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Effect of nitrogen scheduling on yield, nutrient content and uptake in boro rice lowland rice ecosystem

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Abstract
A field experiment on boro rice was conducted at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh, 2014-15 to evaluate the effect of different N levels on yield attributes, yield, nutrient content and uptake by rice variety IR-8. Experiment was laid out in randomized complete block design involving different N levels (0, 90, 120 and 150Kgha^{-1}) at different stages (Active tillering, Panicle initiation, Flowering and Heading) replicated three times. Results revealed that increasing N levels up to 150kg (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) significantly improved yield attributes, grain yield and straw yield as well as nutrient content and uptake by grain and straw. However, application of N 120 Kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H) produced comparable results regarding yield attributes and yield. Hence, the study suggests that higher fertilizer dose when applied in splitting at different doses give better performance of the *boro* rice crop.

Keywords: boro rice, nitrogen management, yield, scheduling

Introduction
Rice is the prime food for about 2.7 billion people, mainly belongs to Asia (Hussain *et al.*, 2008) [3]. The boro rice is commonly known as winter rice. The boro rice in India accounted for around 12.6 mtons or about 12% of the total 105.3 mtons of rice production from 2.1m ha area (Ministry of Agriculture, Govt. of India, 2014). Boro rice produces more yields than the *kharif* rice in the same ecology. The fact is mainly attributed to higher solar radiation and lower night temperatures throughout the crop growth in winter and favorable temperature during ripening. Despite the higher cost of boro rice cultivation, particularly due to increased requirement for irrigation, the returns per ha are perceived to be higher (Chatterjee *et al.* 1996) [1]. Nitrogen is an essential element in determining rice grain yield and N fertilizer is one of the major inputs to paddy fields which have favourable effect of promoting tillering and increasing spikelet number per panicle (Qiao *et al*, 2011) [9]. Gregorio *et al*. (1997) has reported that the N level is an important favourable factor determining grain mineral content. Fe, Cu and Zn are important essential micronutrients for both plant and human. Currently, about one third of world population are facing malnutrition problem due to the deficiencies of Fe/Zn or vitamin A. This problem is more severe in developing countries. Traditional nutrient food fortification or medication cannot thoroughly solve this problem due to they only have a temporal role to malnutrition but with expensive costs. However, the micronutrient bio fortification of staple food crop is regarded as an effective way to solve this problem. The main objective of this experiment is to identify the optimum level of nitrogen for obtaining higher yield from *boro* rice to assess the nitrogen, zinc, iron and copper content in rice grain and straw.

Materials and methods
The experiment is planned with in a randomized complete block design with three replications at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh during summer season, 2014-15. The soil of the experimental field was clay loam in texture, neutral in reaction (pH 7.55) (Jackson, 1973) [4], low in organic carbon (0.38%) (Walkley and Black, 1934), medium in available nitrogen (288.17 kg ha^{-1}) (Subbiah and Asija, 1956), low in available P_2O_5 (18.40 kg ha^{-1}) (Olsen *et al.*, 1954) [6] and medium in available K_2O (184.40 kg ha^{-1}) (Jackson, 1973) [4]. Nitrogen was applied as per the treatment. However, 60-60-5 kg PKZn ha^{-1} were applied at the transplanting. The sources of fertilizers for NPK were urea (46% N), diammonium phosphate (18% N and 46% P_2O_5) and muriate of potash (60% K_2O) and Zinc Sulphate (36% Zinc). Nitrogen was applied as per the treatment at Planting, Active tillering, Panicle initiation and Heading.

Full dose of phosphorus and potassium were applied as planting as per treatments to their respective plots. Two to three seedlingshill^{-1} of 92-day old seedlings was transplanted at 20x10 cm spacing on 13th February and harvested on 12th June, 2015 n the well puddle field in lowland ecosystem. Rainfall received in the month of April was 61.3 mm out of total 90.1 mm during the crop period. and about ± 15 cm water level was continuously maintained till flowering. Two manual weeding (35 and 50 DAT) were done to control weeds. Recommended agronomic practices were followed to raise the experimental crop. Six plants per plot were tagged to take the measurements of growth and yield attributes and at every stage six plants per plot were taken for analysis of NPK and Cu, Fe and Zn in laboratory The data recorded were analyzed following standard statistical analysis of variance procedure as suggested by Gomez and Gomez (1984) [2].

