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Growth and Yield of Transplanted Rice [*Orzya sativa* (L.)] as Influenced by NDVI Values of Green Seeker and Graded Levels of Nitrogen

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ABSTRACT

A field experiment was carried out during *kharif*, 2018–19 on a sandy loamy soil at the Agricultural College Farm, Naira to study the effect of NDVI values of green seeker and nitrogen levels on the growth, yield attributes, yield and quality of rice. The experiment was laid out in Split design with four NDVI values as main plot treatments and four graded levels of nitrogen as sub plot treatments. The results of the investigation revealed that the highest number of tillers m^{-2}, drymatter production, leaf area index, productive tillers m^{-2}, number of filled grains per panicle, grain yield (5411 kg ha^{-1}), straw yield and head rice recovery (HRR) were realized with M_3 (NDVI value 0.8). Among all N levels, the highest values of all the above parameters was found with 120 kg N ha^{-1}. Hence, it was concluded that N application through green seeker at NDVI value of 0.8 (M_3) and application of 120 kg N ha^{-1} were found to be suitable for transplanted rice.

Key words: *Growth, NDVI, Nitrogen levels, Yield and HRR.*

Rice is a staple food for more than half of the world's population. India is the world's second largest producer of rice, accounting for 20 percent of world rice production. In Andhra Pradesh, rice, the major staple food crop is grown in both *kharif* and *rabi* seasons in all districts of the state. It accounted for 28.38% of the total cropped area and grown in an area of 21.05 lakh hectares with annual production of 120.03 lakh tonnes at a mean productivity level of 5702 kg ha^{-1} (Directorate of Economics and Statistics, 2016-17).

The current recommendations of split application of N fertilizer with fixed rates at specific growth stages for large rice growing area assume the requirement of rice for fertilizer is constant across large areas and years. The requirement of rice for N fertilizer can, however, vary greatly from location to location, season to season and year to year because of high variability among fields, seasons and years in N supplying capacity of soil (Cassman *et al.,* 1993). These 'blanket' recommendations have served their purpose in producing higher yields, but they are limited in their capacity to increase nutrient use efficiency. Many times, to ensure high yields, farmers apply fertilizer N rates even higher than the blanket recommendation. 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. Real time N management techniques need to be established and followed to improve N use efficiency leading to higher grain yield and minimal fertilizer N loss to the environment (Varinderpal Singh *et al.* 2011). SPAD and LCC have helped in developing real time N management strategies for rice (Ladha *et al.* 2005) but these do not take into account photosynthetic rates or the biomass production and expected yields for working out fertilizer N requirements. Therefore, it has been proposed to study the use of green seeker for need based fertilizer nitrogen management in transplanted rice.

MATERIAL AND METHODS

A field experiment was carried out during *kharif*, 2018–19 at the Agricultural College Farm, Naira which is geographically situated at an altitude of 27 m above mean sea level, 83.56° E longitudes and 18.23° N latitude in the North Coastal Agro climatic Zone of Andhra Pradesh. The soil of the experimental site was sandy loam in texture, slightly alkaline in nature, low in organic carbon (0.35) and available nitrogen (240 kg ha^{-1}), medium in available phosphorus (54 kg ha^{-1}) and available potassium (220 kg ha^{-1}). The mean maximum and minimum temperatures recorded during crop period were 32.7°C and 22.9°C, respectively. A total rainfall of 541.3 mm was received in 22 rainy days during the crop period. The experiment was laid out in Split plot design with three replications. The treatments comprised combination of four NDVI

Table 1. Growth attributes, yield attributes, yield and head rice recovery of rice as influenced by NDVI values of green seeker and nitrogen levels

