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Response of Nitrogen Levels on Productivity and Profitability of Rice Cultivars in Shallow Lowlands of Assam

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A B S T R A C T

A field experiment was carried out during *kharif* season of 2016 at the research farm of Regional Rainfed Lowland Rice Research Station, ICAR-National Rice Research Institute, Assam to assess the response of nitrogen levels through neem coated urea in rice cultivars under shallow lowland ecosystem of Assam .The experiment was laid out in split plot design with four high yielding rice cultivars ('Naveen', 'TTB 404', 'CR Dhan 100', and 'CR Dhan 310') in main plots and five levels of nitrogen (0, 30, 45, 60 and 75 kg/ha N) through neem coated ureain subplots, replicated thrice. Cultivars of rice responded differently to nitrogen levels. 'Naveen' was found most productive and profitable followed by 'TTB 404' and 'CR Dhan 100'. The lowest optimum economic doses of N were 71.1, 89.7, 133.7 and 186.1 kg/ha N for 'Naveen', 'TTB 404', 'CR Dhan 100', and 'CR Dhan 310', respectively. Among the nitrogen levels, 60 kg/ha N was found sufficient to achieve comparable productivity and profitability of rice cultivars under shallow lowland conditions.

Introduction

Rice (*Oryza sativa* L.) is the most important staple food as it feeds approximately half the world population and grown over 163 million hectares (m ha). In Asia, rice is raised on 143 m ha, out of which 43.4 m ha are grown in India, producing about 115.6 million tonnes (m t) of grain. Dry-season (summer/*rabi*/ *boro*) rice contributes 13.6 m t while the remaining 102.0 m t come from wet-season (*kharif*) rice (GOI, 2019).

Fertilizer nitrogen (N) is the most important nutrient contributing about 40% increase in per capita foodgrain production over the past 50 years (Smil, 2002). But the excessive use of N fertilizers has raised some global concerns, mainly due to low efficiency of N fertilizers in shallow lowlands.

Recovery of applied fertilizer N under most of the cropping systems is less than 50% however; nitrogen fertilizer-use efficiency (20–50%) is low in rice fields in India. This low recovery is associated with N losses from nitrate-nitrogen (NO_3 –N) leaching, ammonia (NH_3) volatilization, surface runoff, and denitrification (Shivay *et al.,* 2005). To overcome the low nitrogen use-efficiency (NUE) slow-release coated ureas, such as sulphur coated urea (SCU), phosphogypsum coated, polymer coated urea (PCU) and neem coated urea (NCU) water-soluble fertilizer, and biodegradable fertilizer materials have been developed (Bana and Shivay, 2012). Neem (*Azadirachtaindica* A. Juss) oil and oilcake has the property of inhibiting nitrification process and enhanced NUE in rice (Kumar *et al.,* 2010; Singh *et al.,* 2019). Indian Agricultural Research Institute, New Delhi have indicated an increase in yields and apparent nitrogen recovery (%) of rice by using neem cake, neem-oil emulsion coated urea, pusa neem golden urea and other modified fertilizer materials. Neem coated urea not only increase crop yield but also lower input cost to the farmer. Cost of neem coated urea is only 3-4% higher than ordinary urea (Singh *et al.,* 2019). Considering the advantages of neem oil coated urea (NOCU), Government of India modified the Fertilizer Control Order and bound all fertilizers producing companies to produce neem coated urea and provide it to the farmers at subsidize price. But the exact amount of NCU is not optimize for different rice varieties under shallow lowlands of Eastern Region. Hence the present field study was made to identify the optimum doses of NCU for different rice varieties under shallow lowland conditions.

Materials and Methods

An experimental trial was conducted during kharif season of 2016 at Research Farm of Regional Rainfed Lowland Rice Research Station, Gerua, Assam to quantify the neem coated urea requirement for rainfed lowland rice cultivars. The site is located at 28º 14' 59" N latitude, 91º 33' 44' E longitudes and at an altitude of 49 m above mean sea level. The climate of the region is a subtropical monsoonal climate. The annual average rainfall is 1500 mm of which about 75% falls during June to September. Four high yielding rice cultivars (CR Dhan 100, CR Dhan 310, TTB 404 and Naveen) allotted in main plots and five N levels (0, 30, 45, 60 and 75 kg/ ha) in sub plots were tested in split plot design with three replications.

