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Influence of organic and inorganic sources of nutrients on growth parameters of rice (*Oryza sativa* L.)

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Abstract
The investigation involved the effect of organic and inorganic nutrients sources on rice to estimate their response on plant growth parameters of rice. In This study carried out in randomized block design with rice variety HUR105 having three replication and seven treatments i.e., (Control; NPK 00:00:00) T1, (Recommended Dose of Fertilizer: RDF; NPK 150:60:60)T2, (RDF+S:Zn:B 40:05:1.5) T3,(Customized fertilizer of Tata Chemical having N:P:K:Zn:B: 11:32:13:0.9:0.24% @ 375 kg ha^{-1}+179.34 kg ha^{-1} urea in splits) T4, (75% RDF +25% N through sewage sludge) T5, (75% RDF + 25% N through vermicompost) T6, (75% RDF +25% N through sesbenia (GM)) T7.Plants under treatments T3 and T4 having higher response on growth parameter viz. relative growth rate (RGR), net assimilation rate (NAR), leaf area index (LAI), crop growth rate (CGR) of rice during 2014-15 and 2015-16. Improvements were more in treatments which were provided with inorganic nutrients, that too when these were supplemented with S, Zn and B. Customized fertilizer of Tata Chemical (T4) was also effective in improving these parameters, but to a lesser magnitude than T3. It was evident that for optimal growth of rice in rice-wheat cropping system application of S, Zn and B @ 40:05:1.5 kg ha^{-1} for rice is essential. Replacements of 25% inorganic nitrogen by sewage sludge, vermicompost, and sesbania also improved studied growth parameters, and in all these treatments values of studied parameters were at par, but lower than those treatments which received only inorganic sources of nutrients (T2, T3 and T4).Specific leaf weight (SLW) under different applied nutrient levels, as compared to control, decreased; and indicated that added fertilizers (organic as well as inorganic) increased leaf area per unit dry matter of the leaf.

Keywords: Relative growth rate, net assimilation rate, leaf area index, crop growth rate and specific leaf weight

Introduction
Rice (*Oryza sativa* L.) is a staple food of more than 50% of the world's population (Fageria, 2007) [20] and supplies 20 and 31% of total calories required by world and the Indian population, respectively (Anonymous, 2011). Agricultural Policy Vision 2020 of Indian Council of Agricultural Research, India has projected 112 million tonnes of rice requirement in 2020, which is 23 million tonnes more than the present rice production. Additional rice will have to be produced from the existing rice area (41.9 million ha). Due to the extensive and improper use of chemical fertilizers in the soil, our soil is degrading to an alarming level, causing an imbalance in the ecosystem and environmental pollution as well. More recently, attention is being focused on the global environmental problems; utilization of organic wastes, FYM, compost, vermicompost and poultry manures as the most effective measure for the purpose. Organic materials are the safer sources of plant nutrient without any detrimental effect to crops and soil. Cowdung, farm yard manure, poultry manure and also green manure are excellent sources of organic matter as well as primary plant nutrients (Pieters, 2004) [1]. However, after the industrial revolution widespread introduction of inorganic fertilizers led to a decline in the use of organic material in the cropping systems (Rosegrant and Roumasset, 1988) [2]. The impact of increased fertilizer use on crop production has been large and important (Hossain and Singh, 2000) [3]. However, in recent years there has been serious concern about long term adverse effect of continuous and indiscriminate use of inorganic fertilizers on deterioration of soil structure, soil health and environmental pollution (Ghosh and Bhat, 1998; Shukla *et al*., 2006; Singh, 2000) [5, 21, 6]. The fact that use of green manures and other organic matter can improve soil structure, improve nutrient exchange and maintain soil health has again raised interest in organic farming (Ayoub, 1999; Becker *et al*., 1995) [7, 4]. Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients.