Treatments	No. of tillers m^{-2} at flowering	Drymatter production at harvest	LAI at flowering	No. of productive tillers m^{-2}	No. of filled grains	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Head rice recovery (%)
NDVI values of green seeker								
M_1: 0.6	321	8793	3.55	279	129	3772	5235	62.47
M_2: 0.7	379	11211	4.34	338	145	5097	6339	65.55
M_3: 0.8	389	11740	4.64	350	157	5411	6541	67.32
M_4 :0.9	357	9882	3.94	309	138	4441	5826	63.54
SEm (±)	8.51	246	0.08	7.82	4.76	105.42	143.2	1.18
CD (P=0.05)	30.05	870	0.29	27.59	16.79	371.89	505.17	4.1
CV (%)	8.16	8.21	7.07	8.5	11.61	7.8	8.29	6.35
Nitrogen levels (kg ha^{-1})								
N_1: 60	326	8867	3.65	270	119	3965	5278	62.21
N_2: 80	348	10109	4.01	299	140	4444	5753	63.61
N_3: 100	374	11015	4.24	339	152	4912	6205	65.17
N_4: 120	398	11635	4.56	368	158	5400	6707	67.49
SEm (±)	6.68	186	0.05	8.53	3.39	131.32	144.53	1
CD (P=0.05)	19.63	547	0.16	25.5	9.96	385.58	424.36	2.93
CV (%)	6.41	6.21	4.85	9.27	8.27	9.72	8.36	5.36
Interaction								
SEm (±)	17.03	493	0.16	15.64	9.52	210.84	286.4	2.37
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

values of green seeker *viz.,* M_1: NDVI value 0.6, M_2: NDVI value 0.7, M_3: NDVI value 0.8 and M_4: NDVI value 0.9 and four nitrogen levels (N_1: 60 kg N ha^{-1}, N_2: 80 kg N ha^{-1}, N_3: 100 kg N ha^{-1} and N_4: 120 kg N ha^{-1}).

Application of nutrients was done as per the treatments in the form of urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Basal application of 1/3 rd N was done and the remaining 2/3rd N was top dressed as per green seeker readings. The NDVI values were indicated through green seeker. Spectral properties were measured at 10 days interval starting from 20 days after transplanting (DAT) till flowering stage. The green seeker instrument was hand held at distance of 60-120 cm against the crop canopy and random readings were recorded on pressing the trigger. Whenever these NDVI values fall below the threshold value as mentioned in the main treatments, nitrogen was top dressed immediately to meet the N requirement irrespective of the stage of the crop. The final split application of N was completed by 70 DAT coinciding with the flowering stage. Entire quantity of phosphorus and half dose of potassium was applied at the time of transplanting. Remaining dose of potassium were applied at PI stage of the crop. Field operations such as weeding, irrigation and plant protection measures were taken as per requirement. The data on number of tillers m^{-2}, drymatter production, leaf area index, productive tillers m^{-2}, number of filled grains per panicle, grain yield, straw yield and head rice recovery were recorded as per standard procedures. Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p=0.05)

RESULTS AND DISCUSSION

Effect on growth parameters

Number of tillers m^{-2}

At flowering, higher number of tillers m^{-2} were noticed with NDVI value 0.8 (M_3), while it was found to be on par with NDVI value 0.7 and both of them were significantly superior to other NDVI values

(Table 1). A progressive increase in number of tillers m^{-2} was observed with graded levels of N upto the highest level tried 120 kg ha^{-1} (N4). Number of tillers m^{-2} was minimum with the lowest (60 kg ha^{-1}) level of N_1 tried.

Highest number of tillers m^{-2} were recorded with NDVI value 0.8. This might be owing to adequacy of N with this NDVI value which probably favored the cellular activity during panicle initiation and development that leads to increased number of tillers $hill^{-1}$. The results are in agreement with those of Chamely *et al.* (2015) and Tauseef Bhat (2014). The treatment N_4 (120 kg N ha^{-1}) recorded highest number of tillers m^{-2} which might be due to application of higher nitrogen and thereby higher chlorophyll content at different crop growth intervals eventually leading to better utilization of nitrogen for growth and development. The decrease in number of tillers m^{-2} after PI stage could be due to senescence of late formed tillers. The current results are in line with the findings of previous researchers Jhansi Lakshmi Bai (2012) and Srinivasagam Krishnakumar and Stephan Haefele (2013).

Drymatter production

Highest drymatter production (DMP) at harvesting stage were registered with NDVI value 0.8 (M_3) which was significantly superior to other NDVI values except with NDVI value 0.7 (M_2) (Table 1). As regards to drymatter production, it was highest with the highest level of nitrogen tried (120 kg ha^{-1}). Drymatter production was significantly lowest with 60 kg ha^{-1} (N_1).

