Agric. Sci. Digest., 39(1) 2019: 59-62
Print ISSN:0253-150X / Online ISSN:0976-0547

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Nutrient uptake and nitrogen use efficiency of rice genotypes under LCC- based N application during summer

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Received: 29-10-2018 Accepted: 06-03-2019 DOI: 10.18805/ag.D-4839

ABSTARCT

A field experiment was undertaken at Research Farm, Department of Agronomy, OUAT Bhubaneswar to study the response of rice (*Oryza sativa* L.) varieties to LCC based nitrogen application under Real Time Nitrogen Management (RTNM) during summer 2015 in split plot design with three replications. Four varieties (V_1- Lalat, V_2- Naveen, V_3- Hiranmayee and V_4- Gobinda) were in main plot and sub plots were assigned with six N- management practices (N_1- Control, N_2- RDN@ 80 kg N ha^{-1} while in treatment N_3 to N_6, 20 kg N was applied in each split at LCC level 3 (N_3), LCC level 4(N_4), LCC level 5(N_5) and LCC level 6 (N_6). A uniform dose of phosphorous and potassium @ 40 kg ha^{-1} each along with well decomposed FYM @ 5t ha^{-1} were applied to all the plots as basal. Nitrogen uptake was maximum (88.59 kg ha^{-1}) in variety Naveen, whereas, the variety Gobinda had maximum agronomic efficiency (24.12 kg kg^{-1}), recovery efficiency (37.23 kg kg^{-1}), physiological efficiency (53.33 kg kg^{-1}) and partial factor productivity (44.58 kg kg^{-1}).Application of RDF resulted in maximum uptake of nitrogen (94.20 kg ha^{-1}) and registered the highest agronomic efficiency (32.86 kg kg^{-1}), recovery efficiency (55.40 kg ka^{-1})and partial factor productivity (65.61 kg ka^{-1}). The highest physiological efficiency of 63.93 kg ha^{-1} and minimum N loss of 29.35 kg ha^{-1} was recorded forLCC 4 (N_4) threshold value.

Key words: Nitrogen application, Rice, Nitrogen uptake.

INTRODUCTION

Low recovery of nitrogen (30-35%) is always a concern and remained a researchable issue for the rice scientists. The earlier studies of nitrogen management in rice aimed at time of application , stage based spilt application, placement, formulations along with its release in controlled manner and using the inhibitors (Chaiwanakupt *et al*. 1996; De Datta, 1986; Schnier *et al*. 1990). These studies could achieve higher grain yield with less N loss, but could not increase N use efficiency, appreciable profit to rice farmer, and failed to ensure an optimal match between the supply of added N and the crop N-demand (Dobennann and Gassman, 2002). This triggered the need for congruence between N demand and available N supply from soil and applied N to increase N use efficiency. Site Specific Nutrient Management (SSNM), Real Time Nitrogen Management (RTNM) and Adjus Table Fixed Time Nitrogen Management (AFTNM) are the steps towards this direction. In Real Time N Management, the timing of N fertilizer applications is determined through periodic monitoring of crop N status (Witt *et al*. 2005). Simple and inexpensive Leaf Colour Chart (LCC) consisting of six shades ranging from light yellowish green (No 1) to dark green (No 6) colour strips (8" x 3") fabricated with veins resembling rice leaves are generally used as visual and subjective indicator of rice N fertilizer need (Singh *etal*. 2006). Leaf colour chart intensity is directly related to leaf chlorophyll content and leaf N status and can be an ideal tool to optimize N use. Mention importance and objectives of present study

