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Pooja
 Department of Agronomy,
 Institute of Agricultural
 Sciences, Banaras Hindu
 University, Varanasi,
 Uttar Pradesh, India

Swati Swayamprabha Pradhan
 Department of Agronomy,
 Institute of Agricultural
 Sciences, Banaras Hindu
 University, Varanasi,
 Uttar Pradesh, India

Khushboo Gupta
 Department of Plant Physiology,
 Institute of Agricultural
 Sciences, Banaras Hindu
 University, Varanasi,
 Uttar Pradesh, India

UP Singh
 Professor, Department of
 Agronomy, Institute of
 Agricultural Sciences, Banaras
 Hindu University, Varanasi,
 Uttar Pradesh, India

Corresponding Author:
Pooja
 Department of Agronomy,
 Institute of Agricultural
 Sciences, Banaras Hindu
 University, Varanasi,
 Uttar Pradesh, India

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Effect of different levels of nitrogen on growth and economics of *boro* rice in lowland rice ecosystem

Pooja, Swati Swayamprabha Pradhan, Khushboo Gupta and UP Singh

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Abstract

A field experiment was conducted on *boro* rice crop at Agricultural Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh, 2014-15 to find the effect of different N levels on growth attributes, yield and yield economics by rice variety IR-8. Experiment was conducted in randomized complete block design with different N levels (0, 90, 120 and 150 Kg ha⁻¹) at different stages (Active tillering, Panicle initiation, Flowering and Heading) replicated three times. Results showed that increasing N levels up to 150 kg (¼ at Basal + ¼ at AT + ¼ at PI + ¼ at H) significantly improved growth attributes, yield, yield economics, partial factor productivity and agronomic efficiency. However, application of 120 Kg Nha⁻¹ (¼ at Basal + ¼ at AT + ¼ at PI + ¼ at H) was remained at par in all the parameters. The with one year experiment it can conclude that higher fertilizer dose when applied in splitting at different stages give better performance for the *boro* rice crop than the normal recommended dose.

Keywords: *Boro* rice, nitrogen management, yield, scheduling, partial factor productivity, agronomic efficiency

Introduction

Rice (*Oryza sativa* L) is the primary food of Asiatic people, about more than 75% countries consume rice as a staple food. Rice crop production of 745.70 MT with 164.72 million hectare area is pioneer in production in Asia and playing critical roles in food and nutritional security (FAO, 2014) [2]. Due to warm and humid climate rice crop gets all the favourable conditions for the proper growth and development. India has the world's largest area under rice with 44.0 million ha and is the second largest producer next only to China and contributes 21.5 percent of global rice production (Viraktamath *et al.* 2011) [8]. Average productivity of rice is 2.4 tons ha⁻¹, with the production of 106.54 MT which is far below the global average of 2.7 tons ha⁻¹. Winter rice is commonly known as *boro* rice which is taken from Bengal origin refers to special rice cultivation in low land pockets during the months of Nov.-May in which nursery of the *boro* rice raise in November and transplants in the month of January to February and harvested in month of May, this crop takes advantage of extra water from *kharif* rice. The *boro* rice in India gives the production around 12.6 million tons or about 12% of the total 105.3 million tons of rice production (Ministry of agriculture, 2012). Nitrogen is an most essential element for rice growth and development, it determines production and productivity of rice and N fertilizer is one of the major fertilizer to paddy fields which play important role in tillering and development of spikelet and panicle per plant (Qiao *et al.*, 2011) [6]. N is essential element in building of all cells and plant structure. It is main constituent of chlorophyll, enzymes, proteins, etc. Root growth and crop development as well as uptake of the other nutrients are stimulated by nitrogen. Khatun *et al.* (2014) [4] reported that with increase nitrogen rate, uptake of nitrogen by the plants and protein contents also increases.

Materials and Methods

The experiment was planned 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 details of experimental field are here as soil was clay loam in texture, pH was 7.55 neutral in reaction (Jackson, 1973) [3],

low in organic carbon (0.38%) (Walkley and Black, 1934), medium in available nitrogen (288.17 kg ha⁻¹) (Subbiah and Asija, 1956) [7], low in available P₂O₅ (18.40 kg ha⁻¹) (Olsen *et al.*, 1954) [5] and medium in available K₂O (184.40 kg ha⁻¹) (Jackson, 1973) [3]. Nitrogen was applied as in splitting at different growth stages. However, 60-60-5 kg PKZn ha⁻¹ were applied at the time of transplanting. The sources of fertilizers for NPK were urea (46% N), diammonium phosphate (18% N and 46% P₂O₅) and murate of potash (60% K₂O) and Zinc Sulphate (36% Zinc). Nitrogen was applied as treatment details at Planting, Active tillering, Panicle initiation and Heading (0, 90, 120 and 150 kg ha⁻¹). Phosphorus and potassium were applied at the time of planting as per

treatments to their respective plots. Nursery was raised in the month of November while two to three seedlings hill⁻¹ was transplanted at 20x10 cm spacing on 13th February in the field and harvested on 12th June, 2015 at physiological maturity stage. April month of this year was received 61.3 mm rainfall out of total 90.1 mm during the crop period and about ± 15 cm water level was continuously maintained till flowering. Weeds in the field were controlled by manually at 35 and 50 DAT. Remaining agronomic practices were followed to as per the normal rice crop. To take the observation six plants per plot were tagged and at every stage six plants per plot were taken for analysis of NPK and Cu, Fe and Zn in laboratory.

