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Impact of Site Specific Nitrogen Management on Growth Parameters, Productivity and Profitability of *Kharif* rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out during kharif 2021 (June-November) and 2022 (June-November) at the Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, OUAT, Bhubaneswar. The experiment was laid out in randomized complete block design with twelve

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treatments i.e. T_1-RDF (80:40:40 kg N:P_2O_5:K_2O ha^{-1}), T_2 - 20 kg N ha^{-1} at LCC score <4 with no basal N, T_3 - 20 kg N ha^{-1} at LCC score <4 with 20 kg N ha^{-1} at basal, T_4 - 20 g N ha^{-1} at SPAD value <35 with no basal N, T_5- 20 kg N ha^{-1} at SPAD value <35 with 20 kg N ha^{-1} at basal, T_6- 20 kg N ha^{-1} at Green seeker (GS) >1.25 RI with no basal N, T_7- 20 kg N ha^{-1} at Green seeker (GS) >1.25 RI with 20 kg N ha^{-1} at basal, T_8- 150 kg N ha^{-1} (N rich strip plot), T_9- N omission plot, T_{10}- STBN, T_{11}- INM (20 kg N ha^{-1} as FYM at basal + 40 kg N ha^{-1} at tillering + 20 kg N ha^{-1} at PI stage), T_{12}- Organic nutrient (FYM 10t ha^{-1} at basal + 2t ha^{-1} VC top dressing). Pooled analysis revealed that application of 20 kg N ha^{-1} at Green seeker (GS) >1.25 RI with 20 kg N ha^{-1} at basal recorded maximum dry matter accumulation (1194.1 g m^{-2}), larger leaf area index (3.30), highest number of tillers (381 m^{-2}) at harvest and maximum CGR of 18.73 g m^{-2} day^{-1} during 60 to 80 DAT followed by the treatment receiving 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal. Combined analysis of both years showed that application of 20 kg N ha^{-1} at Green seeker (GS) >1.25 RI with 20 kg N ha^{-1} at basal recorded significantly higher grain yield (5.68 t ha^{-1}), straw yield (6.57 t ha^{-1}) and harvest index (47 %) with maximum net return 55982 Rs ha^{-1} and B:C ratio 1.82.

Keywords: LCC; SPAD; green seeker; CGR; productivity; profitability.

1. INTRODUCTION

Rice is a staple crop and a major source of livelihood for millions of people worldwide. The Asia-Pacific Region produces and consumes almost 90% of the world's rice. Seventy-five percent of the rice produced in Asia is produced on irrigated land, according to FAO [1]. The most significant and widely farmed crop in India is rice which takes up more than 44 million hectares of land.

Crop productivity is greatly influenced by nitrogen, a critical nutrient for plant growth. A sufficient amount of nitrogen encourages the production of chlorophyll, the green pigment necessary for photosynthesis. As a result of chlorophyll's ability to absorb sunlight and transform it into energy, plants are able to make carbohydrates and promote vegetative development. Given that it is necessary for the production of the proteins and enzymes involved in photosynthesis, it is an essential part of the photosynthetic machinery. Adequate nitrogen levels also promote cell expansion, allowing plants to grow taller develop larger leaves, and exhibit an overall robust vegetative structure. Nitrogen stimulates tillering, leading to the development of more tillers. Increased tiller numbers contribute to a higher number of panicles and consequently more potential for grain production.

Traditional blanket nitrogen application practices often lead to inefficient fertilizer use, nutrient imbalances, and environmental degradation. Nitrogen usage efficiency (NUE) has dropped to an unacceptable level due to an excessively high nitrogen use rate. Different renowned rice research institutes have introduced novel N-management techniques based on leaf priorities. For real-time N management, various decision support tools have been developed, including the leaf colour chart (LCC), soil plant analysis development (SPAD) chlorophyll metre, and Green Seeker (GS) optical sensors [2]. Farmers can optimize nitrogen treatment rates based on the unique requirements of different locations within a rice field by adopting site-specific nitrogen management practices. This method allows for more accurate and effective nitrogen fertilizer administration because it takes into consideration variables including soil fertility, crop demand and environmental conditions. So, when nitrogen fertilizer is used properly, it can result in increased plant height, tiller number, dry matter accumulation, leaf area, productivity and profitability. Therefore, the field experiment on “Impact of site specific nitrogen management on growth parameters, productivity and profitability of *kharif* rice” was conducted to monitor crop responses with the objective of improv growth parameters, productivity and profitability.