Table 1: Yield and yield attributes affected by N Scheduling in boro rice Treatment

Treatments	Grains panicle^{-1}	Effective tillers (No. m^{-2})	1000- grain weight (g)	Grain yield (tha^{-1})	Straw yield (kgha^{-1})
T_1=0 kg Nha^{-1}	55.76	256.00	19.57	1676.76	4289.22
T_2=90 kg Nha^{-1} (½ at Basal+ ¼ at AT + ¼ at PI)	71.27	380.33	20.69	3395.28	5989.89
T_3=90 kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼at PI)	73.50	371.33	21.91	2948.82	6101.01
T_4=90 kg Nha^{-1} ($^1/_3$ at Basal+ $^1/_3$ at AT +$^1/_3$ at PI)	71.71	392.00	21.61	3432.32	6020.20
T_5=90 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + 1/4 at H)	72.82	404.67	21.29	3193.60	5050.50
T_6=120 kg Nha^{-1} (½ at Basal+ ¼ at AT+ ¼ at PI)	84.00	380.00	23.75	3870.70	6464.64
T_7=120 kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼ at PI)	82.39	402.00	22.49	3651.85	6141.41
T_8=120 kg Nha^{-1} (½ at Basal+ $^1/_3$ at AT +1/3 at PI)	79.95	376.67	22.04	3676.47	6626.26
T_9=120 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	85.56	386.67	24.25	3930.30	6030.30
T_{10}=150 kg Nha^{-1} (½ at Basal + ¼ at AT+ ¼ at PI)	89.28	419.33	24.45	4001.34	6141.41
T_{11}=150 kg Nha^{-1} (¼ at Basal + ½ at AT + ¼ at PI)	79.99	400.00	23.49	3877.67	6686.86
T_{12}=150 kg Nha^{-1} ($^1/_3$ at Basal + $^1/_3$ at AT+ $^1/_3$ at PI)	82.72	408.67	23.13	3852.86	6474.75
T_{13}=150 kg Nha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H)	102.33	430.67	28.36	4566.66	6787.88
T_{14}=N application based on LCC value 4	87.50	412.00	24.13	3923.90	6080.80
SEm$\pm$	6.34	48.05	1.75	351.18	519.82
CD(P=0.05)	12.80	97.04	3.53	709.22	1049.81

AT = Active tillering; PI = Panicle initiation; H= Heading; F= Flowering

Table 2: Nutrient content (%), protein content (%) and protein Yield (kg ha^{-1}) affected by different N management in boro rice

Treatment	N content (%)		P content (%)		K content (%)		Zn content (mg kg^{-1})		Fe content (mg kg^{-1})		Cu content (mg kg^{-1})		Protein content (%)	Protein yield (kg ha^{-1})
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw		
T_1=0 kg N ha^{-1}	0.71	0.26	0.19	0.09	0.25	1.17	18.28	35.60	47.93	88.45	17.00	6.38	4.42	71.92
T_2=90 kg N ha^{-1} (½ at Basal+ ¼ at AT + ¼ at PI)	1.01	0.36	0.24	0.08	0.30	1.24	21.93	38.09	52.85	98.05	17.38	7.29	6.33	217.06
T_3=90 kg N ha^{-1} (¼ at Basal+ ½ at AT + ¼at PI)	0.98	0.38	0.25	0.09	0.28	1.18	22.67	37.00	54.14	97.27	16.97	8.14	6.10	177.44
T_4=90 kg Nha^{-1} ($^1/_3$ at Basal+ $^1/_3$ at AT +$^1/_3$ at PI)	1.07	0.41	0.27	0.08	0.29	1.23	19.37	35.50	54.11	98.77	19.71	8.81	6.71	229.14
T_5=90 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + 1/4 at H)	1.16	0.41	0.23	0.09	0.30	1.21	24.06	34.04	54.65	99.46	22.19	9.32	7.25	232.00
T_6=120 kg Nha^{-1} (½ at Basal+ ¼ at AT+ ¼ at PI)	1.30	0.51	0.26	0.09	0.31	1.18	27.94	40.51	61.75	104.28	21.54	11.81	8.15	308.24
T_7=120 kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼ at PI)	1.41	0.53	0.24	0.07	0.29	1.20	28.80	43.77	67.42	110.10	21.41	10.60	8.79	321.39
T_8=120 kg Nha^{-1} (½ at Basal+ $^1/_3$ at AT +1/3 at PI)	1.32	0.55	0.26	0.09	0.28	1.29	27.09	49.59	68.04	113.29	20.37	10.62	8.27	300.69
T_9=120 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	1.51	0.59	0.24	0.09	0.31	1.23	30.93	45.96	72.42	111.96	23.81	11.31	9.44	370.70
T_{10}=150 kg Nha^{-1} (½ at Basal + ¼ at AT+ ¼ at PI)	1.73	0.54	0.24	0.08	0.29	1.22	35.02	54.13	75.71	117.27	22.26	11.41	10.83	433.02
T_{11}=150 kg Nha^{-1} (¼ at Basal + ½ at AT + ¼ at PI)	1.68	0.58	0.26	0.09	0.30	1.20	31.30	61.57	76.68	132.79	22.99	12.36	10.48	406.07
T_{12}=150 kg Nha^{-1} ($^1/_3$ at Basal + $^1/_3$ at AT+ $^1/_3$ at PI)	1.73	0.56	0.26	0.07	0.27	1.26	35.41	57.47	75.39	132.82	24.82	13.36	10.83	418.93
T_{13}=150 kg Nha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H)	1.93	0.63	0.28	0.09	0.33	1.25	34.22	62.35	78.11	139.87	26.50	15.07	12.04	553.24
T_{14}=N application based on LCC value 4	1.69	0.53	0.24	0.09	0.27	1.26	32.82	53.73	71.56	122.93	22.35	13.08	10.58	415.77
SEm$\pm$	0.14	0.05	0.02	0.01	0.03	0.12	5.65	6.73	3.46	6.25	1.98	1.21	0.87	48.42
CD(P=0.05)	0.28	0.11	0.05	0.02	0.05	0.24	11.41	13.59	6.98	12.62	4.00	2.44	1.75	97.80

