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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 367-371

www.thepharmajournal.com
Received: 07-11-2021
Accepted: 14-12-2021

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Effect of nitrogen management practices on SPAD values and NDVI readings of rice crop

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Abstract
A field experiment was conducted during *kharif* 2017 and 2018 at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad to study the "Effect of nitrogen management practices on SPAD values and NDVI readings of rice crop". The experiment was laid out in split plot design with two establishment methods [Normal transplanting (M_1) and mechanized system of rice intensification (M_2)] in main plots and six nitrogen management practices [N_1- Nutrient Expert based recommendation of nitrogen with Neem coated urea, N_2- Nutrient Expert based recommendation of nitrogen with Neem coated urea (75%) + vermicompost (25%), N_3- Recommended dose of nitrogen with Neem coated urea, N_4- Recommended dose of nitrogen with Neem coated urea (75%) + vermicompost (25%), N_5- N omission, N_6- Absolute control (No N, P and K fertilizer application)] in sub-plots with three replications.

Mean SPAD values were higher in mechanized SRI (M_2) (35.4, 37.8 and 37.1 at 30, 60 and 90 DAS, respectively) as compared to normal transplanting (M_1) (32.9, 36.9 and 35.7 at 30, 60 and 90 DAS, respectively). At all the growth stages, application of nitrogen as per recommendation of Nutrient Expert with NCU (75%) and VC (25%) (N_2) recorded significantly higher SPAD values as compared to nitrogen omission (N_5) and absolute control (N_6). Mechanized SRI (M_2) recorded higher GreenSeeker® NDVI reading (0.630 and 0.648 at 60 and 90 DAS, respectively) as compared to normal transplanting (M_1) (0.589 and 0.620 at 60 and 90 DAS, respectively). Application of nitrogen as per recommendation of Nutrient Expert with NCU (75%) and VC (25%) (N_2) recorded significantly higher mean GreenSeeker® NDVI values (0.673 and 0.686 at 60 and 90 DAS, respectively) as compared to nitrogen omission (N_5) (0.543 and 0.572 at 60 and 90 DAS, respectively) and absolute control (N_6) (0.509 and 0.543 at 60 and 90 DAS, respectively).

Keywords: Rice, nutrient expert, SPAD values, NDVI reading

Introduction
Rice is primarily a high-energy food. It is staple food of about 2/3rd population of world. In world, India ranks first in terms of acreage and second in terms of production. Method of establishment is one of the cultural practices, which influences the rice crop through its effect on growth and development (Gopi *et al*., 2006) [7]. Manual transplanting is the most common practice of rice cultivation in south and south-east Asia. It combined with labour intensive operations like nursery raising, uprooting of the seedlings, transporting and transplanting in the main field requiring about 250-300 man-h ha^{-1} which is approximately 25% of the total labour requirement of crop (Chaudhary and Varshney, 2003) [5]. To solve this problem, IFFCO joined hands with agricultural department and made efforts to reduce the labour drudgery by introducing mechanization in all operations of SRI technology. Mechanized system of rice intensification (MSRI) is a modification of SRI system in which 18 days old seedlings were transplanted with the power operated rice transplanter at a spacing of 23.5 cm × 15 cm and other remaining principles (Irrigation up to saturation, weed management by cono weeder, use of organics) were same with SRI.

Nitrogen is the key nutrient element required in large quantities by rice. In modern agro ecosystems, it was estimated that the removal of as much as 300 kg N ha^{-1} year^{-1} in the above ground portions of the harvested produce requires substantial inputs of N either through fertilizers, manure or N-fixation to maintain the productivity (Cassman *et al*., 2002) [3]. Higher loss of N from urea necessitates an innovative application technique for increasing the nitrogen use efficiency (NUE). Proper management of N is essential for achieving higher productivity, maximizing N use efficiency (NUE) and improving environmental safety by ensuring minimal losses of applied N. However, efficiency of applied N fertilizer primarily depends on the form of N applied and the ecosystem in which they are used.