2. MATERIALS AND METHODS

The investigation was conducted during the *kharif* season of 2021 and 2022 (consecutively for two years) at Agronomy Main Research Farm of Odisha University of Agriculture and Technology, Bhubaneswar, Odisha. The soil of the experimental site was acidic and sandy loam in texture, low in available nitrogen (194.3 kg ha^{-1}) and organic carbon (0.53%), medium in available phosphorus (18.3 kg ha^{-1}) and medium in available potassium (185.3 kg ha^{-1}) with *p*H of 5.82 and EC of 0.21 dSm^{-1}. Treatments consisted of twelve site specific nitrogen management practices in *kharif* rice i.e. T_1 - RDF (N_2:P_2O_5:K_2O::80:40:40 kg ha^{-1}), T_2 - 20 Kg N ha^{-1} at LCC score <4 with no basal N, T_3 - 20 Kg N ha^{-1} at LCC score <4 with 20 Kg N ha^{-1} at basal, T_4 - 20 Kg N ha^{-1} at SPAD value <35 with no basal N, T_5- 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal, T_6- 20 Kg N ha^{-1} at Green seeker (GS) >1.25 RI with no basal N, T_7- 20 Kg N ha^{-1} at Green seeker (GS) >1.25 RI with 20 Kg N ha^{-1} at basal, T_8- 150 Kg N ha^{-1}(Sufficient level of N2), T_9- nitrogen omission plot, T_{10}- STBN (N_2:P_2O_5:K_2O::100:40:40 kg ha^{-1}), T_{11}- integrated nutrient management (20 Kg N as FYM at basal + 40 Kg N at tillering + 20 kg N at PI stage) and T_{12}- organic nutrient management (FYM 10t ha^{-1} at basal + 2t ha^{-1} VC top dressing). The experiment was conducted in randomized complete block design with three replications. Data was collected from different parameters as follows:

2.1 Plant Height

Height of the 10 tagged plants in each plot was measured at 20,40, 60, 80,100 DAT and at harvest from base of the plant to tip of the tallest leaf/panicle and the average was worked out in cm.

2.2 Tillers per m2

The tillers of 10 tagged hills in each plot were counted at 20,40, 60, 80,100 DAT and at harvest and averaged to express in per m^2 basis.

2.3 Leaf Area Index (LAI)

Leaf area index at 20,40, 60, 80 and 100 DAS was expressed as the ratio of actual leaf surface (one side only) to the ground area occupied by the crop (Watson, 1947) [3].

$$\mathrm{LAI} = \frac{\text{Total area of leaf surface}}{\text{Ground area occupied by the plant}}$$

The functional leaves (fully green or more than half of the lamina green only) were considered for computing LAI.

2.4 Dry Matter Accumulation

The uprooted plants (10 hills) from each treatment at 20,40, 60, 80,100 DAT and at harvest, were washed in water. Different plant parts i.e., leaf, stem and panicle (after panicle emergence) were separated and sun dried. The sun dried sample parts were oven dried at 70^0C for 48 hours and weighed. The mean weight of dry matter was converted to per m^2 basis.

2.5 Crop Growth Rate (CGR)

Crop growth rate (g m^{-2} day^{-1}) is the rate of dry matter production per unit ground area per unit time. [4].

$$\mathrm{CGR} = \frac{\mathrm{W2} - \mathrm{W1}}{\mathrm{t2} - \mathrm{t1}}$$

Where, W_1 and W_2 are the dry weight per unit area at time t_1 and t_2

2.6 Grain and Straw Yield

The crop was harvested on maturity (80-85% of the grains turned straw yellow) from the net plot leaving the border plants of 0.5 m in each end and 2 rows from each side. The produce of individual net plot was left in the field for drying for three days and then threshed separately treatment wise. The grain and straw yields were recorded after final sun drying for 3-4 days to maintain moisture content of about 10% in grains and 14% in straw. The values were converted to ton ha^{-1}.