It was also indicated that poultry manure more readily supplies P to plants than other organic manure sources (Garg and Bahl, 2008) [9]. Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators (Parthasarathi and Ranganathan1999; Chaoui *et al*., 2003) [10, 11] and continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation (Zebarth *et al*., 1999) [22] as well as beneficial effect on the growth of a variety of plants (Atiyeh *et al*., 2002) [12]. In Bangladesh, most of the cultivated soils have less than 1.5% organic matter while a good agricultural soil should contain at least 2% organic matter. Evidences from different AEZ of the country have shown a decrease in the content of organic matter by the range of 15 to 30% over the last 20 years (Miah, 1994) [13]. Moreover, this important component of soil is declining with time due to intensive cropping and use of higher dose of chemical fertilizers with little or no addition of organic manure Use of organic manures alone, as a substitute to chemical inorganic fertilizer is not profitable and will not be enough to maintain the present levels of crop productivity of high yielding varieties (Garrity and Flinn, 1988). Therefore, integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is probably the most effective method to maintain healthy sustainable soil system. While increasing crop productivity (Janssen, 1993) [15]. Combined applications of both chemical and organic fertilizers need to be applied for the improvement of soil physical properties and supply of essential plant nutrients for high yield. However, it is necessary to carry out studies by using fertilizers and manures in an integrated way in order to obtain sustainable crop yield without affecting soil fertility.

Materials and Methods

The field experiment was conducted at the Agriculture Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during 2014-15 and 2015-16. The all laboratory related analysis was done in the Tissue Analysis Laboratory of the Department of Plant Physiology, Institute of Agricultural Sciences, BHU. The geographical situation of the farm lies in the Northern Gangetic Alluvial Plain at 25°18’ North latitudes, 83°03’ East longitude and at an altitude of 128.93 meters above the mean sea level. The experimental field was well drained with uniform topography and assured source of water supply for regular and timely irrigation. The experiment was conducted in field plots of size (8m × 2.8m) and distance between two plots was 1 m. The treatments were i.e., (Control; NPK 00:00:00) T1, (Recommended dose of fertilizer: RDF;NPK 150:60:60) T2, (RDF +S:Zn:B 40:05:1.5) T3, (Customized fertilizer of Tata Chemical N:P:K:Zn:B: 11:32:13:0.9:0.24% @375 kg ha^{-1} +179.34 kg ha^{-1} urea in splits) T4, 75% RDF +25% N through sewage sludge (T5), 75% RDF +25% N through vermicompost (T6), 75% RDF +25% N through sesbania (GM) (T7). 50% N was given as basal dose remaining in two equal splits at tillering and heading stages of rice by top dressing. All other nutrients were supplied as basal well before transplanting. 30 days old rice seedlings of variety HUR 105 were transplanted. The experiment was conducted in randomized block design (RBD) with three replications. Growth parameters were observed on rice plants taken at an interval of 20 days after transplanting to till maturity. The procedures which are involved to estimate the growth parameters of rice during 2014-15 and 2015-16 are follows:

(i) Relative growth rate (RGR)

Relative growth rate (rate of increase in the dry weight per unit time and per unit dry weight) was measured by Radford (1967) method between 20-40, 40-60, 60-80 and 80 days after transplanting to maturity stages and expressed as gg^{-1} $20day^{-1}$.

$$RGR = (\log_e W_2 - \log_e W_1)/(T_2 - T_1)$$

Where,
W_1= Dry weight (g $hill^{-1}$) at time T_1
W_2= Dry weight (g $hill^{-1}$) at time T_2

(ii)Net assimilation rate (NAR)

NAR (rate of dry matter increase per unit of leaf area per unit time) was measured by Radford (1967) method between 20-40, 40-60, 60-80 DAT stages and expressed as g cm^{-2} day^{-1} and calculated as follows:

$$NAR = (W_2 - W_1)/(T_2 - T_1) \times (\log_e A_2 - \log_e A_1)/(A_2 - A_1)$$

Where,
A_1 and W_1= Leaf area (cm) and dry weight (g $hill^{-1}$), respectively at time T_1
A_2 and W_2= Leaf area (cm) and dry weight ($ghill^{-1}$), respectively at time T_2

(iii) Leaf area index (LAI)

LAI was calculated by dividing the leaf area per hill with the land area occupied $hill^{-1}$ (Sestak *et al*. 1971). Land area under each hill was calculated by dividing plot area with number of hills in each plot. It was measured at 20, 40, 60, 80 DAT and maturity stages.