MATERIALS AND METHODS

The field experiment was undertaken at Agronomy Research Farm, OUAT, Bhubaneswar to study the nutrient uptake and nitrogen use efficiency of rice (*Oryza sativa* L.) genotypes under LCC- based N application during summer 2015. The soil (0-15 cm) of the experimental site was sandy loam in texture with pH 5.3, EC 0.44 dSm^{-1}, medium in available nitrogen (303.20 kg ha^{-1}), phosphorus (19.71 kg ha^{-1}), potassium (240.58 kg ha^{-1}) and organic carbon (0.64%). The experiment was laid out in split plot design with three replications consisted of twenty four treatment combinations comprising of four medium duration (125-130 days) rice genotypes, Naveen(V_1), Lalat(V_2), Hiranmayee(V_3) and Gobinda(V_4) in the main plots and six fertilizer N management treatments ($N_1 – N_6$) were allotted to sub-plots, N_1 Controlno nitrogen , In N_2 treatment, nitrogen was applied at recommended dose @ 80 kg ha^{-1}(RDF) in 1:2:1 ratio at the time of sowing, maximum tillering and panicle initiation stages, respectively. Treatments from N_3 to N_6 received a

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dose of 20 kg N ha^{-1}in each split when leaf colour fell below LCC panel 3,4,5 and 6, respectively and designated as N_3, N_4, N_5 and N_6, respectively. A uniform dose of phosphorous and potassium @ 40 kg ha^{-1} each along with well decomposed FYM @ 5t ha^{-1} were applied to all the plots as basal. Thirty days old seedlings were transplanted @ 3 seedlings $hill^{-1}$at a spacing of 15 cm x 15 cm. LCC observations were taken at weekly interval starting from 14 days after transplanting to 50% flowering stage. A dose of 20 Kg N ha^{-1} was applied when the leaf colour fell below the threshold values. The crop was irrigated with 7cm depth of water 1 day after its disappearance from the plots.

Plant samples were collected from each treatment at the time of harvest and the content of N,P,K was determined using standard methods such as Modified Micro-Kjeldahl method for nitrogen (Jackson,1973), colorimetric estimation for phosphorus (Piper,1966) and neutral normal Ammonium acetate flame photometer method for potassium (Jackson, 1973), respectively. The uptake of N, P and K by grain andstraw was calculated separately by multiplying the respective yields with the corresponding nutrient contents and were expressed in kg ha^{-1}.

Nutrient removal= Nutrient content (%) in grain or straw x grain or straw yield (kg ha^{-1}) / 100

Nitrogen use efficiencies like recovery efficiency (RE_N), agronomic efficiency (AE_N) and physiological efficiency (PE_N) as described by (Cassman *et al*,1998) were computed using following formula:

$$RE_N \text{ (kg kg}^{-1}) = \frac{\text{(Total N uptake in N fertilized plot - Total N uptake in no N plot)}}{\text{(Quantity of N fertilizer applied in N fertilized plot)}} \times 100$$

$$AE_N \text{ (kg grain/kg N applied)} = \frac{\text{(Grain yield in N fertilized plot – Grain yield in no N plot)}}{\text{Applied N fertilizer}}$$

$$PE_N \text{ (kg grain /kg N uptake)} = \frac{\text{(Grain yield in N fertilized plot – Grain yield in no N plot)}}{\text{(Total N uptake in N fertilized plot - Total N uptake grain yield in no N plot)}}$$

$$PFP_N \text{ (kg kg}^{-1}) = \frac{\text{Yield of control plot+ } AE_N}{\text{N dose applied}}$$

A balance sheet showing gain/loss of soil nitrogen was prepared by taking into account initial soil nitrogen status, N added as per N management practices, total N removal from soil. Expected and actual nitrogen balance was calculated by the following formula:

Soil nitrogen loss/ gain (kg ha^{-1}) = Actual – Expected soil nitrogen balance (kg ha^{-1})

where,

Expected soil N balance (kg ha^{-1}) =
Initial soil N status (kg ha^{-1}) + amount of N added (kg ha^{-1}) - total N removal (kg ha^{-1}) by plant

The net balance shows the net gain or loss of soil N after harvest, the values are presented by negative or positive sign showing the loss and gain, respectively.

