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Effect of plant Sensor based real time Nitrogen management on growth, yield and economics of rice (*Oryza sativa L*.) crop

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ABSTRACT

A field experiment was conducted at RARS Nandyal during Kharif season of 2017 to study the precision nitrogen management in rice crop, grown under conservation agriculture. The experiment was laid out in a randomized block design with seven treatments (absolute control, recommended dose of fertilizers (100% RDF), STBF, precision N management practices like green seeker, LCC, SPAD) in vertisols. Amongst tested N management strategies; a saving of N by 45 and 20 kg with green seeker, LCC and SPAD, respectively was found compared to recommended dose of fertilizers (RDF). There was no significant difference between any treatment for yield attributes like plant height, production tillers per hill , panicle length and grains per panicle. Among all the treatments, Green Seeker directed N application recorded highest grain (5.5 t ha^{-1}) and straw yield (8.4 t ha^{-1}) compared to all the treatments followed by LCC based N application (5.2 t ha^{-1}). By using Green seeker 45 kg N ha^{-1} was minimized as compared to RDN. Benefit cost ratio was found to be highest (2.76) with Green seeker which also was statistically at par with LCC (2.45) and SPAD (2.32) and lowest with control (0.72).

Key words: Rice crop, Nitrogen management, Plant Sensors, Green seeker, LCC, SPAD

INTRODUCTION

Management of fertilizer nitrogen in rice developed for large areas or zones having similar climate and land forms. It cannot help to increase the Nutrient-use efficiency beyond a limit. Further improvement can be achieved only by planning strategies for fertilizer nitrogen management in rice (*Oryza sativa L*.). Gadgets like Green seeker, chlorophyll-meter (SPAD-meter) and inexpensive leaf color chart (LCC) have proved quick and reliable tools to decide the time when fertilizer N needs to be applied to the crop. Rice is one of the input intensive crops in the world and input of nutrient contributes approximately 20–25% to the total production costs of rice. At present rice production alone consumes nearly 24.7 Mt of fertilizer (N + P_2O_5 + K_2O) which accounts for approximately 14 % of total global fertilizer consumption in a year. Scientists have predicted that a hike of at least 60% in rice yield is essential in order to ensure food and nutritional security of 9 billion populations that are expected to inhabit the globe by 2050. With increasing demand for food production, demand for nutrients is likely to increase further. Despite several decades of research, the average recovery efficiency of N, P and K in rice is only 30-35%, 20-25% and 35-40%, respectively. Determination of the extent to which the crop will respond to additional nitrogen can help the farmers to apply only what is needed. It uses the crop sensor to estimate the topdressing nitrogen rate at stem elongation stage (Bijay Singh *et al.,* 2017). Green Seeker-based precision management and chlorophyll meter-based site-specific N management increased the partial factor productivity of farmers by 48 and 65 %, respectively, without significant change in grain yield. Bowen *et al.* (2005) illustrated that Green Seeker NDVI could be used to variably apply nitrogen to malt barley at Feekes Growth Stage 6 and to potato before row closure. Teal *et al.* (2006) showed that yield potential in corn could be accurately predicted in season with Green Seeker NDVI. A higher SPAD value means a healthier plant. Chlorophyll meter helps in saving time and resources (Netto *et al.,* 2005) and it offers strategy for synchronization between crop demand and application of N (Babu *et al..,* 2000).

Leaf Color Chart (LCC) is an ideal tool & ecologically-friendly to optimize Nitrogen use efficiency irrespective to N applied. Many research findings shows that the crop sensor can be used to calculate rice yield potential

without additional topdressing N application at stem elongation or booting stage (Sapkota *et al.,* 2014). Recommended dose of fertilization (100% RDF) for paddy in Nandyal region is 240:80:80 Kg NPK ha^{-1}, which is very high recommendation of nitrogen when compared to other zones of Andhra Pradesh and most of the farmers were used to apply nitrogen @ 350 Kg/ha also and reluctant to minimize the Nitrogen doses in rice in this region. To minimize the urea application, and green house gases emissions from paddy fields, we conducted this experiment for precise nitrogen management in rice crop.

MATERIALS AND METHODS

The field experiment was conducted during the kharif season of 2017 at Regional Agricultural Research Station, Nandyala, Andhra Pradesh, under irrigated conditions. The soil of experimental site was medium deep black, low in organic carbon (3.6 g kg^{-1}), low in Nitrogen (180 kg ha^{-1}) high in available P_2O_5 (69.5 kg ha^{-1}) and available K_2O (536 kg ha^{-1}). The experiment was laid out in randomized block design with 7 treatments namely T1 -Recommended dose of fertilizers (100% RDF), T2-Soil test based fertilizer application, T3-Green Seeker directed N application(if it is<0.5 applied 25N $Kgha^{-1}$) at weekly intervals,T4-LCC based N application (if <4.0 applied 25 N $kgha^{-1}$) at weekly intervals, T5-SPAD based N application (if <50 applied 25 N $kgha^{-1}$) at weekly intervals, T6- Farmers Fertilizer Practice and T7- Control replicated in three times. Rice (variety, NDLR-7) was sown during second week of July, transplanted in second week of August by adopting 15x15cm spacing with three seedlings per hill and fertilizers applied as per the treatments protocol. Soil and plant samples were collected in each treatment and analyzed by following standard procedures. Recommended dose of fertilization (100% RDF) for paddy in Nandyal region is 240:80:80 Kg NPK ha^{-1}. Basal dose of nitrogen (120 Kg ha^{-1}) was applied to all treatments and top dressing of remaining 120 Kg ha^{-1} was applied based on LCC, SPAD and Green Seeker values recorded at weekly intervals. All the data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Yield increase and economic advantage due to Precision nutrition

Data (Table 1) showed that there was no significant difference between any treatment for yield attributes like plant height, production tillers per hill, panicle length and grains per panicle. Highest plant height (90.1cm), production tillers/hill (20) and panicle length (21cm) were observed with Greens seeker based N fertilization. The highest no of grains per panicle (204), with green seeker based N fertilization. Lowest no of grains per panicle was observed in control (171 grains) which may be due to lower nitrogen fertilization than recommended dose of fertilization.

