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Effect of different doses of nitrogen fertilizer on growth and yield of T. Aman rice variety (BRRI Hybrid Dhan4)

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ABSTRACT

Nitrogen is one of the most yield-limiting nutrients for rice production, and proper nitrogen fertilizer management is critical for high yield. In rice research, more time and energy are devoted to managing nitrogen fertilizer than any other nutrient because of the high potential for a return on the fertilizer investment.Considering this, an experiment was conducted at the Soil Science farm, Bangladesh Agricultural University, Mymensingh, Bangladesh during July 2017 to December 2017 in Aman season to examine the effect of different doses of nitrogen fertilizer on growth and yield of T. Aman rice variety (BRRI Hybrid Dhan4). The experiment consisted of four nitrogen levels (viz. 0,40, 80and 100 kg N ha-1) in a randomized complete block design with three replicates. The grain yield increased over control varied from 47% to 53%. The highest grain yield was observed 53% for treatment T_3 (N_{80}) and the lowest was recorded 47% in treatment T_2 (N_{40}). The highest N uptake was recorded 134.16 kg $ha^{-1}$for treatment T_3 when rice plants were fertilized with 80 kg N ha which was statistically similar to T_4 and the lowest 62.45 kg ha^{-1} in treatment T_1 (control). However the overall performance on yield contributing parameters was found on T_3 treatment. We concluded that application of the intermediate levelof nitrogen (80 kg N ha^{-1}) was economical and environment-friendly for the cultivation of BRRI Hybrid Dhan4.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops of the world, grown in wide range of climatic zones, to nourish the mankind. Introduction of hybrid rice is an important step towards augmentation of rice yield. Hybrid rice yields about 15-20% more than the promising high-yielding commercial varieties. Earlier studies reveal that judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (Place et al., 1970).

Nitrogen is an essential mineral nutrient for crop growth and yield (Xu et al., 2012). During the past three decades, N application rates have increased rapidly and excessive quantities of N fertilizers have been used to enhance crop yields. However, Excessive N application could lead to soil acidification as well as worsen the soil environment thus, ultimately has a negative impact on crop growth and yield (Guo et al., 2010; Schroder et al., 2011). Zhao et al. (2014) found that the application of lower N rates sustained high yields compared with higher N rates. Yield reductions in crops with high N fertilization are primarily caused by physiological disorders associated with excessive uptake of N and soil degradation (Qiao et al., 2012). Although, optimum N rates are affected by many factors, studies have shown that a moderate reduction in N inputs does not lead to a decrease in crop yield (Luo Z. et al., 2018) but, conversely, improved N use efficiency (Zhang et al., 2015a). Excessive N fertilization has caused low N use efficiencies and serious environmental problems (Cui et al., 2016; Zhu et al., 2016). Therefore, rational N fertilization strategies must be considered for achieving high crop production and sustainable agroecosystem. Nitrogen fertilization can significantly affect soil properties. Soil factors are closely associated with soil nutrient cycling and plant nutrient uptake, and therefore affect productivity. Urease, phosphatase and invertase play key roles in soil N, P, and C cycles (Zhao et al., 2009). These enzyme activities are directly involved in various biochemical reactions in the soil. Soil available nutrients can be directly absorbed by crops and contribute to soil fertility. Soil organic matter (SOM) is responsible for some important soil processes such as soil respiration, soil aggregate stability and water holding capacity (Herencia et al., 2011). These soil properties are considered as important factors determining soil quality (Gong et al., 2015). Nitrogen fertilization can also affect plant physiological characteristics such as chlorophyll concentration, plant metabolic enzyme activities and soluble proteins, and ultimately, crop production was affected. Leaf chlorophyll concentration is an

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important photosynthetic capacity attributes for monitoring the N status of plants. Nitrate reductase (NR) and glutamine synthetase (GS) are key enzymes in nitrogen assimilation (Kichey et al., 2006). Sucrose synthase (SS) and sucrose phosphate synthase (SPS) are essential components involved in sucrose to starch conversion (Yang et al., 2004), and their activity can be linked to sink strength and crop yield subjected to N fertilization. Understanding the effects of N fertilization on soil and crop factors can help with developing strategies to explore appropriate N application rates, and therefore improve crop yields and environmental sustainability. To meet the needs of increasing crop production and intensive agriculture, excessive N application is still widespread in these regions (Yang et al., 2015; Hu et al., 2016). These N management practices have led to nitrate leaching (Zhou et al., 2016) and negative impacts on soil fertility (Guo et al., 2010; Zhu et al., 2018). As a result, crop growth and production are limited. The response of soil properties and crop physiological attributes to N fertilization depends on soil type, climate conditions and other factors (Lupwayi et al., 2012; Giacometti et al., 2013). Therefore, optimal N fertilization strategies must be based on specific site and conditions. Various studies have focused on the single effects of N fertilization on soil properties or crops physiology.

Material and Methods

Experimental site, weather, soil and variety

The experiment was carried out at Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh. The experimental field belongs to Sonatala soil series, Aeric Haplaquept (USDA taxonomy) under Old Brahmaputra Floodplain, (AEZ-9) (FAO-UNDP, 1988). 24.75ºN latitude and 90.5ºE longitude, elevation 18m above the sea level. The average temperature, rainfall and relative humidity were respectively 26.4ºC, 190.2 mm and 84.5%. Thesoil was typical rice growing silt loam soil. BRRI Hybrid dhan4, a high yielding variety of rice was used as the test crop in this experiment.