Production of drymatter depended upon the metabolic activities and its corresponding growth in plants. Obviously, increase in chlorophyll content by virtue of higher leaf N concentration results in higher photosynthetic rate and therefore resulted in higher biomass production. These findings are in corroboration with Blackmer and Schepers (1994), Kropff *et al*., 1993 and Peng *et al*., 1995. This might be the reason for higher DMP at NDVI value of 0.8 and fall of chlorophyll content resulted in lower DMP at NDVI value 0.6. Higher drymatter production was recorded with the application of 120 kg N ha^{-1}. Azarpour *et al.* (2014) reported that the drymatter partitioning to various parts of the plant is influenced by the amount of nitrogen. Higher nitrogen application significantly enhanced drymatter partitioning at the vegetative stage. The results are in close conformity with the findings of Qinglin *et al.* (2000).

Leaf Area Index

From Table 1, it can be inferred that irrespective of the NDVI values tried, significantly higher leaf area index at flowering stage was recorded with NDVI value 0.8 (M_3) and the lowest with NDVI value 0.6 (M_1). With regard to N levels, 120 kg ha^{-1} (N_4) recorded highest LAI and was higher for 100 kg ha^{-1} (N_3) and 80 kg ha^{-1} (N_2) while lowest leaf area index of rice was recorded with 60 kg ha^{-1} (N_1).

The increased N supply at NDVI value 0.8 might have increased the auxin activity, production of carbohydrate and organic compounds leading to accelerated meristematic activity at the shoot apex which in turn increased leaf area. The results are in close conformity with Gupta *et al*. (2011) in LCC based management in rice. Increase in nitrogen levels helped in better development of leaves and was also involved in chlorophyll formation that is the main source of photosynthesis and hence resulted in increase in LAI. These results were also supported by Jagjot Singh Gill and Sohan Singh Walia (2013).

Effect on yield parameters

Productive tillers m^{-2}

Among all the NDVI values, NDVI value 0.8 (M_3) recorded the highest productive tillers m^{-2} which was comparable with NDVI value 0.7 (M_2) and both of them exhibited statistical supremacy over rest of the treatments (Table 1). Significantly, the highest productive tillers m^{-2} of rice was produced with application of nitrogen @ 120 kg ha^{-1} (N_4). The lowest number of productive tillers m^{-2} was noticed with the lower level of nitrogen (60 kg ha^{-1}) compared to that at higher levels.

Highest number of productive tillers m^{-2} were recorded with NDVI value 0.8. This might be owing to better conversion efficiency to productive tillers m^{-2} and also due to higher uptake of nitrogen which had significant role to play in photosynthesis and tillering of rice. These findings are in align with those of Kumar and Ikrammullah (2004). Conspicuous increase in the number of productive tillers m^{-2} was observed with 120 kg N ha^{-1} (N_4) and this might be due to increasing levels of N and sink capacity, which ultimately resulted in increasing the productive tiller at high fertility status.

Total number of filled grains per panicle

The data presented in (Table 1) revealed that highest filled grains per panicle of rice was registered with NDVI value 0.8 (M_3) which was however, comparable with NDVI value 0.7 (M_2) and 0.9 (M_4). Regardless of the nitrogen levels studied, highest filled grains per panicle was obtained with nitrogen level of 120 kg ha^{-1} (N_4) and the lowest were registered with 60 kg N ha^{-1} (N_1).

Higher number of filled grains per panicle with NDVI value 0.8 might be owing to effective translocation of assimilates to the sink, which might have resulted in sound filling of grains as revealed by highest number of filled grains panicle^{-1}. This has been documented by Pradhan Adikant *et al.* (2014) in their findings. Highest number of filled grains per panicle was recorded with the application of 120 kg N ha^{-1} (N_4) resulting in better nourishment, decreased the sterility percentage thereby increased number of filled grains.