Actual soil N balance (kg ha^{-1}) = Soil N status after harvest

RESULTS AND DISCUSSION

Nutrient uptake (kg ha^{-1}): Data on uptake of nitrogen, phosphorus and potassium as influenced by various treatments is presented in Table 1. Rice genotypes showed significant variation in nitrogen uptake but phosphorus and potash remained un affected. Variety Naveen (V_2) proved to be efficient and responded to varying levels of nitrogen application with significantly highest N uptake of 88.59 kg ha^{-1} and registered an increase to the tune of 8.11, 7.99 and 1.88% over varieties Lalat (V_1), Hiranmayee (V_3) and Gobinda (V_4), respectively. Ortiz-Monasterio *et al*, (2001) concluded that crop varieties respond to nutrient supply in four different ways namely-being efficient or inefficient under nutrient deficiency and as a responder or non-responder under nutrient sufficiency. Efficient genotypes possess high (uptake) efficiency, whereas, responders are characterized by high internal (utilization) efficiency. All the varieties were efficient in using P and K available from native source as well supplied through fertilizers. Kumar and Malarvizhi (2014) reported that genotypes may differ in their response to phosphorus utilization and screened out varieties for cultivation. Similar observations were also made by Fageria and Santos (2014) with respect to potassium utilization.

Different N management practices showed significant difference in total uptake of all the three nutrients. With regards to nitrogen, the maximum removal of 94.20 kg ha^{-1} was observed under N_2 whereas,N_6 removed the maximum of phosphorus (23.76 kg ha^{-1}) and potassium (135.44 kg ha^{-1}). Treatment with no nitrogen application recorded the lowest amount of nutrient.

Nitrogen use efficiency (kg kg^{-1}): A perusal of data (Table 2) indicated that variety Gobinda (V_4) proved to be significantly efficient in terms of AE_N (24.12 kg kg^{-1}), RE_N (37.23 kg kg^{-1}), PE_N (53.33kg kg^{-1}) and PFP_N (44.58 kg kg^{-1}).It implies that variety Gobinda could express, comparatively, not only more yield increasing effect on account of N application but also showed higher ability to transform absorbed nutrient into economic yield and fertilizer nitrogen recovery in above ground plant biomass. Cassman *et al*. (1998) reported partial factor productivity of N (PFPN) a useful measure in conventional cropping systems as it provides an integrative index of the total economic output in relation to the utilization of all N sources in the system.

The N use efficiency varied significantly due to various Real Time Nitrogen Management (RTNM) practices and recommended dose of fertilizer (N_2) registered the highest agronomic (32.86 kg kg^{-1}), recovery (55.40 kg ka^{-1}) efficiencies and partial factor productivity (65.61 kg ka^{-1}), whereas, nitrogen application based on LCC 4 (N_4) produced the highest physiological efficiency (63.93 kg kg^{-1}). All N use efficiencies except physiological recorded higher values at lower levels of LCC and was in the order of N_2> N_3> N_4> N_5> N_6> N_1. The trend with respect to physiological efficiency was in the order of N_4> N_2> N_6> N_5> N_3> N_1, the highest being 63.93 kg kg^{-1} at N_4. The corresponding values were lowest at LCC 6 thresh hold limit. Hussain *et al*. (2000) concluded that need based nitrogen application results in greater agronomic and physiological efficiency than the commonly practiced methods and thus helps in careful design of dose. Bhatt(2014) also confirmed that N use efficiency *viz*. RE_N, AE_N, PE_N, PFP_N decreased with increased N application and higher values were recorded with LCC $\leq$ to 3 as compared to higher LCC value and recommended dose.

Varietal response to LCC based application: Data revealed that varieties responded differently to different threshold values of LCC and, therefore the crop N-demand varied with growth stages (Table 3). All the varieties received an equal amount of nitrogen under RDF (N_2) and N application as per LCC 3 (N_3), the value being 80 kg N ha^{-1}. Varieties Lalat and Naveen responded in similar fashion to LCC values 4, 5 and 6 and received a total amount of 120,140 and 140 kg N ha^{-1}, respectively. Whereas, the varieties Hiranmayee and Gobinda responded to LCC threshold value 4 and 6 and received 100 and 160 kg N ha^{-1}, respectively.

Table 1: Nitrogen, phosphorus and potassium uptake as influenced by varieties and N management practices.

