDN through conventional Urea + 40% RDN through Nano Urea which was at par with 40% RDN through conventional Urea + 60% RDN through Nano Urea treatment, while significant over rest of the treatment during both the years of investigations. Increased in net assimilation rate enhances photosynthetic capacity of leaves with improved nutrition of the plants thereby increasing dry matter accumulation at final harvest. The results are in close conformity. Ahmad *et al.* (1990) and Meena *et al.* (2014)

4. Conclusions

It is concluded that, 60% RDN through conventional Urea + 40% RDN through Nano Urea which was at par with 40% RDN through conventional Urea + 60% RDN through Nano Urea treatment for different crop establishment methods and nitrogen levels was found better for all growth indices crop growth rate (CGR), relative growth rate (RGR), and net assimilation rate (NAR) under transplanted rice.

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1.

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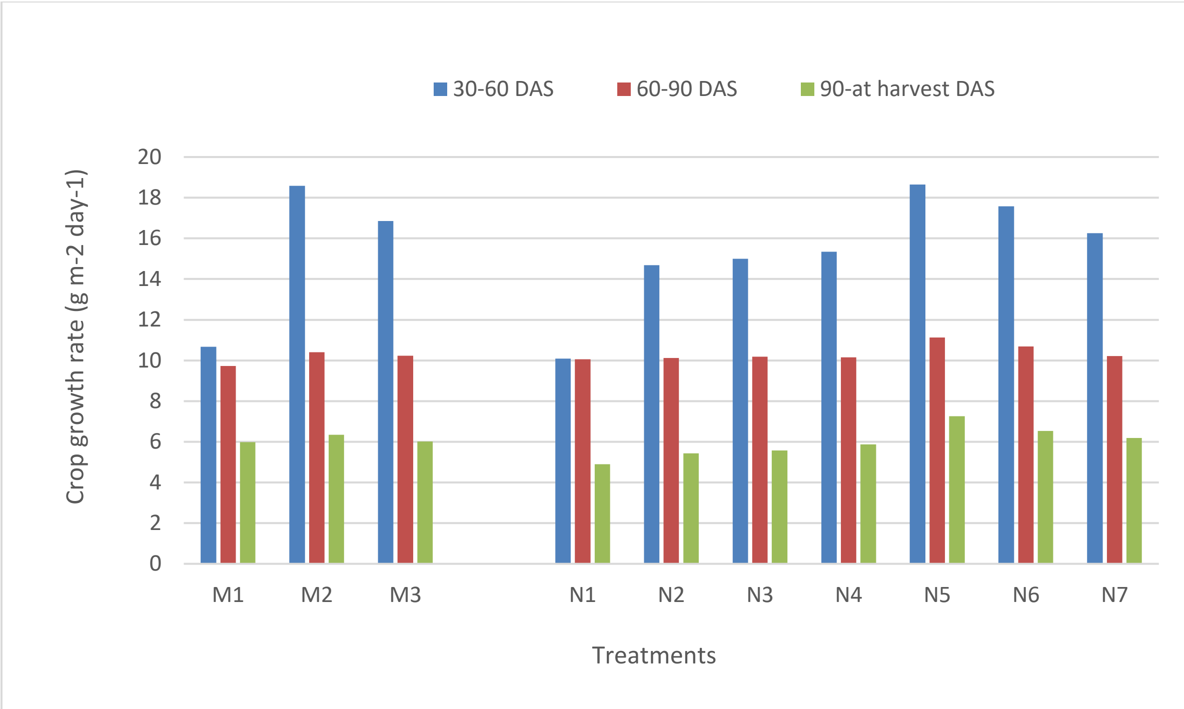

Fig. 1a. Effect of different crop establishment methods and nitrogen levels on crop growth rate (g m^{-2} day^{-1}) of rice during 2022