2.7 Harvest Index (HI)

It denotes the ratio of economic yield (grain yield) to biological yield (grain + straw).

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (t/ ha)}}{\text{(Grain + straw yield)(t/ha)}} \mathrm{X}\ 100$$

2.8 Economics

The economics of various treatments was worked out taking into account the existing market rate of various production factors and produce during the course of investigation.

2.9 Cost of Cultivation (Rs ha^{-1})

Cost of cultivation for each treatment was calculated by using the rates of different agronomic practices and the inputs used in a particular treatment.

2.10 Net Returns (Rs ha^{-1})

To find out the most profitable treatment, economics of different treatments was worked out in terms of net returns (Rs ha^{-1}) by taking into account the cost of cultivation and gross returns per hectare. The cost of cultivation was subtracted from gross returns to find out net returns.

2.11 Benefit Cost Ratio (B:C)

Treatment wise benefits cost (B:C) ratio was calculated to ascertain economic viability using the following formula:

$$B:C = \frac{\text{Gross returns (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

3. RESULTS AND DISCUSSION

Observations on plant height, tiller number, dry matter accumulation, leaf area at different stages, grain yield, straw yield, cost of cultivation and net return of rice cultivation in *kharif* were taken during course of study. The detailed experimental findings of “Impact of site specific nitrogen management on growth parameters, productivity and profitability of *kharif* rice” on above mentioned characters are given below.

3.1 Plant Height

Data recorded on plant height of rice at different growth stages are presented in Table 1. The plant height increased successively with advancement in crop growth stages till harvest. The rate of increase in plant height was maximum during 40-60 DAT which coincided with reproductive stage of crop and it reached nearly plateau at the time of maturity. Pooled analysis suggested that significantly taller plant (129.8 cm) was recorded with application 150 Kg N ha^{-1} (Sufficient level of N_2) over other treatments and closely followed by the treatment receiving 20 Kg N ha^{-1} at green seeker (GS) >1.25 Response index with 20 Kg N ha^{-1} at basal (126.0 cm) and 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal (125.3 cm) at harvest. The shortest plant (107.5 cm) at harvest was found under the treatment nitrogen omission plot and also followed the same trend in other growth stages.

Nitrogen increases the chlorophyll content at all growth stages as it is a constituent and might have increased the photosynthesis and resulted in increased plant height. Significant increase in plant height might be due to increase in mobilization of higher nitrogen, resulting in more chlorophyll content, higher photosynthesis and finally taller plant height. Further, greater availability and steady release of nutrients from inorganic sources of nitrogen might have enabled the recovery of plant height towards reproductive stage. Manzoor et al. [5] also reported similar results with increasing plant height with higher nitrogen application and attributed to enhance the vegetative growth. Again, the maximum plant height might be ascribed to applied nitrogenous fertilizer which accelerated the metabolic and physiological activity of the plant and put up more growth by assimilating more amounts of major nutrients and ultimately increased the plant height. These results are in close conformity with findings of Pramanik and Bera [6] and Kumar et al*.* (2017) [7].

Table 1. Plant height (cm) of rice as influenced by Site specific nitrogen management

Treatment	**Days after transplanting**					
	20	**40**	**60**	**80**	**100**	**Harvesting**
RDF	32.9	70.8	109.6	117.6	120.6	121.2
LCC BN-0	21.5	66.6	112.3	120.3	123.3	123.7
LCC BN-20	31.8	72.6	114.1	122.0	124.0	124.5
SPAD BN-0	21.0	65.0	110.1	118.1	121.1	121.6
SPAD BN-20	33.6	74.0	114.8	121.7	124.7	125.2
GS BN-0	22.1	66.9	113.0	120.9	123.9	124.4
GS BN-20	31.0	72.8	115.5	122.4	125.4	126.0
N-150	42.0	82.2	123.1	127.8	129.3	129.8
N-0	18.0	56.1	95.7	104.0	106.9	107.4
STBN	33.8	72.8	112.4	120.4	121.6	123.2
INM	30.0	72.0	115.0	121.9	124.2	124.7
ORGANIC	22.9	63.5	105.3	113.4	116.4	117.1
MEAN	28.4	69.6	111.7	119.2	121.8	122.4
SEm (±)	0.072	0.148	0.072	0.072	0.048	0.26
CD (0.05)	0.22	0.46	0.22	0.23	0.15	0.77