Treatment	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Variety									
Lalat (V_1)	52.17	29.77	81.94	13.26	5.65	18.91	19.87	107.69	127.56
Naveen(V_2)	55.76	32.83	88.59	13.31	5.14	18.45	19.62	108.46	128.08
Hiranmayee(V_3)	52.34	29.70	82.03	13.36	5.81	19.17	19.49	107.36	126.85
Gobinda (V_4)	54.70	32.25	86.95	14.11	5.01	19.12	21.13	106.46	127.59
SEm $\pm$	0.42	0.32	0.33	0.350	0.45	0.43	0.34	0.50	0.45
CD (P=0.05)	1.50	1.10	1.16	NS	NS	NS	1.16	NS	NS
Nitrogen management practices									
No nitrogen (N_1)	24.62	25.26	49.88	7.95	2.76	10.71	17.47	90.15	107.62
RDF (N_2)	60.24	33.96	94.20	12.73	4.21	16.94	18.28	106.76	125.04
As per LCC 3 (N_3)	58.01	32.60	90.61	13.05	4.23	17.29	22.26	107.07	129.33
As per LCC 4 (N_4)	59.28	31.65	90.92	15.20	5.89	21.09	20.97	111.61	132.59
As per LCC 5(N_5)	60.68	32.20	92.88	16.18	7.49	23.67	20.40	114.69	135.10
As per LCC 6 (N_6)	59.63	31.15	90.78	15.93	7.83	23.76	20.78	114.66	135.44
SEm $\pm$	0.58	0.61	0.55	0.34	0.35	0.40	0.64	0.47	0.56
CD (P=0.05)	1.64	1.76	1.57	0.96	1.01	1.14	1.82	1.35	1.60

Table 2: Nitrogen use efficiencies as influenced by varieties and nitrogen management practices.

Treatment	Agronomic efficiency (kg kg^{-1})	Recovery efficiency (kg kg^{-1})	Physiological efficiency (kg kg^{-1})	Partial factor productivity (kg kg^{-1})
Variety				
Lalat (V_1)	16.01	29.48	45.15	36.92
Naveen (V_2)	19.34	34.61	47.18	41.05
Hiranmayee (V_3)	19.54	32.97	50.07	39.93
Gobinda (V_4)	24.12	37.23	53.33	44.58
SEm +	0.22	0.37	0.34	0.18
CD (P=0.05)	0.77	1.27	1.18	0.64
Nitrogen management practices				
No nitrogen (N_1)	-	-	-	-
RDF (N_2)	32.86	55.40	58.91	65.61
As per LCC 3 (N_3)	28.52	50.91	55.64	61.27
As per LCC 4 (N_4)	24.38	37.80	63.93	48.35
As per LCC 5 (N_5)	16.91	29.83	56.97	35.06
As per LCC 6 (N_6)	15.85	27.50	58.17	33.43
SEm +	0.31	0.38	0.42	0.35
CD (P=0.05)	0.90	1.09	1.20	0.99

Table 3: Soil nitrogen balance as affected by different nitrogen management practices.

Treatment	N initial (kg ha^{-1})	N added (kg ha^{-1})	N removed (kg ha^{-1})	Expected N balance (kg ha^{-1})	Actual N balance (kg ha^{-1})	Net gain/loss (kg ha^{-1})
N management practices						
No nitrogen (N_1)	303.2	0	49.88	253.32	229.38	-23.94
RDF (N_2)	303.2	80	94.20	289.00	251.99	-37.00
As per LCC 3 (N_3)	303.2	80	90.61	292.59	256.46	-36.14
As per LCC 4 (N_4)	303.2	110	90.92	322.28	293.01	-29.35
As per LCC 5 (N_5)	303.2	145	92.88	355.32	313.69	-41.66
As per LCC 6 (N_6)	303.2	150	90.78	362.43	319.20	-43.23
SEm +			0.55	0.78	0.65	0.53
CD (P=0.05)			1.57	2.22	1.87	1.51
Mean	302.2	94.17				

However, the amount of N received differed with these two cultivars when the N was applied at LCC value 5 being 160 and 140 kg N ha^{-1}, respectively. The differential response of varieties to applied N might be due to the fact that either the nutrients are not taken up by the plants, applied at wrong time or transformation of nutrients has made them unavailable to plants or if absorbed by the plants, not used for grain production due to other growth limiting factors (Bartholomew,1972). Differential varietal response to real time nitrogen management based on LCC thresh hold values has also been reported by Sen *et al* (2011).

