Response of nutrient management on growth indices and grain yield of different crop establishment methods in rice (*Oryza sativa* L.)

ABSTRACT

A field experiment was conducted during two consecutive seasons of *kharif* 2021 and 2022 at Agronomy Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj Ayodhya (U.P.) to assess the effect of crop establishment methods and nutrient management on growth indices and yield of rice (*Oryza sativa* L.). The experiment was conducted in split plot design which comprised of four crop establishment methods *viz.* Transplanting (Conventional), DSR, Drum seeded, broadcasting sprouted seed under puddled condition and five nutrient management practices *viz*. Control, RDF (150:60:40 kg/ha NPK), RDF + Zn@5kg/ha, RDF + S@40 kg/ha, RDF + Zn + S (@5 + 40 kg/ha). The experiment was replicated three times. Significantly higher CGR, AGR, RGR and NAR growth and grain yield was recorded in transplanting methods during both the years of investigation. Among the nutrients management; higher value of all the growth indices and grain yield was recorded in 150:60:60 kg/ha NPK + Zn (5 kg/ha) + Sulphur (40 kg/ha).

Key words: *DSR, Drum seeder, grain yield, Growth indices, transplanted rice.*

INTRODUCTION

Rice (*Oryza sativa* L.) is a most important staple food crops in India as well as in the world. It plays a major role in food security. Rice is the major source of calories for 40 percent of the world population (Virdia and Mehta, 2009). In general, it is considered one of the fertilizers use efficient food crops besides being labour intensive. Recent advances in the development of varieties suiting to different rice eco systems, have offered opportunity to harvest higher yields. However, escalating costs of irrigation, labour, fertilizers, plant protection measures have contributed in bringing down the benefit–cost ratio of rice cultivation. As a result, research efforts have been made to develop cost effective technologies.

Crop establishment methods largely affects the performance of rice as a result of its growth and development. Rice cultivation in India is predominantly practiced under transplanting method that involves raising, uprooting and transplanting of seedlings. It is the most prominent and traditional method of establishment on low land irrigated area.

Nutrient-management practices play an important role in growth and development of rice. Proper utilization and combination of nutrients have a significant effect on the proper growth which in turn enhances its yield attributes and yield. As rice is the major nutrient draining crop, there will be huge deficit in the soil nutrients in rice-based cropping system. To overcome the problem and maintain soil fertility, there is need for integration of nutrients from organic and inorganic sources which can help in obtaining good crop yields as well as the production sustainability (Shankar *et al.* 2020).

Nitrogen is the most important nutrient in the productivity of rice. Worldwide N recovery efficiency for cereal production including rice is approximately 35%. Among the micronutrients, Zn deficiency is occurring in both crops and humans (White and Zasoski 1999). Zn deficiency results in the inability of rice plant to support root respiration during flooded conditions (Slaton et al. 2005). Sulphur is ranked as 4th most essential nutrient after nitrogen, phosphorous and potassium which plays a vital role in crop production. Sulphur as an essential mineral nutrient plays a key role in protein production, chlorophyll formation and oil synthesis.

MATERIALS & METHODS

A field experiment was conducted during *kharif* seasons of 2021 and 2022 at Agronomy Research farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), which is situated at latitude of 26˚47′ North and longitude 82˚12′ East and at an altitude of 113 metre above mean sea level. The climate of the site is semi-arid with hot summer and cold winter with average rainfall received during the cropping period (June-September) was 796.9 mm. The experiment was conducted in split plot design (SPD). Twenty treatment combinations which comprised of four crop establishment methods, M_1: Transplanting (Conventional); M_2: Direct seeded rice; M_3: Drum seeded under puddled condition and M_4: Broadcasting of sprouted seed under puddled condition were kept in the main plot while, five nutrient management practices N_0: Control; N_1: RDF (150:60:60 kg/ha NPK); N_2: RDF + Zn @5 kg/ha; N_3: RDF + Sulphur @40 kg/ha and N_4: RDF + Zn (5 kg/ha) + Sulphur (40 kg/ha), respectively were kept in sub plots and replicated three times in split plot design. Soil was sampled before sowing/transplanting and after harvest of the crop to know the fertility status of the experiment field. The growth analysis was done as per standard procedures;

Crop Growth rate was worked out by using the following formula proposed by Watson (1947) and expressed as g/m^2/day.

$$\mathbf{CGR} = \frac{\mathbf{1}}{\mathbf{A}} \times \frac{\mathbf{W_2 - W_1}}{\mathbf{T_2 - T_1}}$$

Where,

W_1 and W_2 are dry matter of crop (g) at time t_1 and t_2 respectively.