3.2 Tillers m^{-2}

The data pertaining to tillers m^{-2} at 20, 40, 60, 80, 100 DAT and at harvesting are shown in Table 2. The tillers m^{-2} at all growth stages was significantly influenced by site specific nitrogen management practices in *kharif* rice. There is rapid increase in tiller number from 40 DAT to 60 DAT with a little increase from 60 DAT to 80 DAT and thereafter tillers m^{-2} decreased till harvest. The maximum tillers m^{-2} was recorded at 60 DAT in all the treatments. The treatment receiving 20 Kg N ha^{-1} at GS >1.25 Response index with 20 Kg N ha^{-1} at basal recorded the highest number of tillers m^{-2} (422) at 60 DAT closely followed by 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal (415). Lowest tillers m^{-2} was observed under the nitrogen omission plot at all growth stages. This might be due to greater availability of nutrients from applied nitrogen fertilizer and supply of soil nitrogen over time and space to match the requirements of crops by applying the right amount of nitrogen at right time. The results are inconformity with Yoshida et al. [8], Lee et al. [9] and Singh et al. [10].

3.3 Leaf Area Index

Leaf Area Index (LAI) is a key parameter for measuring the growth and productivity of crops. It is a measure of the amount of photosynthetic area available for light interception, and therefore is closely related to crop growth and yield. The estimated leaf area index at 20, 40, 60, 80 and 100 DAT influenced by site specific nitrogen management practices are mentioned in Table 3. Leaf area index of rice increased gradually with increase in crop age and reached maximum at 80 DAT then decreased at 100 DAT. At 80 DAT, maximum LAI (5.82) was observed with nitrogen sufficiency plot which was at par with application of 20 Kg N ha^{-1} at GS >1.25 Response index with 20 Kg N ha^{-1} at basal (5.73). At 100 DAT, maximum LAI was observed with application of 20 Kg N ha^{-1} at GS >1.25 Response index with 20 Kg N ha^{-1} at basal treatment which was at par with application of 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal. Least LAI, 3.82 and 2.53 was obtained in nitrogen omission plot at 80 DAT and 100 DAT, respectively. Adequate nitrogen supply promotes vegetative growth, resulting in larger and more abundant leaves, and therefore, a higher LAI. Increases leaf expansion.

Nitrogen is involved in the process of photosynthesis, which is responsible for the production of energy for plant growth. Adequate nitrogen supply promotes leaf expansion, resulting in larger and thicker leaves, and therefore, a higher LAI (Reena et al. [11] and Kumar et al. [7]. A high dose of nitrogen application can prolong the life of leaves, resulting in a higher LAI. However, it is important to note that excessive nitrogen application can lead to adverse effects such as lodging, nutrient imbalances, and environmental pollution. Therefore, the nitrogen dose should be optimized based on the specific requirements of the rice crop, taking into account factors such as soil fertility, water availability, and climate conditions as reported by Sen et al. [12] and Mohanta et al. [13].

Table 2. Number of tillers m^{-2} of rice as influenced by Site specific nitrogen management

Treatments	Days after transplanting					
	20	40	60	80	100	Harvesting
RDF	72	208	322	311	302	295
LCC BN-0	69	212	335	321	307	298
LCC BN-20	73	216	354	337	321	316
SPAD BN-0	70	220	337	328	311	305
SPAD BN-20	75	245	415	398	381	366
GS BN-0	72	236	348	323	312	310
GS BN-20	78	262	422	406	392	381
N-150	79	260	355	329	303	278
N-0	65	217	297	272	257	248
STBN	76	216	369	347	334	326
INM	76	242	376	351	341	332
ORGANIC	58	182	303	284	274	271
MEAN	72	226	353	334	320	311
SEm (±)	0.14	1.03	1.37	1.47	1.57	1.16
CD (0.05)	0.45	3.2	4.3	4.6	4.9	3.6