LAI = Leaf area/ Land area

(iv) Specific leaf weight (SLW)

SLW indicates the leaf thickness and was determined by the formula of Radford (1967). It was expressed as g cm^{-2}. SLW was measured at 20, 40, 60, 80 days after transplanting (DAT) stages.

SLW= Leaf dry weight (g) $hill^{-1}$/Leaf area (cm^2)$hill^{-1}$.

(v)Crop growth rate (CGR)

CGR is the rate of dry matter produced per unit of ground area per unit time (Watson, 1952). It was calculated by using formula given below and expressed as g cm^{-2} 20 day^{-1}. Land area under each hill was calculated by dividing plot area with number of hills in each plot. Dry matter produced $hill^{-1}$ in that ground area was used to calculate CGR. It was measured between 20-40, 40-60, 60-80 DAT and between 80 DAT to maturity stages.

$$CGR = [(W_2 - W_1)/(T_2 - T_1)] \times 1/A$$

Where,
W1 = Dry weight $hill^{-1}$ (g) at time T_1
W2 = Dry weight $hill^{-1}$ (g) at time T_2
A = Land area (cm^2) $hill^{-1}$

Statistical analysis
Statistical analysis was done by method of "Analysis of Variance" for factorial randomized block design. Critical differences were calculated at 5% level of significance in order to compare the treatment means (Gomez and Gomez, 1984) [16].

Experimental results
Relative growth rate (g g^{-1}20 days^{-1})
Relative growth rate (RGR) of rice genotype HUR-105 was analyzed between 20-40, 40-60, 60-80 DAT and 80 DAT to maturity stages during 2014-15 and 2015-16. During 2014-15 significance differences were recorded in RGR values with respect to treatment, stage and treatment ×stage (Table 1). Mean RGR was 1.39 g g^{-1} 20 days^{-1} which increase to 1.50 g g^{-1} 20 days^{-1} between 40-60 DAT and then declined sharply between 60-80 DAT. RGR further increase significantly between 80 DAT to maturity stage. This pattern was observed under all treatments. Mean RGR was the maximum (1.04 g g^{-1} 20 days^{-1}) in plants under T3 treatment and the minimum in plant under T1 (0.81 g g^{-1} 20 days^{-1}) treatment. Under different treatments mean RGR varied as: T3 >T4 = T7 >T2 = T5 =T6 >T1.Almost similar trends were recorded during 2015-16 (Table 1).

Table 1: Relative growth rate (g g^{-1}20 day^{-1}) in rice genotype HUR 105 at different stages of growth and treatments during 2014-15 and 2015-16.

S.No.	#Treatment	Year									
		2014-15				Mean	2015-16				Mean
		Days after transplanting					Days after transplanting				
		20-40	40-60	60-80	80-maturity		20-40	40-60	60-80	80-maturity	
1	T1	1.22	1.22	0.15	0.65	0.81	1.17	1.22	0.09	0.88	0.84
2	T2	1.38	1.55	0.17	0.95	1.01	1.42	1.43	0.30	0.92	1.02
3	T3	1.56	1.52	0.13	0.93	1.04	1.55	1.46	0.27	0.97	1.06
4	T4	1.54	1.53	0.11	0.95	1.03	1.46	1.45	0.23	0.99	1.03
5	T5	1.27	1.60	0.29	0.87	1.01	1.32	1.55	0.24	0.95	1.01
6	T6	1.35	1.55	0.27	0.86	1.01	1.33	1.53	0.30	0.92	1.02
7	T7	1.38	1.56	0.24	0.95	1.03	1.34	1.49	0.33	0.91	1.02
	Mean	1.39	1.50	0.20	0.88	0.81	1.37	1.45	0.25	0.93	0.84

Particular	S.Em±	CD (P≤0.05)	S.Em±	CD (P≤0.05)
Treatment	0.025	0.070	0.019	0.054
Stage	0.019	0.053	0.014	0.041
Treatment × Stage	0.049	0.139	0.038	0.108

#(Control; NPK 00:00:00) T1, (Recommended Dose of Fertilizer: RDF; NPK 150:60:60)T2, (RDF + S:Zn:B 40:05:1.5) T3,(Customized fertilizer of Tata Chemical having N:P:K:Zn:B: 11:32:13:0.9:0.24% @ 375 kg ha^{-1}+ 179.34 kg ha^{-1} urea in splits) T4, (75% RDF +25% N through sewage sludge) T5, (75% RDF +25% N through vermicompost) T6, (75% RDF +25% N through sesbenia (GM)) T7.