P= Ground area covered by crop (m^2).

Absolute growth rate is expressed in g/day was calculated as follow;

$$\mathbf{AGR} = \frac{\mathbf{W_2 - W_1}}{\mathbf{T_2 - T_1}}$$

Where,

W_2 and W_1 are the total dry weight of the plant (g) at time t_2 and t_1, respectively.

Relative Growth rate is expressed in g/g/day was calculated using the following formula suggested by Blackman (1919).

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

Where,

W_1 and W_2 are dry weight (g) of crop at time t_1 and t_2 respectively.

Net Assimilation Rate is expressed in g/cm^2/day was calculated by using the formula as suggested by Gregory (1917) and expressed as mass /unit leaf area per unit time (g/cm^2/day).

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

Where,

W_1 and W_2 is dry weight of 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.

RESULTS AND DISCUSSION

Crop Growth rate (CGR): Crop Growth rate was significantly affected due to crop establishment methods and nutrient management practices (Table-1). The higher crop growth rate (10.50 and 10.63 and 11.05 and 11.18 g/m^2/day) at 60-90 and 90-120 DAS/DAT was recorded with transplanting method of crop establishment treatment during both the years, which was at par with M_3 treatment except during second year of 60-90 DAS/DAT, while during 2021 higher CGR was recorded with M_1 (10.98 g/m^2/day) and in 2022, it was recorded with M_3 (11.43) being at par with M_1. However, the lowest CGR 9.45 and 9.76, 8.73 and 8.90 and 9.19 and 9.26 was recorded with M_4 at all the stages of crop growth.

Among the different nutrient management practices, higher CGR of 12.50 and 12.11, 12.88 and 12.58, 10.38 and 10.28, 10.59 and 10.37, 10.93 and 10.82, 11.02 and 10.91 was noted between 30-60, 60-90, 90-120 DAS/DAT stage with N_4 treatment which was at par with N_2 and superior over rest of the treatment. Although, lowest CGR was observed at all the stages during both the years of investigation.

This 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)

Table 1. Crop growth rate (g m^{-2} day^{-1}) of rice as affected by different crop establishment methods and Nutrient management

Treatments	Crop Growth Rate (g m^{-2} day^{-1})					
	30-60 DAS /DAT		60-90 DAS /DAT		90-120 DAS /DAT	
	2021	2022	2021	2022	2021	2022
Crop establishment methods						
M_1	10.98	11.35	10.50	10.63	11.05	11.18
M_2	9.70	10.13	9.29	9.37	9.78	9.86
M_3	10.96	11.43	9.89	9.97	10.4	10.49
M_4	9.45	9.76	8.73	8.90	9.19	9.26
SEm±	0.22	0.21	0.20	0.18	0.22	0.23
CD at 5%	0.77	0.73	0.69	0.63	0.76	0.78
Nutrient management practices						
N_0	5.25	5.42	7.06	7.17	7.44	7.54
N_1	10.65	11.10	10.07	10.15	10.60	10.68
N_2	12.11	12.58	10.28	10.37	10.82	10.91
N_3	10.87	11.34	10.23	10.31	10.77	10.85
N_4	12.50	12.88	10.38	10.59	10.93	11.02
SEm ±	0.20	0.20	0.21	0.19	0.22	0.20
CD at 5%	0.59	0.58	0.62	0.55	0.63	0.59

Absolute growth rate (AGR): Absolute growth rate (g day^{-1}) decreased with advancement of the crop growth and reaches to minimum between 90-120 DAS/DAT, irrespective of the treatment during both the years (Table-2). Between various treatment of crop, AGR of rice differed significantly due to crop establishment methods and nutrient management practices. The maximum AGR (1.07 and 0.97, 1.09 and 0.99, 0.50 and 0.47, 0.52 and 0.49, 0.29 and 0.28, 0.30 and 0.29) was recorded in M_1 at all the stages of crop growth. While, the minimum absolute growth rate was noted under M_4.