Table 1: Plant height, LAI, root dry weight, shoot dry weight, dry matter partitioning, crop growth rate and yield affected by different N levels in *boro* rice

Treatment	Plant height (cm)	LAI	Root dry wt. (g plant ⁻¹)	Shoot dry wt. (g plant ⁻¹)	Dry matter partitioning (g)				Crop growth rate (g d ⁻¹)	Grain yield (kg/ha)
					Root	Stem	Leaf	Panicle		
T ₁ =0 kg Nha ⁻¹	74.79	1.87	10.4	37.79	10.4	5.79	7.13	24.87	0.69	1676
T ₂ =90 kg Nha ⁻¹ (½ at Basal+ ¼ at AT + ¼ at PI)	91.84	2.47	11.14	47.06	11.14	7.63	9.86	29.56	0.66	3395
T ₃ =90 kg Nha ⁻¹ (¼ at Basal+ ½ at AT + ¼ at PI)	92.03	2.89	13.02	50.44	13.02	8.64	9.46	32.34	0.74	2949
T ₄ =90 kg Nha ⁻¹ (⅓ at Basal+ ⅓ at AT + ⅓ at PI)	92.86	2.64	11.57	52.35	11.57	8.03	10.25	34.07	0.73	3432
T ₅ =90 kg Nha ⁻¹ (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	90.98	2.75	11.45	52.07	11.45	8.08	9.61	34.39	0.88	3193
T ₆ =120 kg Nha ⁻¹ (½ at Basal+ ¼ at AT+ ¼ at PI)	92.35	2.76	13.52	51.98	13.52	8.47	10.33	33.19	0.89	3871
T ₇ =120 kg Nha ⁻¹ (¼ at Basal+ ½ at AT + ¼ at PI)	89.50	2.70	11.39	53.57	11.39	8.87	10.06	34.64	0.89	3652
T ₈ =120 kg Nha ⁻¹ (½ at Basal+ ⅓ at AT + ⅓ at PI)	93.52	2.71	13.18	54.20	13.18	9.60	10.59	34.01	0.85	3676
T ₉ =120 kg Nha ⁻¹ (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	94.27	3.06	12.38	55.54	12.38	9.30	10.97	35.27	0.92	3930
T ₁₀ =150 kg Nha ⁻¹ (½ at Basal + ¼ at AT+ ¼ at PI)	92.81	3.24	11.34	57.02	11.34	8.76	12.41	35.86	0.97	4001
T ₁₁ =150 kg Nha ⁻¹ (¼ at Basal + ½ at AT + ¼ at PI)	93.70	2.85	12.32	55.46	12.32	9.92	11.49	34.04	0.92	3877
T ₁₂ =150 kg Nha ⁻¹ (⅓ at Basal + ⅓ at AT+ ⅓ at PI)	94.78	3.15	13.01	54.62	13.01	9.74	10.54	34.34	0.82	3853
T ₁₃ =150 kg Nha ⁻¹ (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H)	96.46	3.83	14.21	61.29	14.21	12.32	12.33	36.64	1.04	4566
T ₁₄ =N application based on LCC value 4	89.55	2.84	11.85	50.74	11.85	9.72	8.82	32.20	0.72	3924
SEM+	2.93	0.30	1.41	3.29	1.41	1.32	1.25	2.32	0.10	351
CD (P=0.05)	5.92	0.61	2.86	6.65	2.86	2.66	2.53	4.68	0.20	709.22

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

Table 2: Yield economics affected by different N levels in *boro* rice

Treatment	Cost of cultivation ₹ ha ⁻¹	Gross returns ₹ ha ⁻¹	Net returns ₹ ha ⁻¹	B:C ratio
T ₁ = 0 Kg N/ha	32824	39325	6501	0.20
T ₂ = 90 Kg N/ha (½ at Basal+ ¼ at AT+ ¼ at PI)	33636	70196	36559	1.09
T ₃ = 90 Kg N/ha (¼ at Basal+ ½ at AT+ ¼ at PI)	33636	64111	30475	0.91
T ₄ = 90 Kg N/ha (⅓ at Basal+ ⅓ at AT+ ⅓ at PI)	33636	70839	37203	1.11
T ₅ = 90 Kg N/ha (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	33636	63984	30347	0.90
T ₆ = 120 Kg N/ha (½ at Basal+ ¼ at AT+ ¼ at PI)	33988	78751	44763	1.32
T ₇ = 120 Kg N/ha (¼ at Basal+ ½ at AT + ¼ at PI)	33988	74447	40458	1.19
T ₈ = 120 Kg N/ha (⅓ at Basal+ ⅓ at AT + ⅓ at PI)	33989	76500	42512	1.25
T ₉ = 120 Kg N/ha (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	33989	78095	44107	1.30
T ₁₀ = 150 Kg N/ha (½ at Basal + ¼ at AT+ ¼ at PI)	34341	79514	45173	1.32
T ₁₁ = 150 Kg N/ha (¼ at Basal + ½ at AT + ¼ at PI)	34341	79630	45289	1.32
T ₁₂ = 150 Kg N/ha (⅓ at Basal + ⅓ at AT+ ⅓ at PI)	34341	78528	44187	1.29
T ₁₃ = 150 Kg N/ha (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H)	34341	89974	55633	1.62
T ₁₄ = N application based on LCC value 4	33929	78179	44250	1.30
SEM+	4019	5645	5645	0.17
CD(P=0.05)	9149.81	11400.63	11400.63	0.34