Table 1: Influence Plant Sensor based real time nitrogen management on yield & yield attributes of paddy

Treatments	Plant height (cm)	Prod. Tillers/hill	Panicle length (cm)	Grains/ panicle	Grain yield t ha^{-1}	Straw yield t ha^{-1}
T_1- 100%RDF	81.5	12	21.2	188	4.80	6.85
T_2- Soil test-based fertilizers	88.2	18	20.6	183	4.90	7.26
T_3- Green Seeker directed N application	90.1	20	21	204	5.50	8.34
T_4- LCC based N application	83.1	18	19	191	5.30	8.23
T_5- SPAD based N application	87	19	20.6	195	5.10	7.65
T_6- Farmers Fertilizers Practice	85.9	18	21	197	4.90	7.45
T_7- Control	70	7	18.2	171	2.60	4.95
S.Em $\pm$	3.8	0.9	1	8	0.23	0.53
C.D (P=0.05)	N.S	N.S	N.S	N.S	0.72	1.47
C.V	7.6	8.2	8.4	7	12	14

Among all the treatments, Green Seeker directed N application recorded highest grain yield (5.53 t ha^{-1}) and straw yield (8.34 t ha^{-1}) followed by LCC based N application (5.30 t ha^{-1}). Similar results were reported by Veerendra Pateel *et al.,* (2017). All the treatments were on

par in terms of grain yield and there were no significant difference in any treatment at harvest and yield attributing characters. Nutrient application based on SSNM principles resulted in significantly higher grain yields over farmers practice and 100% RDF. Rice yields ranged from 2.6 (control) to 5.5 t ha^{-1} (Green seeker treatment) under precision nutrition practices, Average rice yields were 5.53, 5.25, and 5.12 t ha^{-1}in the sensor based practices, signifying 14% higher productivity due to SSNM over 100% RDF and 12 % over Farmers practice. These results were in accordance with Gurupadappa *et al.,* (2019)**.** By using Green seeker 45kg N ha^{-1} was minimized compared to RDN (Table 2).

Table 2: Plant Sensor based diagnostic information for real time nitrogen management in Rice crop – Effect of Different crop sensors on N Minimisation

Treatments	Dates after Transplanting													
	0	30	37	44	51	58	65	72	79	86	93	100	Applied N (kg ha^{-1})	N minimisation
T_3-Green Seeker Values based on NDVI	0	0.5	0.6	0.58	0.58	0.54	0.45	0.6	0.58	0.54	0.5	0.54	-	-
Applied N based on NDVI	120	25	0	0	0	0	25	0	0	0	25	0	75	45
T_4- SPAD values	0	48	52	52	48	53	50	52	51	46	54	52	-	-
Applied N based on SPAD	120	25	0	0	25	0	25	0	0	25	0	0	100	20
T_5- L.C.C values	0	3	4	5	5	4	5	5	5	4	5	5	-	-
Applied N based on LCC values	120	25	25	0	0	25	0	0	0	25	0	0	100	20

Economics

The economic considerations are the deciding factor for any technology to be adopted by farmers. Data pertaining to net return and B: C ratio as affected by different precision nutrient management practices and fertility levels of the rice crop are presented in Table 3. Significantly highest net return (Rs.1,28,165 ha^{-1}) and B C ratio (2.76) were obtained with Green seeker over 100% RDF, farmers fertilizer practice and absolute control. Net return was highest (Rs.1,28,165 ha^{-1}) in Green seeker which was statistically at par with LCC (Rs. 1,18, 660 ha^{-1}). However, benefit cost ratio was found to be highest (2.76) with Green seeker which also was statistically at par with LCC (2.45) and SPAD (2.32) and lowest with control (0.72) treatment. Mahajan *et al.* (2013) also reported STCR-IPNS technology ensures higher profitability. Similarly B: C ratio was higher in STCR approach in wheat over general recommended dose and control (Keram*et al.,* 2012).

Table 3: Economics of Paddy crop as influenced by different Precision Nitrogen management practices

Treatments	Fertilisers (kg/ha)	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C Ratio
T_1- 100%RDF	240:80:80	51200	148490	97290	1.90
T_2- Soil Test Based Fertilizers	312:56:56	52300	152690	100390	1.92
T_3- Green Seeker directed N application	195:80:80	46500	174665	128165	2.76
T_4- LCC based N application	220:80:80	48500	167160	118660	2.45
T_5- SPAD based N application	220:80:80	48550	161150	112600	2.32
T_6- Farmers Fertilizers Practice	320:150:75	57000	153650	96650	1.70
T_7-Control	Nil	50650	87150	36500	0.72

**price 24/- per kg of rice grain & 5/- per kg straw of rice*

From the results it may be concluded that Green Seeker directed N application recorded highest Grain yield and straw yield. All the treatments were on par in terms of grain yield and there were no significant difference in any treatments in soil available nutrients at the time of harvest and yield attributing characters. By using Green seeker 45kgN.ha^{-1} was minimized compared to RDN. There are many constraints which leads to low adoption of precision nutrient management techniques in India, therefore proper research and fine tuning of instruments is necessary for easier adaptation by farmers.

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