Net assimilation rate (mg cm^2 20 days^{-1})
Net assimilation rate (NAR) during 2014-15 registered significant differences with respect to treatment, stage, treatment × stage (Table 2). NAR was estimated between 20-40, 40-60 and 60-80 DAT. Mean NAR between 20-40 DAT was 12.52mg cm^2 20 days^{-1} with increase significantly to 18.77 mg cm^2 20 days^{-1} between 40-60 DAT and then declined sharply (4.21 mg cm^2 20 days^{-1}) between 60-80 DAT. When mean NAR value for plant under different treatments were determine; it was the maximum (13.47 mg cm^2 20 days^{-1}) for plants under T3 treatment and the minimum (9.90 mg cm^2 20 days^{-1}) in plants under T1 treatment. Mean NAR values under different treatments followed a trend as: T3 >T4 >T6 >T7 >T5 >T2 >T1.
During 2015-16 NAR values obtained were comparable with those recorded during 2014-15 (Table 2).

Table 2: Net assimilation rate (mg cm^2 20 day^{-1}) in rice genotype HUR 105 at different stages of growth and treatments during 2014-15 and 2015-16.

S.No.	#Treatment	Year							
		2014-15			Mean	2015-16			Mean
		Days after transplanting				Days after transplanting			
		20-40	40-60	60-80		20-40	40-60	60-80	
1	T1	13.67	13.60	2.64	9.97	11.46	14.50	1.45	9.13
2	T2	11.75	18.20	2.94	10.96	10.54	16.31	5.00	10.62
3	T3	14.60	20.63	5.16	13.47	8.88	20.30	4.63	11.27
4	T4	13.73	20.07	4.33	12.71	9.24	16.75	4.05	10.01
5	T5	10.54	19.50	5.35	11.80	10.97	19.73	4.26	11.65
6	T6	11.88	19.45	4.84	12.06	10.83	19.21	5.38	11.80
7	T7	11.49	19.96	4.22	11.89	10.85	19.31	5.98	12.05
	Mean	12.52	18.77	4.21		10.40	18.01	4.39	

Particular	S.Em±	CD (P≤0.05)	S.Em±	CD (P≤0.05)
Treatments	0.42	1.21	0.33	0.96
Stage	0.28	0.79	0.22	0.63
Treatment × Stage	0.73	2.09	0.58	1.65

#(Control; NPK 00:00:00) T1, (Recommended Dose of Fertilizer: RDF; NPK 150:60:60)T2, (RDF + S:Zn:B 40:05:1.5) T3,(Customized fertilizer of Tata Chemical having N:P:K:Zn:B: 11:32:13:0.9:0.24% @ 375 kg ha^{-1}+ 179.34 kg ha^{-1} urea in splits) T4, (75% RDF +25% N through sewage sludge) T5, (75% RDF +25% N through vermicompost) T6, (75% RDF +25% N through sesbenia (GM)) T7.

Leaf area index

Leaf area index (LAI) was estimated at 20, 40, 60 and 80 DAT during 2014-15 (Table 3). Mean values of LAI at 20 DAT, was 0.45 which increased steadily and attained the maximum (4.06) at 60 DAT and then declined (3.56) at 80 DAT. At all stages plants under T3 treatment registered the maximum LAI, while it was the minimum for plants under T1 treatment. Mean LAI values indicated a pattern as: T3 >T4 >T2 >T7 >T6 >T5 >T1. During 2015-16 similar trends were recorded (Table 3).