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

Table 3: Partial factor productivity and Agronomic efficiency affected by different N levels in *boro* rice

Treatments	Partial factor productivity (kg grain kg ⁻¹ N)	Agronomic efficiency (kg grain kg ⁻¹ N)
T ₁ = 0 Kg N/ha	0.00	0.00
T ₂ = 90 Kg N/ha (½at Basal+ ¼ at AT+ ¼ at PI)	37.73	19.09
T ₃ = 90 Kg N/ha (¼at Basal+ ½ at AT+ ¼ at PI)	32.76	14.13
T ₄ = 90 Kg N/ha (⅓ at Basal+ ⅓ at AT+ ⅓ at PI)	38.14	19.51
T ₅ = 90 Kg N/ha (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	35.48	16.85
T ₆ = 120 Kg N/ha (½ at Basal+ ¼ at AT+ ¼ at PI)	32.26	18.28
T ₇ = 120 Kg N/ha (¼ at Basal+ ½ at AT + ¼ at PI)	30.43	16.46
T ₈ = 120 Kg N/ha (⅓ at Basal+ ⅓ at AT + ⅓ at PI)	30.64	16.66
T ₉ = 120 Kg N/ha (¼ at Basal+ ¼ at AT+ ¼ at PI + ¼ at H)	32.75	18.78
T ₁₀ = 150 Kg N/ha (½ at Basal + ¼ at AT+ ¼ at PI)	26.68	15.50
T ₁₁ = 150 Kg N/ha (¼ at Basal + ½ at AT + ¼ at PI)	25.85	14.67
T ₁₂ = 150 Kg N/ha (⅓ at Basal + ⅓ at AT+ ⅓ at PI)	25.69	14.51
T ₁₃ = 150 Kg N/ha (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H)	30.44	19.27
T ₁₄ = N application based on LCC value 4	34.12	19.54
SEM±	2.86	3.08
CD(P=0.05)	5.77	6.22

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

Result and Discussion

Effect on plant height, LAI, root dry weight, shoot dry weight, dry matter partitioning, CGR and Yield

Application of nitrogen increased the plant height, LAI, root dry weight, shoot dry weight, dry matter partitioning, CGR and yield and all these parameters was found significantly higher with application of 150 Kg Nha⁻¹ (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) (T₁₃) at all growth stages. High rate of cell division, enlargement and development of plant cells might be a reason of increment in plant height because there are sufficient amount of nitrogen supplied by the plants during rapid growth stage.

LAI was also found higher this might be due to more number of tillers per running meter and increased plant height, which is a main reason to increase the chances of more favourable utilization of nitrogen, because nitrogen is a key element in all metabolic activity and precursor of amino acid.

While increment in levels of nitrogen, dry matter partitioning at all stage of crop increases simultaneously. This might be due to increased plant height, leaf area index, improved tillering and increase in uptake of nutrients. Increasing the level of nitrogen significantly increasing the crop growth rate (CGR) due to increasing level of nitrogen increase chlorophyll content in leaf resulted increase biomass accumulation per unit time and per unit weight of leaf. Azarpour *et al.* (2014) [1] also reported this.

Effect on yield economics

The cost of cultivation was affected by the different doses of nitrogen application at different stages. The gross return, which is totally depend on how much crop has yielded and it's price in the local and national market, differed under different treatments and this accompanied with cost of cultivation influenced the overall net return and B: C ratio. The gross return, net returns and benefit: cost ratio was found significantly higher with the application of 150 Kg Nha⁻¹ (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) (T₁₃). Yield attributes and grain and straw yield was found maximum than all other nitrogen treatments might be a reason of high yield economics.

Effect on partial factor productivity and agronomic efficiency

With the application of 150 Kg Nha⁻¹ (¼ at Basal + ¼ at AT + ¼ at PI+ ¼ at H) (T₁₃), maximum partial factor productivity of nitrogen was recorded. With increasing rate of nitrogen, value of partial factor productivity was declined. Table 3

showed that significantly maximum agronomic efficiency of nitrogen was found with application of N application based on LCC value 4 which is significant over control.

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 (½ at Basal+¼ at Active Tillering+¼ at Panicle Initiation) and N application based on LCC, due to increasing application rate of N biomass of the plant increases, because N play important role in protein synthesis as it is a key element of amino acid these treatments gave significantly higher growth attributes, yield, yield economics, partial factor productivity and agronomic efficiency.

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