In rice crop leaf nitrogen content is closely related to photosynthesis rate and grain yield (Peng *et al*. 1995) [10]. The optimum rate and application timing of Nitrogen (N) fertilizer are crucial in achieving a high yield in rice cultivation; however, conventional laboratory testing of plant nutrients is time-consuming and expensive. To develop a site-specific spatial variable rate application method to overcome the limitations of traditional techniques, especially in fields under a double-cropping system, this study focused on the relationship between Soil Plant Analysis Development (SPAD) chlorophyll meter readings and N content in leaves during different growth stages to introduce the most suitable stage for assessment of crop N and prediction of rice yield. As leaf nitrogen content is strongly correlated with chlorophyll content the use of Soil Plant Analysis Development (SPAD) meter has been introduced as a popular, fast, and cheap technique to estimate N levels from the measurement of leaf transmittance. The SPAD chlorophyll meter provides a simple, rapid, and nondestructive method for estimating leaf chlorophyll content (Watanabe *et al*., 1980) [12]. SPAD chlorophyll meter reading is used to assess the nitrogen status in crops and determine the right time of nitrogen application (Ladha *et al*., 2005) [9].

The GreenSeeker® handled crop sensor was used to assess the crop health or vigour in order to make better nutrient management decisions. GreenSeeker® normalized difference vegetation index (NDVI) reading is commonly used to measure plant health and vigour which is an excellent indicator of biomass (amount of living plant tissue). Hand-held GreenSeeker offer distinct advantage over need based N management tools like SPAD meter and leaf colour chart in that it can work out fertilizer N requirement of rice. Recently, methods based on measurements of reflectance in the red (defined by chlorophyll content) and near infrared (defined by living vegetation) region of the electro-magnetic spectrum for estimating N requirement of crops using early season estimates of N uptake and potential yield have been developed. Normalized difference vegetative index based on in- season sensor reading can predict biomass, plant N concentration and plant N uptake. The strategy based on optical sensors hold promise in developing N management options because it offers distinct advantage of working out the fertilizer N requirement of rice crop based on expected yields as well as achievable greenness of the leaves. These techniques help the real-time N control, which leads to variable rate application and site-specific crop management. SPAD threshold values and NDVI threshold values might to be useful for different varietal groups and agro-climatic conditions. (Balasubramarian *et al.*, 2003 and Singh *et al.*, 2010) [11].

In this context, application of nitrogen made by right source (Neem coated urea and vermicompost), right time (Basal, panicle initiation and heading stage by using Nutrient Expert) and in right amount (Nutrient Expert) to see the effect on SPAD values and NDVI reading.

Material and Methods

A field experiment was conducted during *kharif* 2017 and 2018 at ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad is located in the Southern Telangana agro-climatic zone of Telangana state. Geographically, it lies at 17^0 19' N latitude, 78^0 23' E longitude with an altitude of 542.3 m above mean sea level (MSL). During the crop growth period, a total rainfall of 861.4 mm was received in 43 rainy days during *kharif* 2017 and 333.8 mm in 21 rainy days during *kharif* 2018. The daily mean bright sunshine during crop growth period ranged from 2.1 to 8.8 hours with an average of 5.1 hours during *kharif* 2017 and 0.6 to 8.1 hours with an average of 5.1 hours during *kharif* 2018. The daily mean evaporation (mm) during the crop growth period was 3.9 mm and 4.6 mm during *kharif* 2017 and *kharif* 2018, respectively.

The analysis of soil sample revealed that soil was clay loam in texture having low organic carbon and available nitrogen, high in available phosphorus and available potassium contents with moderate alkaline in reaction. Rice variety RNR-15048 (Telangana Sona) was tested in the experiment.

The experiment was laid out in split plot design with two establishment methods [Normal transplanting (M_1) and mechanized SRI (M_2)] in main plots and six nitrogen management practices [N_1- Nutrient Expert based recommendation of nitrogen with Neem coated urea, N_2- Nutrient Expert based recommendation of nitrogen with Neem coated urea (75%) + vermicompost (25%), N_3- Recommended dose of nitrogen with Neem coated urea, N_4- Recommended dose of nitrogen with Neem coated urea (75%) + vermicompost (25%), N_5- N omission, N_6- Absolute control (No N, P and K fertilizer application)] in sub-plots with three replications.