Table 3: Leaf area index in rice genotype HUR 105 at different stages of growth and treatments during 2014-15 and 2015-16.

S.No.	#Treatment	Year									
		2014-15				Mean	2015-16				Mean
		Days after transplanting					Days after transplanting				
		20	40	60	80		20	40	60	80	
1	T1	0.20	0.80	2.42	1.28	1.17	0.27	0.80	2.27	1.51	1.21
2	T2	0.42	1.55	4.28	3.67	2.48	0.57	1.75	4.24	4.12	2.67
3	T3	0.56	2.16	4.96	4.46	3.03	0.93	2.62	5.41	4.92	3.47
4	T4	0.51	1.73	4.85	4.30	2.85	0.91	2.30	5.10	4.65	3.24
5	T5	0.48	1.29	3.71	3.81	2.32	0.55	1.37	4.22	3.64	2.45
6	T6	0.48	1.25	4.05	3.66	2.36	0.55	1.37	4.10	3.88	2.47
7	T7	0.48	1.23	4.17	3.74	2.40	0.55	1.34	3.71	3.90	2.38
	Mean	0.45	1.43	4.06	3.56		0.62	1.65	4.15	3.80	
Particular		S.Em±	CD (P≤0.05)				S.Em±		CD (P≤0.05)		
Treatment		0.07	0.20				0.07		0.21		
Stage		0.05	0.15				0.06		0.16		
Treatment × Stage		0.14	0.40				0.14		0.41		

#(Control; NPK 00:00:00) T1, (Recommended Dose of Fertilizer: RDF; NPK 150:60:60)T2, (RDF +S:Zn:B 40:05:1.5) T3, (Customized fertilizer of Tata Chemical having N:P:K:Zn:B: 11:32:13:0.9:0.24% @ 375 kg ha^{-1}+179.34 kg ha^{-1} urea in splits) T4, (75% RDF +25% N through sewage sludge) T5, (75% RDF +25% N through vermicompost) T6, (75% RDF +25% N through sesbenia (GM)) T7.

Specific leaf weight (mg cm^2)

Specific leaf weight (SLW) was estimated between 20, 40, 60 and 80 DAT. Significant differences were recorded with respect to treatment, stage, treatment × stage during both years. During 2014-15 (Table 4), mean SLW was the minimum (3.76 mg cm^2) at 20 DAT and it increased steadily to the maximum (5.69 mg cm^2) at 80 DAT. SLW under different treatments also followed a similar trend. When mean SLW for different treatments were compared it was the maximum (5.51 mg cm^2) for plants under T1 treatment and the minimum (4.67 mg cm^2) in plants under T3 treatment. Mean SLW under different treatment followed a trend as: T1 >T6 >T7 >T5 >T2 >T4 >T3. During 2015-16 similar trends were recorded and values of both years were comparable. It was interesting to note that during both years plants under T1 treatments registered the highest SLW value and plants under T3 treatment the lowest (Table 4).

Table 4: Specific leaf weight (mg cm^2) in rice genotype HUR 105 at different stages of growth and treatments during 2014-15 and 2015-16.

S.No.	#Treatment	Year									
		2014-15				Mean	2015-16				Mean
		Days after transplanting					Days after transplanting				
		20	40	60	80		20	40	60	80	
1	T1	5.47	5.10	5.55	5.93	5.51	5.38	4.83	4.88	5.92	5.25
2	T2	3.46	4.54	5.69	5.50	4.80	2.98	4.07	5.51	5.48	4.51
3	T3	3.39	3.73	5.83	5.73	4.67	2.35	3.52	5.41	5.47	4.19
4	T4	3.26	4.89	5.35	5.56	4.76	2.35	3.91	5.57	5.34	4.29
5	T5	3.39	4.55	5.73	5.64	4.83	3.44	4.85	5.45	5.97	4.93
6	T6	3.74	5.10	5.70	5.80	5.09	3.37	4.77	5.61	5.75	4.87
7	T7	3.60	5.18	5.58	5.69	5.02	3.30	4.82	5.73	5.51	4.84
	Mean	3.76	4.73	5.63	5.69		3.31	4.39	5.45	5.63	
Particular		SEm±		CD (P≤0.05)			SEm±		CD (P≤0.05)		
Treatment		0.11		0.31			0.11		0.31		
Stage		0.08		0.23			0.08		0.23		
Treatment		0.22		0.61			0.22		0.62		