AT = Active tillering; PI = Panicle initiation; H= Heading; F= Flowering

Table 3: Nutrient uptake (kg ha^{-1}), Partial factor productivity (kg grain kg^{-1} N), Agronomic efficiency (kg grain kg^{-1} N), Recovery efficiency (%) and N harvest index (%) affected by different N management in boro rice

Treatment	N (Grain+Straw)	P Grain+Straw)	K Grain+Straw)	Cu Grain+Straw)	Fe Grain+Straw)	Zn Grain+Straw)	RE (kg grain kg^{-1} N)	N harvest index (%)
T_1=0 kg Nha^{-1}	22.60	7.05	54.77	0.06	0.46	0.18	0.00	3.11
T_2=90 kg Nha^{-1} (½ at Basal+ ¼ at AT + ¼ at PI)	56.71	12.85	85.42	0.10	0.77	0.30	37.90	1.83
T_3=90 kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼at PI)	51.42	12.59	80.74	0.10	0.75	0.29	32.02	1.90
T_4=90 kg Nha^{-1} (1/3 at Basal+ 1/3 at AT +1/3 at PI)	61.43	14.33	83.31	0.12	0.78	0.28	43.14	1.76
T_5=90 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + 1/4 at H)	57.59	11.79	70.88	0.12	0.68	0.25	38.88	2.03
T_6=120 kg Nha^{-1} (½ at Basal+ ¼ at AT+ ¼ at PI)	82.14	16.10	87.97	0.16	0.91	0.37	49.61	1.57
T_7=120 kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼ at PI)	84.21	13.08	83.81	0.14	0.92	0.37	51.34	1.68
T_8=120 kg Nha^{-1} (½ at Basal+ 1/3 at AT +1/3 at PI)	84.57	15.35	96.05	0.15	1.00	0.44	51.64	1.60
T_9=120 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	94.47	14.69	87.08	0.16	0.96	0.41	59.89	1.62
T_{10}=150 kg Nha^{-1} (½ at Basal + ¼ at AT+ ¼ at PI)	102.92	14.62	85.99	0.16	1.03	0.47	53.54	1.71
T_{11}=150 kg Nha^{-1} (¼ at Basal + ½ at AT + ¼ at PI)	103.57	16.12	91.73	0.17	1.18	0.53	53.98	1.63
T_{12}=150 kg Nha^{-1} (1/3 at Basal + 1/3 at AT+ 1/3 at PI)	103.26	14.76	92.40	0.18	1.15	0.51	53.77	1.69
T_{13}=150 kg Nha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H)	131.22	18.60	99.63	0.22	1.31	0.58	72.41	1.47
T_{14}=N application based on LCC value 4	99.00	14.56	86.87	0.17	1.03	0.46	66.44	1.71
SEm±	9.60	1.34	10.29	0.02	0.08	0.05	7.73	0.17
CD(*P*=0.05)	19.39	2.70	20.79	0.03	0.16	0.11	15.60	0.35