Effect on grain and straw yield

NDVI value 0.8 (M_3) out yielded rest of the NDVI values and exhibited its statistical supremacy in producing the highest grain and straw yield except with NDVI value 0.7 (M_2) while it was minimum with NDVI value 0.6 (M_1). Among the graded levels of nitrogen application, grain and straw yield of rice obtained were highest with 120 kg ha^{-1} (N_4) followed by 100 kg ha^{-1} (N_3). The lowest yield was recorded with 60 kg ha^{-1} (N_1) (Table 1).

Nitrogen application through NDVI value 0.8 was found to be ideal for achieving higher yield. It might have matched crop N demand. It might also be due to higher quantity of nitrogen applied in more number of splits compared to other levels. These results are also in close conformity with the findings of Maiti and Das (2006) who have reported higher grain yield with LCC based nitrogen management. In NDVI value 0.9, where major share of 'N' was applied at 20 DAT, 30 DAT and 40 DAT which might have been resulted in lower yield. Lowest yield with NDVI value 0.6 was due to the lowest stature of yield components which reduced the grain yield and the wide gap between the 'N' applications. It is obvious that the nitrogen as a major nutrient can influence leaf N and chlorophyll content and thus consequently SPAD and NDVI values, ultimately in the final yield (Veerendra Pateel *et al*., 2017). The decline in the relationship between grain yield and NDVI values at later stages of growth can be attributed to canopy closure (Harrell *et al.,* 2011).

Increase in the grain yield of rice with each increment in nitrogen level clearly indicated crop response to the application of nitrogen upto the highest level of nitrogen studied i.e. 120 kg ha^{-1}. This could be attributed mainly to the highest number of productive tillers m^{-2}, filled grains per panicle and also improved growth parameters (LAI and drymatter production) and N uptake at harvest which ultimately contributed to increase in yield. Increase in yield components are associated with plant growth, better nutrition, and increased nutrient uptake. It is well known that yield is a manifestation of the individual yield components and therefore in this case also the nitrogen dose which resulted in highest grain yield (120 kg N ha^{-1}) was due to the similar results with graded levels of nitrogen noticed by various researchers *viz.,* Ramana Murthy *et al.* (2012) and Kabat and Satapathy (2013).

Higher straw yield with NDVI value 0.8 might be owing to favorable influence on vegetative growth. Application of higher dose of 'N' promoted more drymatter production resulting in significant increase in straw yield which is again attributed to highest LAI, tillers m^{-2} and higher level of N uptake at panicle initiation stage. The results are in line with the findings of Ravi *et al*. (2007). Higher and continuous supply of 'N' to rice resulted in increased production of growth parameters such as plant height, drymatter production and number of tillers m^{-2}, which ultimately contributed to increased straw yield. These findings are in conformity with Jagjot Singh Gill and Sohan Singh Walia (2013) and Prathibhasree *et al.* (2016).

Effect on Head Rice Recovery

Among all the NDVI values, highest head rice recovery (HRR) was found to be highest with NDVI value 0.8 (M_3), while HRR between NDVI value 0.7 (M_2) and 0.9 (M_4) was found to be statistically comparable. The HRR was minimum with NDVI value 0.6 (M_1). Application of the highest level of nitrogen 120 kg N ha^{-1} (N_4) resulted in highest HRR. While the differences in HRR among N_3 (100 kg ha^{-1}), N_2 (80 kg ha^{-1}) and N_1 (60 kg N ha^{-1}) were found to be on par with each other (Table 1).

Maximum head rice recovery was observed with NDVI value 0.8 which might be due to enhanced availability of nitrogen for longer duration. Head rice recovery is a genetic trait but environmental factors and post harvest handling play vital role and persuade the grain breakage during milling. Similar findings on quality parameters were reported by Ghosh *et al*. (2004). The increase in head rice recovery with an increase in nitrogen levels might be attributed to higher protein content of rice receiving higher dose of nitrogen. These findings were in agreement with the views expressed by Zhu Da Wei *et al.* (2018).

CONCLUSION

Based on the above results and discussion, it can be concluded that N application through green seeker at NDVI value of 0.8 (M_3) and application of 120 kg N ha^{-1} were found to be suitable for transplanted rice and can be recommended for obtaining highest productivity and profitability.

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