Among the different nutrient management practices, higher AGR of 12.50 and 12.11, 12.88 and 12.58, 10.38 and 10.28, 10.59 and 10.37, 10.93 and 10.82, 11.02 and 10.91 was noted between 30-60, 60-90, 90-120 DAS/DAT stage with N_4 treatment which was at par with N_2, while significant over rest of the treatment.

The higher growth rate with the combined use of organic and inorganic was due to rapid growth caused by adequate nutrient supply to the crops, which resulted in an increase of various metabolic processes and better mobilisation of synthesized carbohydrates in amino acids and proteins, which in turn increased the rapid cell division and cell elongation and allowing the plant to grow faster (Awan *et al.,* 2000 and Parasuraman 2005).

Table 2. Absolute growth rate (g day^{-1}) of rice as affected by different crop establishment methods and Nutrient management

Treatments	Absolute Growth Rate (g day^{-1})					
	30-60 DAS/DAT		60-90 DAS/DAT		90-120 DAS/DAT	
	2021	2022	2021	2022	2021	2022
Crop establishment methods						
M_1	1.07	1.09	0.50	0.52	0.29	0.30
M_2	0.90	0.92	0.45	0.47	0.27	0.28
M_3	0.97	0.99	0.47	0.49	0.28	0.29
M_4	0.84	0.87	0.44	0.46	0.26	0.27
SEm±	0.02	0.02	0.01	0.01	0.005	0.01
CD at 5%	0.07	0.07	0.03	0.03	0.01	0.02
Nutrient management practices						
N_0	0.6	0.62	0.33	0.34	0.15	016
N_1	0.96	0.97	0.46	0.48	0.27	0.27
N_2	1.06	1.08	0.52	0.54	0.34	0.35
N_3	0.99	1.05	0.48	0.51	0.27	0.29
N_4	1.11	1.12	0.54	0.55	0.36	0.37
SEm±	0.02	0.02	0.01	0.011	0.01	0.01
CD at 5%	0.06	0.05	0.03	0.03	0.02	0.02

Relative growth rate (RGR): Higher Relative growth rate (g/g/day) was recorded between 30-60 DAS/DAT and decreases with the advancement of crop growth irrespective of the treatment (Table-3). Between various treatment of crop, RGR of rice did not differed significantly due to crop establishment methods at various interval of crop growth, except between 30-60 DAS/DAT, while varied significantly due to nutrient management practices at various intervals of crop growth during both the years, except between 90-120 DAS/DAT.

Higher RGR was recorded in M_1 between 60-90, 90-120 DAS/DAT, while the minimum was under M_4, however between 30-60 DAS/DAT the maximum RGR (29.69 and

30.15 g/g/day) was found in M_3 which was at par with M_1 and M_2 and differed significantly with M_4 during both the years.

Among different nutrient management practices, the higher RGR was recorded under control between 60-90, 90-120 DAS/DAT, being on 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 RGR (32.37 and 32.60 g/g/day) was recorded under N_4 which differed significantly with rest of treatments.

Higher plant height, leaf area index with more number of tillers contributed to the growth parameters of rice resulted in higher RGR. As the result of more 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. Baloch *et al.*, 2006.