AT = Active tillering; PI = Panicle initiation; H= Heading; F= Flowering

Results and Discussion

Effect of on yield attributes

Among the different treatment combinations, scheduling of 150 kg Nha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) was recorded significantly highest Grains panicle^{-1}, Effective tillers (Number m^{-2}), 1000- grain weight (g) and Grain yield (tha^{-1}) as compare to N application based on LCC value 4, 120 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H), 120 kg Nha^{-1} (½ at Basal+ ¼ at AT+ ¼ at PI), 150 kg Nha^{-1} (1/3 at Basal + 1/3 at AT+ 1/3 at PI), 150 kg Nha^{-1} (¼ at Basal + ½ at AT + ¼ at PI), 120 kg Nha^{-1} (1/3 at Basal+ 1/3 at AT +1/3 at PI), 90 kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼ at PI), 90 kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H), 90 kg Nha^{-1} (1/3 at Basal+ 1/3 at AT +1/3 at PI), 90 kg Nha^{-1} (½ at Basal+ ¼ at AT + ¼ at PI) followed by control, and it was statistically at par with 150 kg Nha^{-1} (½ at Basal + ¼ at AT+ ¼ at PI) (Table 1). Research are corroborated with Maiti and Bhattacharya (2013) [5].

Effect of on nutrient content

An application of 150 kg Nha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) was recorded significantly the highest nutrient content as compare to an application of 150 kg Nha^{-1} (¼ at Basal + ½ at AT + ¼ at PI), 150 Kg Nha^{-1} (1/3 at Basal + 1/3 at AT+ 1/3 at PI), 120 Kg Nha^{-1} (1/3 at Basal+ 1/3 at AT + 1/3 at PI), 150 Kg Nha^{-1} (½ at Basal + ¼ at AT+ ¼ at PI), 120 Kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼ at PI), N application based on LCC value 4, 120 Kg Nha^{-1} (½ at Basal+ ¼ at AT+ ¼ at PI), 90 Kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + 1/4 at H), 90 Kg Nha^{-1} (1/3 at Basal+ 1/3 at AT+ 1/3 at PI), 90 Kg Nha^{-1} (¼ at Basal+ 1/2 at AT + 1/4 at PI), 90 Kg Nha^{-1} (½ at Basal+ 1/4 at AT + 1/4 at PI) followed by control, respectively and it were statically at par with 120 Kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H) (Table 2).

Effect of on Protein content and Protein yield

Among the various combination of treatments 150 Kg Nha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) was experienced significantly higher than N application based on LCC value 4, 150 Kg Nha^{-1} (¼ at Basal + ½ at AT + ¼ at PI), 120 Kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H), 120 Kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼ at PI), 120 Kg Nha^{-1} (1/3 at Basal+ 1/3 at AT + 1/3 at PI), 120 Kg Nha^{-1} (½ at Basal+ ¼ at AT+ ¼ at PI), 90 Kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ atPI + 1/4 at H), 90 Kg Nha^{-1} (¼at Basal+ 1/2 at AT+ 1/4 at PI), 90 Kg Nha^{-1} (1/3 at Basal+ 1/3 at AT+ 1/3 at PI), 90 Kg Nha^{-1} (½at Basal+ 1/4 at AT+ 1/4 at PI) followed by control respectively, it were significantly atpar with treatments 150 Kg Nha^{-1} (½ at Basal + ¼ at AT+ ¼ at PI) and 150 Kg Nha^{-1} (1/3 at Basal + 1/3 at AT+ 1/3 at PI)(Table 2).

Effect of on nutrient uptake

An application of 150 Kg Nha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) was found significantly highest nutrient uptake as compare to, 150 Kg Nha^{-1} (1/3 at Basal + 1/3 at AT+ 1/3 at PI), 150 Kg Nha^{-1} (½ at Basal + ¼ at AT+ ¼ at PI), N application based on LCC value 4, 120 Kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H), 120 Kg Nha^{-1} (1/3 at Basal+ 1/3 at AT + 1/3 at PI), 120 Kg Nha^{-1} (¼ at Basal+ ½ at AT + ¼ at PI), 120 Kg Nha^{-1} (½ at Basal+ ¼ at AT+ ¼ at PI), 90 Kg Nha^{-1} (1/3 at Basal+ 1/3 at AT+ 1/3 at PI), 90 Kg Nha^{-1} (¼ at Basal+ ¼ at AT+ ¼ at PI +¼ at H), 90 Kg Nha^{-1} (¼ at Basal+ 1/2 at AT + 1/4 at PI), 90 Kg Nha^{-1} (½ at Basal+ ¼ at AT + ¼ at PI), 0 Kg Nha^{-1} respectively and 150 Kg Nha^{-1} (¼ at Basal + ½ at AT + ¼ at PI) treatment was showed at par (Table 3).

Conclusion

On the basis of one year field experimentation it may be concluded that independent application of 150 Kg N ha^{-1} (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) (T13) followed by 150 kg N ha^{-1} ($^{1}/_{2}$ at Basal+$^{1}/_{4}$ at Active Tillering+$^{1}/_{4}$ at Panicle Initiiation) and N application based on LCC are recommended as these treatments fetched significantly higher grain yield, nutrient content as well as in uptake.

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