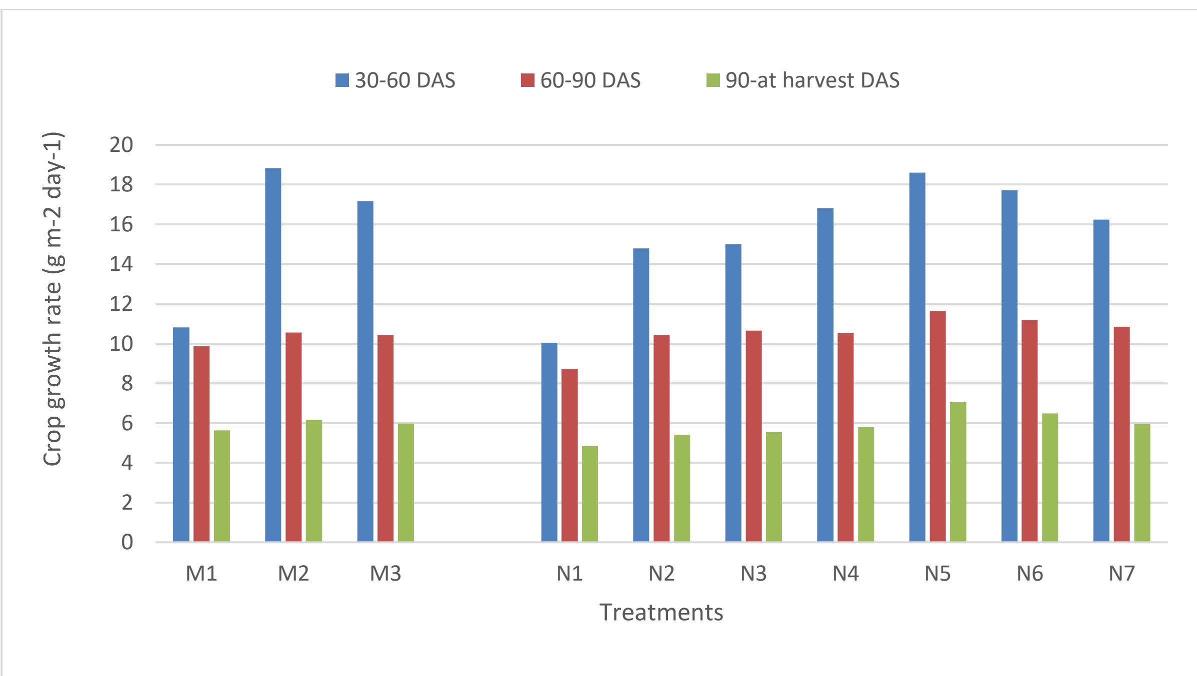

Fig. 1b. Effect of different crop establishment methods and nitrogen levels on crop growth rate (g m^{-2} day^{-1}) of rice during 2023