Table 3. Relative growth rate (g g^{-1} day^{-1}) of rice as affected by different crop establishment methods and Nutrient management

Treatments	Relative Growth Rate (g g^{-1} day^{-1})					
	30-60 DAS/DAT		60-90 DAS/DAT		90-120 DAS/DAT	
	2021	2022	2021	2022	2021	2022
Crop establishment method						
M_1	29.50	29.73	14.96	14.83	10.75	10.68
M_2	27.56	28.01	14.56	14.29	10.55	10.41
M_3	29.69	30.15	14.37	14.08	10.45	10.31
M_4	27.22	27.5	14.07	13.97	10.31	10.16
SEm±	0.61	0.64	0.32	0.35	0.24	0.22
CD at 5%	2.13	2.21	1.13	1.23	0.85	0.77
Nutrient management						
N_0	18.12	18.32	14.94	14.83	10.75	10.68
N_1	29.89	30.37	14.81	14.53	10.68	10.53
N_2	31.94	32.35	14.02	13.76	10.28	10.15
N_3	30.13	30.61	14.81	14.52	10.67	10.52
N_4	32.37	32.60	13.86	13.81	10.2	10.07
SEm±	0.53	0.64	0.28	0.31	0.21	0.20
CD at 5%	1.53	1.87	0.82	0.89	0.62	0.58

Net Assimilation Rate (NAR) and Grain yield: Higher NAR at 30-60 DAS/DAT was recorded under Drum seeded technique which was at par with transplanting method while 60-90 DAS/DAT highest NAR was recorded under transplanting method which was at par with Drum seeded technique while significant over rest both of the establishment method. Among different nutrient management practices, the higher NAR at 30-60 DAS/DAT was recorded under N_4 treatment which was at par with N_2 treatment while 60-90 DAS/DAT highest NAR was recorded under N_3 treatment which was at par with N_2 treatment while significant over rest of the nutrient management practices. Increased in net assimilation rate enhances photosynthetic capacity of leaves with improved nutrition of the plants thereby increasing dry matter accumulation at final harvest (Ahmad *et al.,* 1990).

Grain yield was recorded higher in transplanting method (51.25 and 52.54 q/ ha) which was at par with Drum seeded techniques while significantly superior over rest of the treatment during both the years (Table-4). Among different nutrient management practices, the higher grain yield was recorded under N_4 treatment which was at par with N_2 treatment both the year while significant over rest of the nutrient management practices.

Improvement in yield attributes may be ascribed to adequate and regular nutrients supplying capacity of the soil and translocation of nutrients to the sink. The improvement in yield and yield traits under higher level nutrients might be due to higher absorption of nutrients and increased photosynthesis activity leading to higher accumulation of biomass. Similar findings were also reported by Mahmud *et al.,* 2016.

Table 4. Net assimilation rate (g cm^{-2} day^{-1}) of rice as affected by different crop establishment methods and Nutrient management

Treatments	Net Assimilation Rate (g cm^{-2} day^{-1})				Grain yield (q ha^{-1})	
	30-60 DAS/DAT		60-90 DAS/DAT			
	2021	2022	2021	2022	2021	2022
Crop establishment method						
M_1	3.16	3.21	1.99	1.97	51.25	52.54
M_2	2.97	3.04	1.92	1.90	46.46	47.64
M_3	3.27	3.34	1.97	1.94	49.34	50.58
M_4	2.95	2.99	1.86	1.86	44.54	45.67
SEm±	0.067	0.062	0.048	0.044	0.96	0.89
CD at 5%	0.23	0.21	0.16	0.15	3.31	3.07
Nutrient management						
N_0	1.71	1.73	1.63	1.62	32.58	33.4
N_1	3.27	3.35	2.05	2.02	49.81	51.08
N_2	3.57	3.65	2	1.98	52.70	54.01
N_3	3.27	3.35	2.03	2	50.76	52.05
N_4	3.61	3.65	1.97	1.97	53.64	55
SEm±	0.070	0.063	0.042	0.039	0.98	0.95
CD at 5%	0.20	0.18	0.12	0.11	2.81	2.73

CONCLUSION AND RECOMMENDATIONS

Conclusively, transplanting of rice (Conventional) at 20 x 10 cm with application of RDF (150:60:60 kg/ha NPK) + Zinc (5 kg/ha) + Sulphur (40 kg/ha) recorded the higher value of growth indices, and grain yield of rice crop under agroclimatic condition of Eastern U.P.

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