Soil nitrogen balance sheet: A balance sheet showing gain/ loss of soil nitrogen taking in to account initial nitrogen status, N added as per N management practices, total N removal from soil, expected and actual nitrogen balance was worked out and data are presented in Table 4. Data revealed a significant minimum loss of nitrogen under no nitrogen treatments. However, among the Real Time Management practices, significantly lowest (29.35 kg ha^{-1}) N- loss was observed under the treatment N_4. The percentage loss over N_4 increased to the tune of 26.06, 23.13, 41, 94 and 47.29% under N_2, N_3, N_5 and N_6, respectively.

REFERENCES

Bartholomew, W.V. (1972). Soil nitrogen supply; process and crop requirement. *Technical Bulletin* **6:**68.

Bhatt, N. T.A. (2014). Real time nitrogen management in rice genotypes (*Oryza sativa* L.) based on LCC. Ph.D Thesis submitted to Sher-e Kashmir University of Agriculture &Technology, Kashmir.

Cassman, K.G., Peng, S.O.K., Ladha, D.C., Reichardt, J.K., Dobermann,W., Singh,A U. (1998). Opportunities for increased nitrogen-use efficiency from improved resource management in irrigated rice systems, *Field Crops Research*, **56**: 7–39.

Chaiwanakupt ,P., Frency, J.R., Keerthisinghe, D.G.,Phongpan, S.and Blakely, R.L. (1996).Use of urease, algal inhibitors and nitrification inhibitors to reduce nitrogen loss and increase the grain yield of flooded rice. *Biology,Fertilizer,Soils.***22**:89-95.doi:101007/ BF00384438.

De Datta, S.K. (1986). Improving nitrogenous fertilizer efficiency in lowland rice in tropical Asia, *Fertilizer Research*, **9**: 1-2, 171-186.

Dobermann, A., Witt, C., Dawe, D., Gines, H.C., Nagarajan. R, Satawathananont, S., Son, T.T, *et al*. (2002). Site-specific nutrient management For intensive rice cropping systems in Asia, *Field Crops Research*, **74:** 37–66.

Fageria, N.K and Santos A.B.Dos. (2014). Lowland rice genotypes evaluation for nitrogen use efficiency. *Journal of Plant Nutrition*, **37**:1410-1423.

Hussain, F., Broson, K.F., Singh, Y., Singh, B. and Peng, S. (2000). Using chlorophyll meter sufficiency indices for N management of irrigated rice in Asia. *Agronomy Journal*,**92**: 875-879.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall India Pvt. Ltd. New Delhi, India. 46.

Kumar, Sanjeev and Malarvizhi, P.(2014). Differential response of P utilization efficiency in rice by tracer technique using P-32 under phosphorus stress environment. *Journal of Applied and Natural Science*, **6**: 362-365.

Ortiz-Monasterio., Gunthe., M and Marteen, V.G. (2001). Nitrogen and Phosphorus use efficiency, Chapter 1 7. *Research Gate*, 200-207.

Piper, C.S.(1966). Soil and Plant Analysis. Hans Publication, Bombay, India.

Schnier, H.F., Dingkuhn, M., De Datta, S. K, Mengel, K and Faronilo, J. E. (1990), Nitrogen fertilization ondirect seeded flooded vs. transplanted rice: I. nitrogen uptake, photosynthesis, growth and yield. Alliance of Crop, Soil and Environment Science Societies Digital Library

Sen, A., Srivastava, V.K., Singh, M.K., Singh, R.K, Kumar, S. (2011). Leaf colour chart vis-a-vis nitrogen management in different rice genotypes, *American Journal of Plant Science*, **2**: 223-236.

Singh, B., Singh, Y., Singh, V., Gupta, R.K. (2006). Using leaf color chart for need based nitrogen application to rice, *Extension Bulletin*, **9**: 1-10.

Witt, C., Pasuquin, J.M.C.A., Mutters, R., Buresh, R.J., (2005). New leaf color chart for effective nitrogen management in rice. *Better Crops*, **89**, 36–39.