#(Control; NPK 00:00:00) T1, (Recommended Dose of Fertilizer: RDF; NPK 150:60:60)T2, (RDF + S:Zn:B 40:05:1.5) T3,(Customized fertilizer of Tata Chemical having N:P:K:Zn:B: 11:32:13:0.9:0.24% @ 375 kg ha^{-1}+ 179.34 kg ha^{-1} urea in splits) T4, (75% RDF + 25% N through sewage sludge) T5, (75% RDF +25% N through vermicompost) T6, (75% RDF + 25% N through sesbenia (GM)) T7.

Crop growth rate (g cm^2 20 days^{-1})

Crop growth rate (CGR) was determine between 20-40, 40-60, 60-80 DAT and 80 DAT to maturity stages during 2014-15 and 2015-16. Differences were significance with respect to treatment, stage, treatment × stage. During 2014-15 (Table 5), The mean CGR was 103.07 g cm^2 20 days^{-1} which increased with crop developmental stage and attain the maximum (1195.52 g cm^2 20 days^{-1}) between 80 DAT to maturity stage It was evident that as compared to other stages CGR increased the maximum between 80 DAT to maturity stage. When mean CGR under different treatments were comparing, it was maximum (586.13 g cm^2 20 days^{-1}) for plants under T3 treatment and the minimum (304.42 g cm^2 20 days^{-1}) for plants under T1 treatment. As compare to other treatments at all stages of plants under T3 treatment registered the maximum CGR while those under T1 treatment the minimum. The mean CGR followed a trends as: T3 >T4 >T7 >T2 >T5 >T6 >T1. During 2015-16 almost similar trends were recorded (Table 5).

Table 5: Crop growth rate (g cm^2 20 day^{-1}) in rice genotype HUR105 at different stages of growth and treatments during 2014-15 and 2015-16.

S.No.	#Treatment	Year									
		2014-15				Mean	2015-16				Mean
		Days after transplanting					Days after transplanting				
		20-40	40-60	60-80	80-maturity		20-40	40-60	60-80	80-maturity	
1	T1	58.50	198.33	47.00	913.83	304.42	56.33	205.17	40.17	951.50	313.29
2	T2	98.50	488.67	117.50	1169.50	468.54	111.00	458.00	208.33	1288.83	516.54
3	T3	150.67	628.83	118.00	1447.00	586.13	144.83	597.17	222.67	1548.00	628.17
4	T4	136.67	627.83	91.00	1419.67	568.79	138.33	587.00	195.17	1518.67	609.79
5	T5	86.17	473.67	200.67	1095.50	464.00	98.33	499.00	168.33	1273.83	509.88
6	T6	95.17	478.50	185.17	1091.50	462.58	96.83	477.00	214.67	1237.83	506.58
7	T7	95.83	479.50	165.83	1231.67	493.21	96.33	447.17	227.33	1187.17	489.50
	Mean	103.07	482.19	132.17	1195.52		106.00	467.21	182.38	1286.55	
Particular		**S.Em±**		**CD (P≤0.05)**			**S.Em±**		**CD (P≤0.05)**		
Treatment		18.75		53.32			16.51		46.93		
Stage		14.18		40.31			12.47		35.47		
Treatment × Stage		37.51		106.64			33.01		93.85		

#(Control; NPK 00:00:00) T1, (Recommended Dose of Fertilizer: RDF; NPK 150:60:60)T2, (RDF + S:Zn:B 40:05:1.5) T3,(Customized fertilizer of Tata Chemical having N:P:K:Zn:B: 11:32:13:0.9:0.24% @ 375 kg ha^{-1}+ 179.34 kg ha^{-1} urea in splits) T4, (75% RDF +25% N through sewage sludge) T5, (75% RDF +25% N through vermicompost) T6, (75% RDF +25% N through sesbenia (GM)) T7.