Seedlings of 25 days were carefully uprooted from the nursery beds and transplanted in the last week of July in the well-puddled experimental plots with spacing of 20 cm × 15 cm. A recommended fertilizer doses of 60-30-30 kg/ ha of N-P_2O_5-K_2O was applied to grow the crop. Whole N was applied in the form of neem coated urea while P_2O_5 and K_2O were applied through di-ammonium phosphate (DAP) and muriate of potash (MOP) in the field. One-third N and full doses of P_2O_5 and K_2O were applied as basal dose at the time of final land preparation and incorporated well into the soil. Remaining nitrogen was applied in two equal doses at maximum tillering and panicle initiation. All other agronomic practices were kept normal and uniform for all the treatments of the experiment. Growth, yield attributes and yield recorded on the basis of quadrat of 1 $m^2$and net plot 6 x 5 m^2 harvested and threshed. Nitrogen response to rice cultivars, agronomic efficiency (AE) and partial factor productivity (PFP) were also estimated based on grain yield and prevailing price of paddy. The statistical analysis was performed for each parameter recorded based on a split plot design using online data analysis software of Indian Agricultural Statistics Research Institute, New Delhi. Means were compared by LSD at the 5% level of significance.

Results and Discussion

Growth parameters

The data pertaining to growth parameters of rice cultivars influenced by nitrogen levels presented in Table 1. Growth parameters were significantly influenced by the rice cultivars as all these traits were genetically controlled. The maximum plant height was recorded from TTB 404 and found significantly higher over CR Dhan 100 and Naveen and at par with CR Dhan 310. CR Dhan 100 and CR Dhan 310 recorded significantly higher values for LAI at 30 days after transplanting (DAT) over TTB 404 and Naveen while vice-versa trend was obtained at 60 DAT. Crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) values at 30 DAT were obtained significantly higher from CR Dhan 100 and TTB 404 over CR Dhan 310 and Naveen however, at 60 DAT Naveen and TTB 404 recorded significantly higher values for CGR, RGR and NAR over CR Dhan 100 and CR Dhan 310. CR Dhan 100 and TTB 404 cultivars were initially at 30 DAT more vigorous as compared to Naveen and CR Dhan 310 but TTB 404 and Naveen found more vigorous in later stages. These differential growth parameters from rice cultivars might be due to its varietal characteristics as variety and nitrogen level interaction remained non-significant. Similar findings were also reported for various rice cultivars (Singh *et al.,* 2004 and Kant *et al.,* 2018).

Growth parameters were significantly increased with increasing the N levels. The maximum values for growth parameters such as plant height, LAI, CGR, RGR and NAR were obtained with the highest level of N (75 kg/ ha) and found significantly superior over control and 30 kg/ ha N. However, LAI and CGR at 30 DAT and RGRand NAR at both stages (30 and 60 DAT) found significantly superior with the highest level of N (75 kg/ ha) over 45 kg/ ha N but LAI and CGR at 60 DAT remained statistically at par with 45 kg/ ha N. Both 75 and 60 kg/ha N obtained statistically at par values for plant height, LAI, CGR and NAR values at 60 DAT, however, LAI, CGR and NAR at 30 DAT and RGR at both stages (30 and 60 DAT) were found significantly higher with 75 kg/ ha N over 60 kg/ ha N. The increment in growth parameters with increasing N level mainly due to acceleration of above ground plant parts with the application of N. Successive level of N enhanced the growth parameters such as plant height, LAI and dry matter accumulation of rice (Shivay *et al.,* 2015, Anil *et al.,* 2014, Kant *et al.,* 2018).