The recommended dose of fertilizer (RDF) for rice is 120, 60 and 40 kg N, P_2O_5 and K_2O ha^{-1}, respectively. Nutrient expert based recommendation for rice is 125, 34 and 55 kg N, P_2O_5 and K_2O ha^{-1}, respectively. Nitrogen was applied in three equal split doses i.e. basal, 60 DAS and 90 DAS. Full dose of P and K were applied as basal dose. The nutrients N, P_2O_5 and K_2O were supplied through Neem coated urea, single super phosphate and muriate of potash, respectively.

Seedlings were transplanted at spacing of 20 cm x 15 cm under normal transplanting and 23.5 cm x 15 cm under mechanized SRI. For transplanting, 25 and 18 days old seedlings were used under normal transplanting and mechanized SRI, respectively.

Soil was kept wet with thin film of water during the first one week under normal transplanting. Depth of irrigation may be increased to 2.5 cm progressively along the crop age. The experimental plot was provided with adequate drainage facilities to drain excess water. In case of mechanized SRI, the soil was kept saturated and standing water was avoided until the transplanted seedlings established well. Thereafter the field was kept saturated by supplementing irrigation whenever there was insufficient rainfall. The excess rain or irrigation water was drained from the field. Last irrigation was scheduled 15 days ahead of harvest in both the methods of establishment.

Chlorophyll meter (model SPAD 502 of Minolta co., Japan) was used to measure SPAD values. The leaf selected for measurement of SPAD reading was between fourth from base to leaf tip of the plant. The SPAD values were measured on 10 leaves in each plot and then mean value was calculated.

The Trimble® GreenSeeker® handheld crop sensor was used to assess the health or vigor of crop in order to make better nutrient management decisions. The GreenSeeker® system uses optical sensors to measure and quantify the variability of the crop. Red light is absorbed by plant chlorophyll as an energy source during photosynthesis. Therefore, healthy plants absorb more red light and reflect larger amounts of near infra-red (NIR) light than those that are unhealthy. Normalized difference vegetation index (NDVI) is commonly used to measure plant health and vigor and an excellent indicator of biomass (amount of living plant tissue). NDVI is calculated using the following equation.

$$\text{NDVI} = \frac{\text{NIRreflected} - \text{REDreflected}}{\text{NIRreflected} + \text{REDreflected}}$$

The GreenSeeker® NDVI reading were measured at three places in each plot and then mean value was calculated.

Results and Discussion

SPAD Value

The mean SPAD values were 34.1, 37.3 and 36.4 at 30, 60 and 90 DAS, respectively. Mean SPAD values were higher in mechanized SRI (M_2) (35.4, 37.8 and 37.1 at 30, 60 and 90 DAS, respectively) as compared to normal transplanting (M_1) (32.9, 36.9 and 35.7 at 30, 60 and 90 DAS, respectively). This might be due to more chlorophyll content in mechanized SRI than normal transplanting (Dhital, 2011) [6].

Absolute control (N_6) recorded significantly lower SPAD values at all the growth stage as compared to all other nitrogen management practices except nitrogen omission (N_5) which was at par with absolute control (N_6) during both the years of study. At all the growth stages, application of nitrogen as per recommendation of Nutrient Expert with NCU (75%) and VC (25%) (N_2) recorded significantly higher SPAD values as compared to nitrogen omission (N_5) and absolute control (N_6) and it was on par with all other nitrogen management practices *i.e.* N_1, N_3 and N_4 during both the years of study. Application of nitrogen in organic and inorganic form at right time enhances chlorophyll content which resulted to higher SPAD values. Nitrogen is part of the enzymes associated with chlorophyll synthesis (Chapman and Barreto, 1995) [4] and the chlorophyll concentration reflects relative crop nitrogen status and yield level (Blackmer and Schepers, 1995) [2].