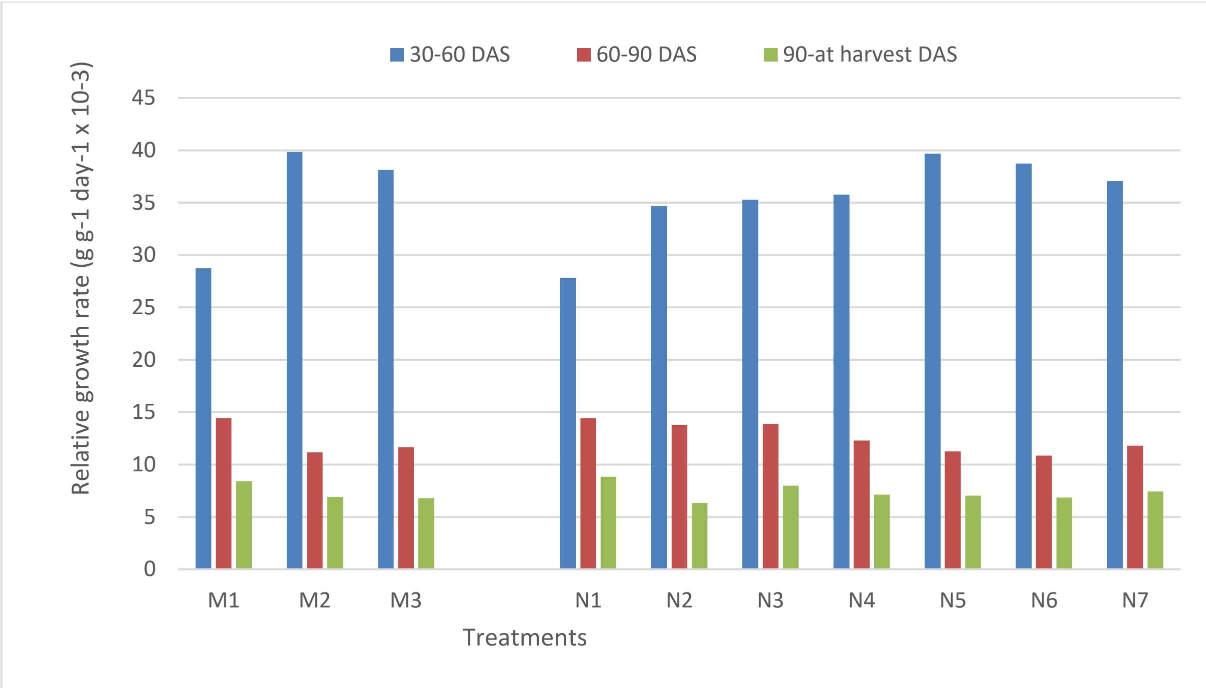

Fig. 2a. Effect of different crop establishment methods and nitrogen levels on relative growth rate (g g^{-1} day^{-1}) of rice during 2022