Yield attributes and productivity

Yield attributes except panicle weight were significantly influenced by the rice cultivars (Table 2). CR Dhan 310 reported significantly highest number of panicles (m^2) and panicle length as compared to rest of the rice cultivars but reported lowest number of filled grains/ panicle and fertility percentage. Naveen was the second-best cultivar in terms of panicles (m^2) and panicle length and found significant superior over TTB 404 and CR Dhan 100. Naveen also recorded the highest number of filled grains/ panicle and statistical superior over all rice cultivars. However, CR Dhan 100 reported lowest values of panicles(m^2) and panicle length but recorded significantly highest 1000-seed weight over all other cultivars. Among rice cultivars, TTB 404 recorded the highest fertility percentage and found superior over all other cultivars. Among these yield attributes, number of panicles (m^2), filled grains/ panicle and fertility percentage were the most important for determining grain yield. CR Dhan recorded highest number of panicles (m^2) but resulted lowest grain and straw yield which was mainly due to lowest number of filled

grains/panicle. Naveen recorded the highest grain yield and found significant over CR Dhan 310 and CR Dhan 100 but remained at par with TTB 404. Higher grain yield of Naveen was mainly contributed by filled grains/ panicle and number of panicles (m^2). TTB 404 recorded the highest straw yield and significant over all rice cultivars. Yield and yield attributes of rice cultivars were differed each other due to genetic potential of individual variety (Singh *et al.,* 2004, Kant *et al.,* 2018)

Yield attributes such as panicles (m^2), filled grains/panicle, panicle length and fertility percentage showed significant differences between the N nutrition levels, while panicle weight and 1000-grain weight were remained unaffected. The maximum values of yield attributes except panicle length recorded with the highest level of N (75 kg/ha) and found significantly higher as compared N level up to 45 kg/ha, however, remained statistically at par with 60 kg/ha N. The maximum panicle length was obtained from 60 kg/ha N and significantly higher over control, 30 and 45 kg/ha N but remained at par with 75 kg/ha N.

The higher values of yield attributes resulted higher grain and straw yield with the highest level of N (75 kg/ha). Grain and straw yield remained at par with 60 and 75 kg/ha N. The successive increment in N levels significantly increased grain yield up to 45 kg/ha N. Grain and straw yield of rice increased significantly with successive level of N up to 75 kg/ha (Jisan *et al.,* 2014 and Kant *et al.,* 2018).

Economics and crop duration

The results exhibited that there were variations in gross, net returns and net B:C ratios due to rice cultivars and nitrogen levels (Table 3). Naveen rice cultivar was the most profitable in terms of gross, net returns and net B;C and took least time in maturity and 50% flowering which is mainly due to highest production efficiency. TTB 404 was the second most profitable variety but took more duration in maturity and 50% flowering. CR Dhan 100 and CR Dhan 310 were less profitable due to lower production efficiency under shallow lowland conditions of Assam . There were increased in gross, net returns and net B:C ratios with successive level of N level. The maximum gross, net returns and net B:C ratio were recorded with 75 kg/ha N but these values were marginally higher over 60 kg/ha N whereas least profit was obtained with control.The gross, net returns and net B:C ratio were higher with successive level of NCU as compared to prilled urea (Kumari and Choudhary, 2018, Kumar *et al.,* 2020).

Agronomic efficiency and partial factor productivity

Agronomic efficiency (AE) and partial factor productivity (PFP)were decreased with increased N level (Figure 1). The maximum values of PFP and AE were obtained at lowest level of N. Reduction in PFP was steep whereas AE reduced gradually up to 60 kg/ha N and thereafter drastic reduction trend was observed in AE.This might be due to poor utilization by the crop at higher levelsof N because of curvilinear return to the conversion of plant N to grain asyield approach the ceiling at higher levels of N (Cassman *et al.,* 2002, Mahajan *et al.,* 2010).

Response of rice cultivars to N levels

The relationship between grain yield and nitrogen levels for rice cultivars were quadratic in nature (Fig. 2). The coefficient of determination revealed that 99.4%, 97.3%, 97.8% and 80.4 % of the variation in grain yield among cultivars ‘Naveen’, ‘TTB 404’, ‘CR Dhan 100’ and ‘CR Dhan 310’, respectively, could be explained by the variation in N response.