Discussion

Relative growth rates (RGR) (Table 1) and net assimilation rates (NAR) (Table 2), as compared to plants under T1 (NPK @ 00:00:00), were significantly higher in plants under other treatments. Therefore, on the basis of analyzed growth parameters (RGR and NAR), it is concluded that recommended doses of NPK though improved RGR and NAR but these parameter are further increased when S, Zn and B are supplied along with RDF, and thus, further signifies the role of S, Zn and B in enhancement of rice growth. Improved in NAR and RGR in rainfed rice under split application of potassium has also been reported by Thakur and Patel (1998). However, Sanjay Kumar *et al*. (2015) reported similar patterns in RGR and NAR in rice under similar treatments in rice-wheat cropping system. Dry matter production in plants is regulated by photosynthetic rate and duration of green leaf area. NAR estimates photosynthetic rate. NAR was higher in plants under T3 (RDF + S:Zn:B @ 40:05:1.5) and the values were comparable with T2 (RDF; NPK @ 150:60:60) and T4 (Tata Chemical N:P:K:Zn:B: 11:32:13:0.9:0.24%), as a result, total dry matter production as well as crop growth rate (CGR) (Table 5) has been higher in T3 (RDF + S:Zn:B @ 40:05:1.5) and T4 (Tata Chemical N:P:K:Zn:B: 11:32:13:0.9:0.24%) followed by T2 (RDF; NPK @ 150:60:60), T5 (75% RDF + 25% N through sewage sludge), T6 (75% RDF +25% N through vermicompost), T7 (75% RDF +25% N through sesbenia) and T1 (NPK @ 00:00:00). Thakur and Patel also (1998) reported that application of potassium is applied in split doses along with FYM improved CGR on account of increased LAI (leaf area index) and NAR in rainfed rice.

No literature is available to indicate the effect of different nutrient sources on specific leaf weight (SLW). SLW indicates the dry matter per unit leaf area or the leaf thickness per unit leaf area. It is well known that when nitrogen doses are increased leaf area is also increased but leaves become thinner. In present study under all treatments, except T1 (NPK @ 00:00:00), total amount of applied nitrogen remained unchanged, i.e., @ 150 kg ha^{-1}. Under such condition it was observed that mean SLW in plants under T1 was higher than rest of the treatments (Table 4). During 2014-15 and 2015-16, mean SLW was always lower in plants under T3 and values under T3 (RDF + S, Zn, B @ 40:05:1.5), T4 (Tata Chemical N:P:K:Zn:B:11:32:13:0.9:0.24%), T2 (RDF; NPK @ 150-60-60) and T5 (75% RDF + 25% N through sewage sludge) were almost comparable. Under stress condition, it is indicated that SLW is increased (Gong *et al*. 2003). It is concluded that plants under T1 experienced nutrient stress as a result SLW increased, while in other treatments higher (applied) N resulted in decreased SLW.

Conclusions

Growth parameters in rice crop studied under organic and inorganic source nutrient supply. Under inorganic and organic sources of nutrients having higher response on growth parameters of rice which was observed at each 20 days after transplanting. It was found following conclusion: Application of organic and inorganic sources of nutrients improved relative growth rate, net assimilation rate leaf area index, and crop growth rate. Improvements were more in treatments which were provided with inorganic nutrients, that too when these were supplemented with S, Zn and B. Customized fertilizer of Tata Chemical (T4) was also effective in improving these parameters, but to a lesser magnitude than T3. It was evident that for optimal growth of rice in rice-wheat cropping system application of S, Zn and B @ 40:05:1.5 for rice is essential. Replacements of 25% inorganic nitrogen by sewage sludge, vermicompost, and sesbania also improved studied growth parameters, and in all these treatments values of studied attributes/parameters were at par, but lower than those treatments which received only inorganic sources of nutrients (T2, T3 and T4).Specific leaf weight (SLW) under different applied nutrient levels, as compared to control, decreased; and indicated that added fertilizers (organic as well as inorganic) increased leaf area per unit dry matter of the leaf.

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