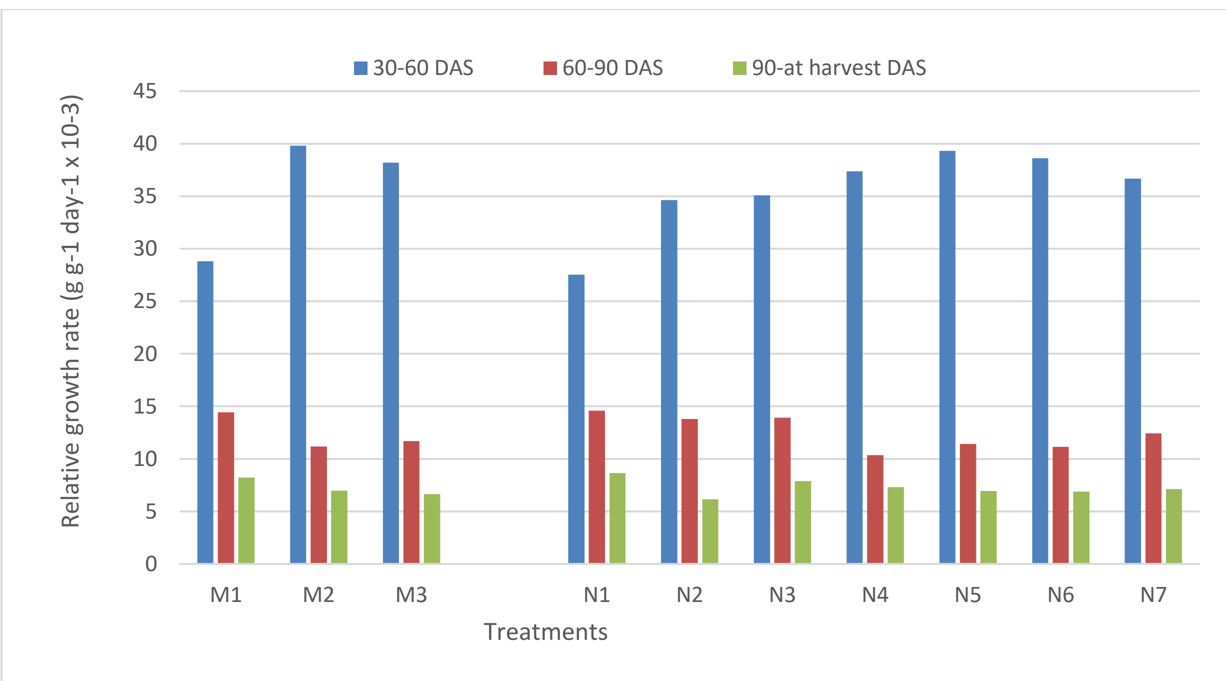

Fig. 2b. Effect of different crop establishment methods and nitrogen levels on relative growth rate (g g^{-1} day^{-1}) of rice during 2023

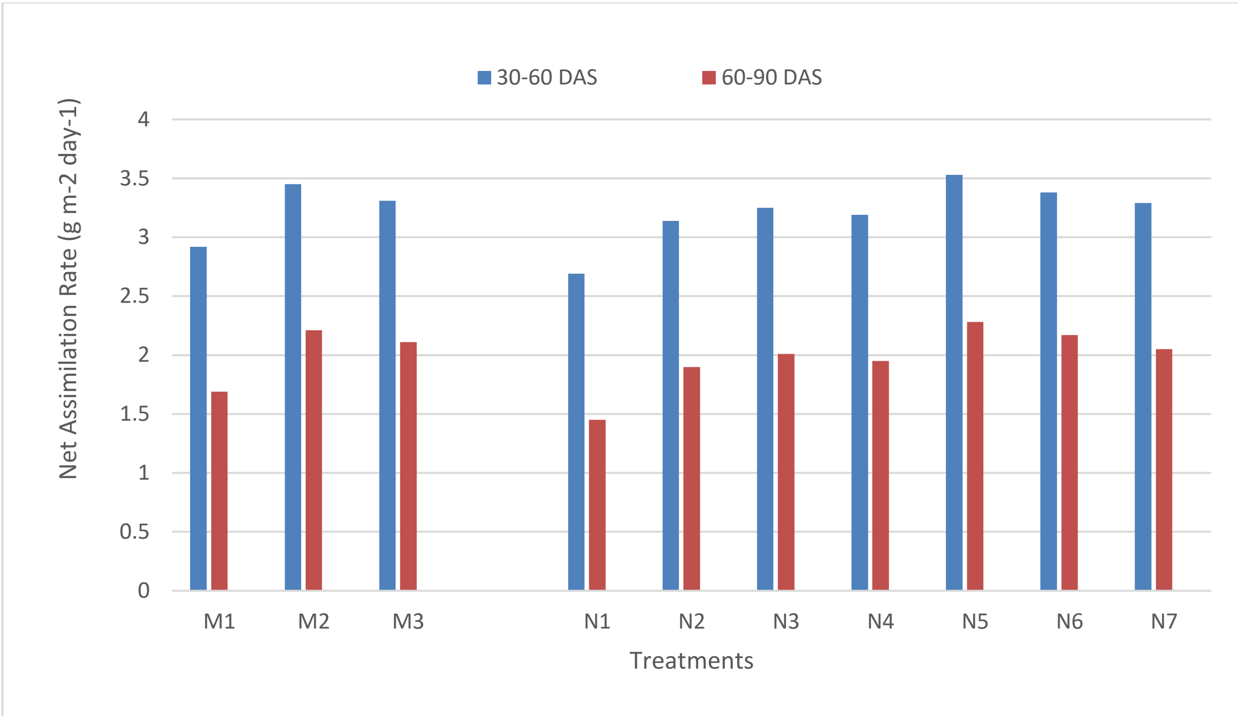

Fig. 3a. Effect of different crop establishment methods and nitrogen levels on net assimilation rate (g m^{-2} day^{-1}) of rice during 2022