Table.1 Effect of varieties and nitrogen levels on growth parameters of rice

Treatment	Plant height (cm)	Leaf area index		Crop growth rate (g/m^2/day)		Relative growth rate (g/g/day)		Net assimilation rate (g/m^2/day)	
		30 DAS	60 DAS	0-30 DAS	30-60 DAS	0-30 DAS	30-60 DAS	0-30 DAS	30-60 DAS
Variety									
CR Dhan 100	121.8	1.9	3.2	19.67	3.34	17.36	1.54	3.45	0.90
CR Dhan 310	131.7	1.9	4.0	15.90	2.86	11.69	1.34	2.45	0.67
TTB 404	133.6	1.7	4.4	19.55	7.48	15.43	3.09	3.04	1.55
Naveen	129.8	1.8	4.3	15.82	8.53	12.83	3.46	2.40	1.83
SEm±	1.09	0.03	0.08	0.58	0.26	0.95	0.09	0.10	0.04
CD (p =0.05)	2.67	0.08	0.19	0.67	0.31	1.10	0.11	0.11	0.05
N levels (kg/ha)									
0 NCU	125.7	1.5	3.5	15.26	4.08	10.84	1.66	2.57	1.03
30 NCU	128.6	1.7	3.8	17.07	5.36	13.39	1.97	2.73	1.08
45 NCU	129.8	1.9	4.1	18.19	5.91	14.61	2.44	2.80	1.16
60 NCU	130.8	2.0	4.2	18.63	6.15	15.96	2.74	2.94	1.39
75 NCU	131.3	2.1	4.2	19.52	6.26	16.84	2.98	3.13	1.52
SEm±	1.00	0.03	0.07	0.74	0.44	0.72	0.16	0.13	0.13
CD (p =0.05)	2.04	0.06	0.15	0.83	0.49	0.81	0.18	0.15	0.14

Table.2 Effect of varieties and nitrogen levels on yield attributes of rice

Treatment	Panicles (m^2)	Filled grains /panicle	Panicle length (cm)	Panicle weight (g)	Spikelet fertility (%)	Test weight (g)	Straw yield (t/ha)	Grain yield (t/ha)
Variety								
CR Dhan 100	206.6	144.0	26.1	3.1	84.2	24.6	5.76	4.81
CR Dhan 310	284.7	133.4	28.9	2.7	83.0	22.0	5.85	4.57
TTB 404	222.9	141.2	27.2	2.9	88.3	20.8	7.92	5.68
Naveen	253.5	149.0	27.2	2.7	84.1	20.8	7.40	5.88
SEm±	6.91	2.89	0.56	0.14	0.75	0.14	0.12	0.10
CD (p =0.05)	16.92	3.36	1.37	NS	0.87	0.35	0.29	0.24
N levels (kg/ha)								
0 NCU	214.3	132.5	25.7	2.7	82.3	21.9	6.00	4.36
30 NCU	237.3	139.9	26.8	2.7	85.0	22.1	6.53	5.06
45 NCU	245.9	143.4	27.2	2.8	85.3	22.1	6.85	5.39
60 NCU	252.5	146.7	29.0	3.0	85.6	22.1	7.08	5.66
75 NCU	259.8	147.1	28.0	3.0	86.2	22.1	7.21	5.71
SEm±	6.03	2.98	0.78	0.17	0.66	0.12	0.19	0.15
CD (p =0.05)	12.29	3.38	1.58	NS	0.75	NS	0.39	0.31

Table.3 Effect of varieties and nitrogen levels on economics of rice

Treatment	Days to 50% flowering (Days)	Days to maturity (Days)	Production efficiency (kg/ha/day)	Gross return (₹/ha)	Net return (₹/ha)	Net B:C
Variety						
CR Dhan 100	95	120	43.9	76467	38587	1.02
CR Dhan 310	85	115	39.7	73029	35149	0.93
TTB 404	104	140	40.3	91416	53536	1.41
Naveen	81	110	48.9	93836	55956	1.48
N levels (kg/ha)						
0 NCU				70092	34892	0.99
30 NCU				80912	42662	1.12
45 NCU				86083	47633	1.24
60 NCU				90282	51632	1.34
75 NCU				91147	52297	1.35