Nutrient Expert based recommendation of nitrogen with NCU (75%) and VC (25%) (N_2) recorded 13.86 and 10.87 per cent higher SPAD values than nitrogen omission (N_5) and 15.96 and 13.43 per cent higher than absolute control (N_6) at 90 DAS during 2017 and 2018, respectively.

In respect of SPAD values at 90 DAS, Nutrient Expert based recommendation of nitrogen with NCU (75%) and VC (25%) (N_2) (39.1 and 37.8) found statistically at par with application of recommended dose of nitrogen (RDN) with NCU (75%) + VC (25%) (N_4) (38.6 and 37.1), Nutrient Expert based recommendation of nitrogen with NCU (N_1) (38.7 and 36.8) and RDN with NCU (N_3) (37.6 and 35.6) during 2017 and 2018, respectively.

NDVI reading

The mean GreenSeeker® NDVI reading was 0.609 and 0.634 at 60 and 90 DAS, respectively. Higher values of GreenSeeker® NDVI recorded under mechanized SRI (M_2) (0.630 and 0.648 at 60 and 90 DAS, respectively) as compared to normal transplanting (M_1) (0.589 and 0.620 at 60 and 90 DAS, respectively). This might be due to more chlorophyll content in plants, better canopy coverage and biomass production under mechanized SRI than normal transplanting (M_1) (Halder *et al*., 2009; Dhital, 2011) [8, 6].

Absolute control (N_6) recorded significantly lower GreenSeeker® NDVI values at all the growth stages as compared to all other nitrogen management practices except nitrogen omission (N_5) which was at par with absolute control during both the years of study. Application of nitrogen as per recommendation of Nutrient Expert with NCU (75%) and VC (25%) (N_2) recorded significantly higher mean GreenSeeker® NDVI values (0.673 and 0.686 at 60 and 90 DAS, respectively) as compared to nitrogen omission (N_5) (0.543 and 0.572 at 60 and 90 DAS, respectively) and absolute control (N_6) (0.509 and 0.543 at 60 and 90 DAS, respectively) and all other nitrogen management practices (N_1, N_3 and N_4) were statistically at par with N_2 during both the years of study. This might be due to more chlorophyll content in plants, better canopy coverage and biomass production by application of nitrogen in organic and inorganic form at right time.

In terms of mean GreenSeeker® NDVI values, Nutrient Expert based recommendation of nitrogen with NCU (75%) and VC (25%) (N_2) (0.673 and 0.686) found statistically at par with application of recommended dose of nitrogen (RDN) with NCU (75%) + VC (25%) (N_4) (0.659 and 0.681), Nutrient Expert based recommendation of nitrogen with NCU (N_1) (0.639 and 0.668) and RDN with NCU (N_3) (0.632 and 0.654) at 60 and 90 DAS, respectively.

Table 1: SPAD chlorophyll meter reading of rice as influenced by establishment methods and nitrogen management practices during *kharif* 2017 and 2018

Treatments	30 DAS			60 DAS			90 DAS		
	2017	2018	Mean	2017	2018	Mean	2017	2018	Mean
Establishment methods (M)									
M_1- Normal Transplanting (NTP)	33.2	32.6	32.9	37.6	36.2	36.9	36.1	35.3	35.7
M_2- Mechanized SRI (MSRI)	35.6	35.3	35.4	38.7	37.0	37.8	37.9	36.4	37.1
S.Em±	0.74	0.62	-	0.75	0.77	-	0.86	0.70	-
CD (p=0.05)	NS	NS	-	NS	NS	-	NS	NS	-
Nitrogen management practices (N)									
N_1- NE based recommendation of N with NCU	35.0	34.6	34.8	40.0	37.9	39.0	38.7	36.8	37.7
N_2- NE based recommendation of N with NCU (75%) + VC (25%)	36.9	36.3	36.6	40.5	38.4	39.5	39.1	37.83	38.5
N_3- RDN with NCU	35.2	34.2	34.7	39.3	37.1	38.2	37.6	35.6	36.6
N_4- RDN with NCU (75%) + VC (25%)	36.2	35.9	36.0	40.1	37.8	38.9	38.6	37.1	37.8
N_5- N omission	31.6	31.3	31.5	34.8	34.4	34.6	34.3	34.1	34.2
N_6- Absolute control (No N, P and K fertilizer application)	31.3	31.1	31.2	34.1	33.8	34.0	33.7	33.4	33.5
S.Em±	0.83	0.72	-	0.96	0.82	-	0.91	0.79	-
CD (p=0.05)	2.45	2.13	-	2.84	2.42	-	2.68	2.35	-
Interactions (M x N)									