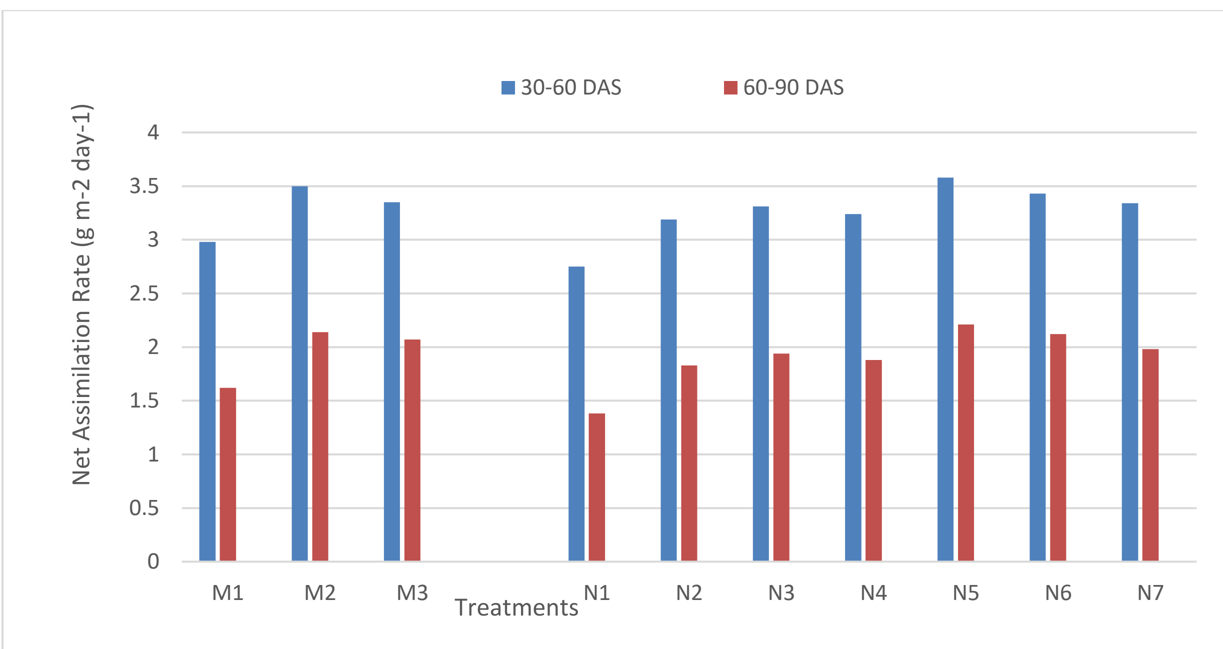

Fig. 3b. Effect of different crop establishment methods and nitrogen levels on net assimilation rate (g m^{-2} day^{-1}) of rice during 2023

Table 1. Crop growth rate (g m^{-2} day^{-1}) of rice as influenced by crop establishment methods and nitrogen levels.

Treatments	Crop growth rate (g m^{-2} day^{-1})					
	30-60		60 -90		90 - At harvest	
	2022	2023	2022	2023	2022	2023
Methods of crop establishment						
M_1: Direct Seeded Rice	10.67	10.81	9.73	9.87	5.98	5.64
M_2: System of Rice Intensification (SRI)	18.58	18.82	10.40	10.55	6.35	6.17
M_3: Transplanted Rice	16.86	17.17	10.23	10.43	6.01	5.97
SEm±	0.233	0.23	0.14	0.14	0.07	0.05
CD at 5%	0.94	0.94	0.56	0.58	0.29	0.24
Nitrogen Levels						
N_1: Control	10.09	10.04	10.05	8.72	4.89	4.85
N_2: 100% RDN through conventional Urea	14.68	14.78	10.12	10.43	5.43	5.41
N_3: 100% RDN through Nano Urea	14.99	15.00	10.19	10.66	5.58	5.55
N_4: 80% RDN through conventional Urea + 20% RDN through Nano Urea	15.35	16.81	10.15	10.52	5.87	5.79
N_5: 60% RDN through conventional Urea + 40% RDN through Nano Urea	18.65	18.60	11.12	11.63	7.25	7.05
N_6: 40% RDN through conventional Urea + 60% RDN through Nano Urea	17.58	17.71	10.68	11.18	6.53	6.49
N_7: 20% RDN through conventional Urea + 80% RDN through Nano Urea	16.26	16.23	10.22	10.84	6.18	5.96
SEm±	0.45	0.46	0.22	0.23	0.33	0.33
CD at 5%	1.29	1.31	0.63	0.65	0.94	0.94