Table 3. LAI of rice as influenced by Site specific nitrogen management

Treatments	Days after transplanting				
	20	40	60	80	100
RDF	0.60	2.63	3.47	4.93	2.72
LCC BN-0	0.49	2.38	3.52	5.02	2.87
LCC BN-20	0.59	2.63	4.41	5.43	3.18
SPAD BN-0	0.47	2.58	4.01	5.20	2.91
SPAD BN-20	0.61	2.80	4.35	5.56	3.26
GS BN-0	0.46	2.30	3.94	5.08	2.97
GS BN-20	0.64	2.77	4.48	5.73	3.30
N-150	0.74	3.11	4.63	5.82	3.12
N-0	0.45	2.04	3.01	3.82	2.53
STBN	0.67	2.84	4.14	5.13	3.03
INM	0.52	2.82	4.08	5.37	3.10
ORGANIC	0.55	2.62	3.39	4.37	2.68
MEAN	0.57	2.63	3.95	5.12	2.97
SEm (±)	0.011	0.029	0.030	0.048	0.014
CD (0.05)	0.034	0.090	0.093	0.150	0.043

Table 4. Dry matter (g m^{-2}) accumulation of rice as influenced by Site specific nitrogen management

Treatments	Days after transplanting					
	20	40	60	80	100	Harvesting
RDF	92.7	286.4	498.3	799.6	945.1	992.8
LCC BN-0	154.0	296.8	523.7	833.0	985.8	1035.0
LCC BN-20	128.5	305.6	553.5	885.4	1054.1	1107.7
SPAD BN-0	124.8	294.0	526.1	839.6	994.5	1044.7
SPAD BN-20	150.3	352.8	572.5	927.2	1102.9	1160.1
GS BN-0	135.3	294.1	530.9	851.6	1014.8	1066.5
GS BN-20	141.0	332.2	578.7	953.3	1135.2	1194.1
N-150	107.2	325.3	563.1	853.3	989.8	1036.0
N-0	80.2	201.4	352.8	578.9	677.1	712.1
STBN	104.6	310.5	531.2	854.0	1020.1	1073.3
INM	110.0	320.7	553.0	896.6	1068.7	1124.2
ORGANIC	99.0	263.1	440.1	720.3	846.3	890.0
MEAN	119.0	298.6	518.7	832.7	986.2	1036.4
SEm (±)	2.72	3.16	7.52	8.71	9.34	8.91
CD (0.05)	7.8	9.0	23.5	27.1	27.4	27.7

3.4 Dry Matter Accumulation

Total dry matter accumulation (g m^{-2}) of rice at different growth stages are presented in Table 4. It was found that total dry matter of rice increased with advancement of age of crop and reached the highest at harvest. The rate of increase was slower in initial stage whereas after 60 DAT, the increment enhanced due to formation of reproductive parts. The rate of increase was maximum during 60-80 DAT during both the years of study. At harvest, significantly maximum dry matter (1194.1 g m^{-2}) was obtained due to application of 20 Kg N ha^{-1} at GS >1.25 Response index with 20 Kg N ha^{-1} at basal followed by application of 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal (1160.1 gm m^{-2}).

Site specific of nitrogen management practices that balance the nutrient availability, resulting in increased conversion of carbohydrates to protein which enhance meristematic cellular activity like cell division and cell elongation expressing morphologically in terms of increasing dry matter accumulation. Nitrogen is essential for rapid accumulation of dry matter per unit time and space resulting in higher production of leaves and stems of rice. Apart from that, nitrogen might have involved in various physiological activities like increased photosynthetic activity and better light interception in turn resulted in higher dry matter accumulation. These results were also inconformity with that of Pant et al*.* [14], Mohanta et al*.* [13] and Shivashankar et al*.* [15].