Nitrogen management practices at same level of establishment method									
S.Em±	1.17	1.02	-	1.36	1.16	-	1.29	1.12	-
CD (p=0.05)	NS	NS	-	NS	NS	-	NS	NS	-
Establishment method at same or different level of nitrogen management practices									
S.Em±	1.30	1.12	-	1.45	1.31	-	1.46	1.24	-
CD (p=0.05)	NS	NS	-	NS	NS	-	NS	NS	-
General Mean	34.4	33.9	34.1	38.1	36.6	37.3	37.0	35.8	36.4
CV (%)	9.2	7.8	-	8.3	8.9	-	9.9	8.3	-

NE- Nutrient Expert; NCU- Neem coated urea; VC- Vermicompost; RDN- Recommended dose of nitrogen

Table 2: Green Seeker NDVI reading of rice as influenced by establishment methods and nitrogen management practices during *kharif* 2017 and 2018

Treatments		60 DAS			90 DAS	
	2017	**2018**	**Mean**	**2017**	**2018**	**Mean**
Establishment methods (M)						
M_1- Normal Transplanting (NTP)	0.597	0.581	0.589	0.633	0.607	0.620
M_2- Mechanized SRI (MSRI)	0.654	0.605	0.630	0.669	0.627	0.648
S.Em±	0.010	0.012	-	0.011	0.014	-
CD (p=0.05)	NS	NS	-	NS	NS	-
Nitrogen management practices (N)						
N_1- NE based recommendation of N with NCU	0.646	0.632	0.639	0.682	0.655	0.668
N_2- NE based recommendation of N with NCU (75%) + VC (25%)	0.674	0.672	0.673	0.701	0.670	0.686
N_3- RDN with NCU	0.638	0.627	0.632	0.666	0.642	0.654
N_4- RDN with NCU (75%) + VC (25%)	0.666	0.653	0.659	0.698	0.663	0.681
N_5- N omission	0.580	0.507	0.543	0.594	0.550	0.572
N_6- Absolute control (No N, P and K fertilizer application)	0.551	0.468	0.509	0.564	0.522	0.543
S.Em±	0.011	0.013	-	0.012	0.016	-
CD (p=0.05)	0.033	0.040	-	0.034	0.048	-
Interactions (M x N)						
Nitrogen management practices at same level of establishment method						
S.Em±	0.016	0.019	-	0.016	0.023	-
CD (p=0.05)	NS	NS	-	NS	NS	-
Establishment method at same or different level of nitrogen management practices						
S.Em±	0.018	0.021	-	0.019	0.025	-
CD (p=0.05)	NS	NS	-	NS	NS	-
General Mean	0.625	0.593	0.609	0.651	0.617	0.634
CV (%)	6.9	8.3	-	7.3	9.5	-

NE- Nutrient Expert; NCU- Neem coated urea; VC- Vermicompost; RDN- Recommended dose of nitrogen

Conclusion

Application of nitrogen as per recommendation of Nutrient Expert with NCU (75%) and VC (25%) (N_2) recorded significantly higher SPAD values as compared to nitrogen omission (N_5) and absolute control (N_6) at all the growth stages and it was on par with all other nitrogen management practices i.e. N_1, N_3 and N_4 during both the years of study.

Comparatively higher values of GreenSeeker® NDVI recorded under mechanized SRI (M_2) as compared to normal transplanting (M_1). Absolute control (N_6) recorded significantly lower GreenSeeker® NDVI values at all the growth stages as compared to all other nitrogen management practices except nitrogen omission (N_5) which was at par with absolute control during both the years of study.

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