Table 2. Relative growth rate (g g^{-1} day^{-1} x 10^{-3}) of rice as influenced by crop establishment methods and nitrogen levels.

Treatments	Relative growth rate (g g^{-1} day^{-1} x 10^{-3})					
	30-60		60 -90		90 - At harvest	
	2022	2023	2022	2023	2022	2023
Methods of establishment						
M_1: Direct Seeded Rice	28.75	28.82	14.43	14.44	8.41	8.23
M_2: System of Rice Intensification (SRI)	39.85	39.81	11.15	11.17	6.92	6.96
M_3: Transplanted Rice	38.13	38.18	11.66	11.70	6.79	6.64
SEm±	0.52	0.51	0.17	0.17	0.10	0.10
CD at 5%	2.08	2.07	0.68	0.69	0.41	0.41
Nitrogen Levels						
N_1: Control	27.83	27.52	14.44	14.59	8.85	8.64
N_2: 100% RDN through conventional Urea	34.66	34.62	13.78	13.81	6.33	6.15
N_3: 100% RDN through Nano Urea	35.28	35.09	13.87	13.93	7.99	7.89
N_4: 80% RDN through conventional Urea + 20% RDN through Nano Urea	35.77	37.38	12.29	10.34	7.14	7.30
N_5: 60% RDN through conventional Urea + 40% RDN through Nano Urea	39.70	39.33	11.24	11.43	7.03	6.93
N_6: 40% RDN through conventional Urea + 60% RDN through Nano Urea	38.75	38.62	10.86	11.16	6.84	6.88
N_7: 20% RDN through conventional Urea + 80% RDN through Nano Urea	37.06	36.66	11.80	12.44	7.43	7.14
SEm±	0.79	0.79	0.27	0.27	0.16	0.16
CD at 5%	2.27	2.27	0.78	0.82	0.46	0.45

Table 3. Net assimilation rate (g m^{-2} day^{-1}) of rice at different growth stages as affected by crop establishment methods and nitrogen levels.

Treatments	Net Assimilation Rate (g m^{-2} day^{-1})			
	30-60 DAS/DAT		60-90 DAS/DAT	
	2022	2023	2022	2023
Methods of establishment				
M_1: Direct Seeded Rice	2.92	2.98	1.69	1.62
M_2: System of Rice Intensification (SRI)	3.45	3.50	2.21	2.14
M_3: Transplanted Rice	3.31	3.35	2.11	2.07
SEm±	0.046	0.047	0.029	0.028
CD at 5%	0.18	0.19	0.12	0.11
Nitrogen Levels				
N_1: Control	2.69	2.75	1.45	1.38
N_2: 100% RDN through conventional Urea	3.14	3.19	1.90	1.83
N_3: 100% RDN through Nano Urea	3.25	3.31	2.01	1.94
N_4: 80% RDN through conventional Urea + 20% RDN through Nano Urea	3.19	3.24	1.95	1.88
N_5: 60% RDN through conventional Urea + 40% RDN through Nano Urea	3.53	3.58	2.28	2.21
N_6: 40% RDN through conventional Urea + 60% RDN through Nano Urea	3.38	3.43	2.17	2.12
N_7: 20% RDN through conventional Urea + 80% RDN through Nano Urea	3.29	3.34	2.05	1.98
SEm±	0.071	0.072	0.044	0.042
CD at 5%	0.20	0.21	0.13	0.12