3.5 Crop Growth Rate

The crop growth rate (CGR) is a measure of dry matter production per unit time and area. A high CGR is desirable as it indicates a higher potential for crop yield. Crop growth rate increased gradually up to 60-80 DAT and thereafter it decreased and attained its least values between 100 DAT to harvesting (Table 5). The maximum crop growth rate of 18.73 g m^{-2} day^{-1} was recorded with application of 20 Kg N ha^{-1} at GS >1.25 Response index with 20 Kg N ha^{-1} at basal at 60-80 DAT. The lowest CGR was obtained with nitrogen omission plot (11.31 g m^{-2} day^{-1}) at 60-80 DAT. Adequate nitrogen supply can increase the photosynthetic capacity of the plant, resulting in increased biomass accumulation. Green Seeker management practice can optimize nitrogen application rates, ensuring that the crop receives the appropriate amount of nitrogen at the right time and in the right place. This can lead to improved nitrogen use efficiency and a higher CGR. This is in conformity with the findings of Shivashankar et al*.* [15].

3.6 Yield

The findings of the grain yield demonstrated that site-specific nitrogen management had a considerable impact on grain production. Significantly higher grain yield (5.74 t ha^{-1}) resulted from application of 20 Kg N ha^{-1} at GS >1.25 Response index with 20 Kg N ha^{-1} at basal over all other treatment. Studies had shown that green seeker-based nitrogen management can lead to higher grain yields than the recommended dose of fertilizer (Table 6).

The reason behind the higher grain yield in green seeker-based nitrogen management is that it allows for more precise application of nitrogen fertilizer, reducing the risk of over-fertilization or under-fertilization. Over-fertilization can lead to nitrogen leaching, which can contaminate groundwater and surface water, while under-fertilization can result in reduced crop yield. Green seeker technology allows farmers to apply the right amount of nitrogen fertilizer at the right time, leading to better crop growth and higher yields (Franzen et al., 2010, Mandal et al., 2019 and Baral et al., 2021). Further results showed that the treatment receiving 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal and INM (20 Kg N as FYM at basal + 40 Kg N at tillering + 20 kg N at PI stage) were at par with each other. The reason behind the similar grain yield in SPAD-based nitrogen management and INM is that both approaches aim to optimize nitrogen management based on the plant's nitrogen status. SPAD technology allows farmers to measure the plant's nitrogen status in real-time, enabling them to adjust the nitrogen application rate accordingly. INM, on the other hand, combines various nitrogen management methods to optimize the availability and utilization of nitrogen by the plant. Both approaches aim to provide the plant with the right amount of nitrogen at the right time, leading to better crop growth and yield. This result is supported by Lafond et al*.* [16], Gupta et al*.* [17] and Chen et al*.* [18]. Significantly higher straw yield 6.53 t ha^{-1} was observed due to application of 20 Kg N ha^{-1} at Green seeker (GS) >1.25 Response index with 20 Kg N ha^{-1} at basal than any other treatments. This may be due to green seeker technology allows farmers to measure the plant's nitrogen status in real-time and adjust the nitrogen application rate accordingly, leading to better nitrogen use efficiency and plant growth. RDF, SPAD-based nitrogen management, and INM, on the other hand, may result in over or under application of nitrogen, leading to suboptimal plant growth and lower straw yield (Singh et al*.* [10] and Liu et al*.* [19]. Among various site specific nutrient management practices, significantly higher harvest index (46.7 %) was recorded with application of 20 Kg N ha^{-1} at Green seeker (GS) >1.25 Response index with 20 Kg N ha^{-1} at basal and was at par with application of 20 Kg N ha^{-1} at SPAD value <35 with 20 Kg N ha^{-1} at basal and application of 20 Kg N ha^{-1} at Green seeker (GS) >1.25 Response index with no basal N. Green seeker technology allowed farmers to measure the plant's nitrogen status in real-time and adjust the nitrogen application rate accordingly, leading to better nitrogen use efficiency and plant growth. This might be resulted in a higher proportion of the plant's biomass being allocated to the grain, leading to higher harvest index. This result is in conformity with Liu et al*.* [19] and Swamy et al*.* [20].