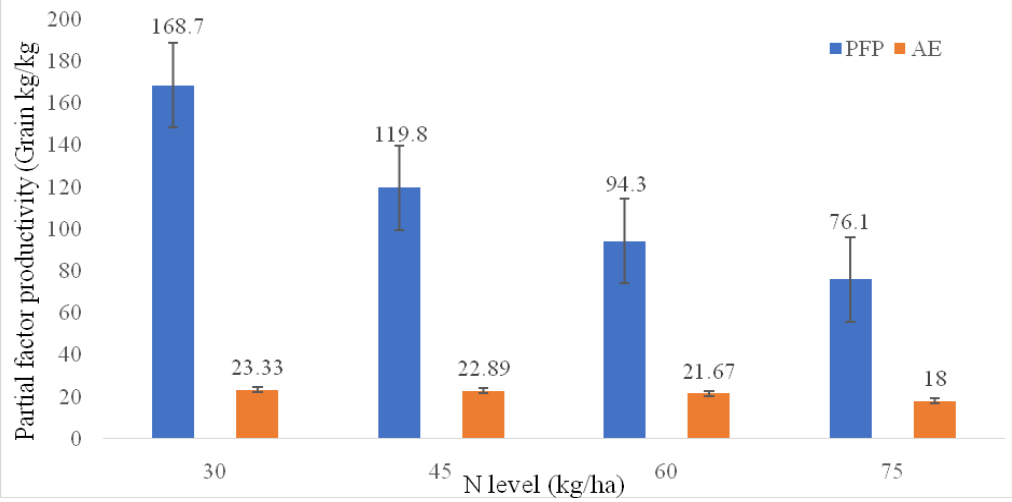

Figure.1 Partial factor productivity (PFP) and agronomic efficiency (AE)

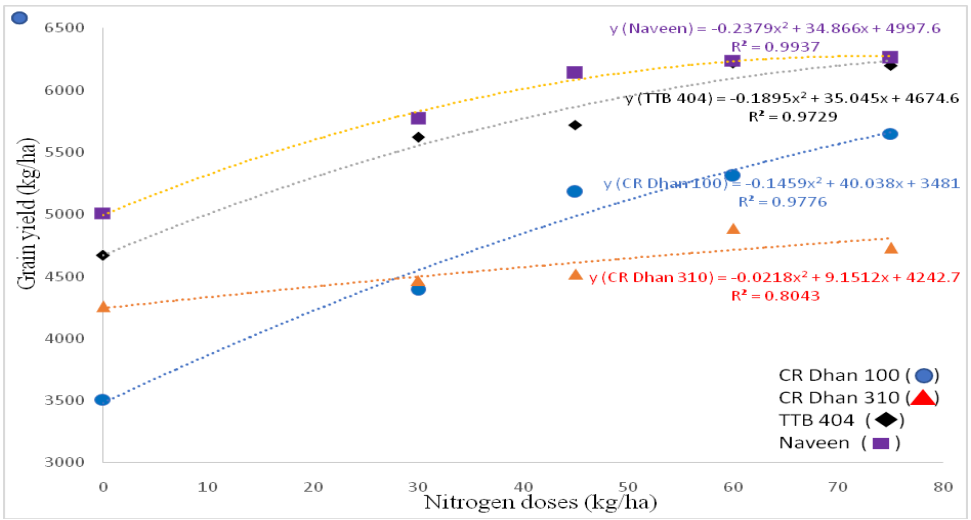

Figure.2 Response of rice cultivars to nitrogen level

The lowest optimum economic nitrogen dose was obtained for 'Naveen' to be 71.1 kg/ha N with grain yield of 6.27 t/ha followed by 'TTB 404' with 89.7 kg/ha N yielding 6.29 t/ha of grains. However, 'CR Dhan 310' required higher doses of N i.e., 186.1 kg/ha with 5.19 t/ha as having higher protein content in grains. The optimum economic doses of N for 'CR Dhan 100' was found to be 133.7 kg/ha N with 6.23 t/ha grain yield.

Our study shown that the response to nitrogen application through neem coated urea in high yielding rice cultivars grown in shallow lowland conditions of Assam .Among the rice cultivars 'Naveen' was found most productive and profitable with lower doses of N followed by TTB 404. Growth and yield attributes increased with increasing nitrogen levels which resulted higher grain and straw yield up to 60 kg/ha N. The lowest optimum economic doses of N were 71.1, 89.7, 133.7 and 186.1 kg/ha N for 'Naveen', 'TTB 404', 'CR Dhan 100', and 'CR Dhan 310', respectively.

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