Table 5. Crop growth rate (g m^{-2} day^{-1}) of rice as influenced by Site specific nitrogen management

Treatments	Days after transplanting				
	20-40	40-60	60-80	80-100	100-Harvesting
RDF	9.69	10.60	15.07	7.28	3.18
LCC BN-0	7.14	11.35	15.47	7.64	3.28
LCC BN-20	8.86	12.40	16.60	8.44	3.58
SPAD BN-0	8.46	11.61	15.68	7.75	3.35
SPAD BN-20	10.13	10.99	17.74	8.79	3.82
GS BN-0	7.94	11.84	16.04	8.16	3.45
GS BN-20	9.56	12.33	18.73	9.10	3.93
N-150	10.91	11.89	14.51	6.83	3.08
N-0	6.06	7.57	11.31	4.91	2.33
STBN	10.30	11.04	16.14	8.31	3.55
INM	10.54	11.62	17.18	8.61	3.71
ORGANIC	8.21	8.85	14.01	6.30	2.92
MEAN	9.0	11.0	15.7	7.7	3.3
SEm (±)	0.101	0.077	0.178	0.044	0.042
CD (0.05)	0.31	0.24	0.55	0.14	0.13

Table 6. Yield and Economics of rice as influenced by Site specific nitrogen management

Treatments	Grain yield (t ha-1)	Straw yield (t ha-1)	HI (%)	Cost of Cultivation (Rs ha-1)	Net return (Rs ha-1)	B:C
RDF	4.59	5.65	44.8	67979	32270.3	1.48
LCC BN-0	4.85	5.83	45.4	67873	37769.8	1.56
LCC BN-20	5.15	6.27	45.1	68315	44135.3	1.65
SPAD BN-0	4.94	5.83	45.9	68445	39050.8	1.57
SPAD BN-20	5.52	6.45	46.1	68601	51280.3	1.75
GS BN-0	4.99	6.01	45.4	68004	40812.3	1.60
GS BN-20	5.74	6.57	46.7	68601	55982.3	1.82
N-150	4.33	6.36	40.5	68892	27723.1	1.41
N-0	2.87	4.27	37.8	66313	-7527.3	0.89
STBN	4.99	6.08	45.1	68240	40629.3	1.60
INM	5.31	6.29	45.8	70531	44955.9	1.64
ORGANIC	3.83	5.35	43.0	84020	4852.0	0.97
MEAN	4.76	5.91	44.3	69651	34328	1.50
SEm (±)	0.11	0.06	0.28	87.6	81.6	0.015
CD (0.05)	0.34	0.17	0.83	272.6	239.1	0.045

3.7 Economics

The economics of rice was influenced by site specific nutrient management practices. The treatment receiving organic nutrient had the highest cost of cultivation (Rs. 84020 ha^{-1}) followed by integrated nutrient management practices (Rs. 70531 ha^{-1}). Lowest cost of cultivation was recorded by nitrogen omission plot (Rs. 66313 ha^{-1}). Highest gross return (Rs. 124583 ha^{-1}), net return (Rs. 55982 ha^{-1}) and B : C ratio (1.82) were recorded with the treatment receiving 20 Kg N ha^{-1} at Green seeker (GS) >1.25 Response index with 20 Kg N ha^{-1} at basal. Lowest gross return (Rs. 58786 ha^{-1}) was obtained in nitrogen omission plot (Table 6). Due to timely supply of nutrients, better mineralization, higher biomass production leading to increased yield and net return in green seeker based nitrogen management, with optimum nitrogen fertilizer application in comparison to LCC, SPAD, STBN and INM, delivered highest return per rupee spent. This is in conformity with Mohanty et al*.* [21], Singh et al*.* [22], Samant et al*.* [23] and Baral et al*.* [24], [25,26].

4. CONCLUSION

From the above study, it could be concluded that site specific nitrogen management consisting of

20 kg N ha^{-1} as basal along with application of 20 kg N ha^{-1} as per Green seeker value (> 1.25 Response index) combined with phosphorus and potassium based on soil test recommendation, accumulated maximum dry matter (1194.1 g m^{-2}), larger leaf area index (3.30), highest number of tillers (381 m^{-2}) and produced the maximum grain yield of 5.74 t ha^{-1}, straw yield of 6.57 t ha^{-1} with harvest index 47% with net return 55982 Rs ha^{-1} and B:C ratio 1.82.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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