Treatments

Rice varieties (BRRI Hybrid dhan4)with four levels of N fertilizer rateswere used as treatments of this experiment.

Table 1: List of treatments with different N fertilizers rates

Treatments	Name of N Fertilizers	Amount of fertilizers (kg ha^{-1})
T_1	Control	-
T_2	Urea	40
T_3	Urea	80
T_4	Urea	100

Fertilizer application

25 days old seedlings of rice variety (BRRI Hybrid dhan4) was transplanted with maintaining distance of 20 cm × 15 cm. The crop was treated with five levels of nitrogen fertilizer viz. 0, 40, 80 and 100 kg N ha^{-1}. The crop was fertilized with15-40-10-1 kg PKSZn ha^{-1} at the time of final land preparation. All other fertilizer was applied in control plots except N fertilizer. Nitrogen was applied in the form of urea in three equal installments as top dressing. Top dressing of nitrogen was done at 6, 25 and 50 days after the transplanting (DAT). Irrigation, weeding and other agronomic practices were done whenever necessary.

Data collection

Data collected on different growth parameters e.g. plant height, effective tillers per hill, panicle length, grains $panicle^{-1}$ and 1000grain weight, grain and straw yield of BRRI Hybrid dhan4were recorded. For determination of yield attributes five hills were selected and number of tillers per hill, number of filled and unfilled grains per panicle and thousand grain weights was measured. The above ground plant parts were segmented into different components as leaf, stem, leaf sheath and panicle. The above ground plant parts were then dried in an oven at 70˚C for 72 hours and weighed. The harvested yield was converted into $t{\cdot}ha^{-1}$ at 14% moisture content.Total N content in soil was determined by micro-Kjeldhal method. Digestion was made with H_2O_2, conc. H_2SO_4 and a catalyst mixture (K_2SO_4:$CuSO_4 5H_2O$: Se =100:10:1). Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01N H_2SO_4 (Page et al., 1982).

All the data were statistically analyzed using Statistics 10 package and the mean differences were ranked by DMRT at 5% level (Gomez and Gomez, 1984). All collected data were subjected to MSTAT-

C software package to perform analysis of variance (ANOVA).

Results and Discussion

Table 2 shows that plant height, panicle length, tillers per hill, grains per panicle responded significantly due to application of different N fertilization rates. Plant height varied from 104.5-132.25 cm. The highest plant height of 132.25 cm was observed for treatment T_4 where the lowest plant height of 104.5 cm in treatment T_1 (control). The maximum panicle (16.6 cm) was observed for T_3 while the minimum panicle (10.51 cm) was recorded in T_1 (control). The highest number of tillers hill^{-1}for treatment T_3(28.72) and the lowest number of tillers hill^{-1}in treatment T_1 (21.15). The highest grain panicle^{-1}was found in for treatment T_3(141.09) where the lowest grain panicle^{-1} in treatment T_1 (114.06). 1000-grain weight varied from 16.7 to 23.08 g. The highest grain weight 23.08 g was observed for treatment T_3 where the lowest grain weight 16.7 g in treatment T_1 (control) for BRRI Hybrid Dhan4.

Table 2: Effect of yield contributing parameters e.g. plant height, panicle length, tillers per hill, grains per panicle responded significantly due to application of N fertilizer in comparison with controlfor BRRI Hybrid dhan4

Treatment	Plant height (cm)	Panicle Length (cm)	Tillers hill^{-1} (no.)	Grains panicle^{-1} (no.)	1000- grain weight(g)	Grain yield (t ha^{-1})	Straw Yield (t ha^{-1})
T_1	104.5c	10.51c	21.15d	114.06c	16.7b	3.26b	5.25b
T_2	118.67b	13.9b	26.48c	130.57b	21.24a	6.24a	7.64a
T_3	130.54a	16.6a	28.72a	141.09a	23.08a	6.85a	8.45a
T_4	132.25a	16.12a	27.85b	140.27a	23a	6.48a	8.52a
*CV%	1.92	7.18	1.58	1.75	7.21	6.00	5.36
LSD	4.66	2.06	0.83	4.60	3.05	0.69	0.80

Grain yield

Grain yield was increased with increasing the fertilizer rates. Grain yield varied from 3.26 to 6.85t ha^{-1}. The highest grain yield was observed 6.85t ha^{-1} for treatment $T_3$when rice plants were fertilized with80 kg N ha^{-1} which was statistically similar to T_4 and T_2 and the lowest grain yield 3.26t ha^{-1} in treatment T_1 (control).Figure 1 shows the percent increase of grain yield over control for all treatments. The grain yield increased over control varied from 47% to 53%. The highest grain yield was observed 53% for treatment T_3 (N_{80}) and the lowest was recorded 47% in treatment T_2 (N_{40}). Similar results were found for some other varieties of rice (Huda et al., 2016), (Kapoor et al., 2008). For instance, in case of BRRI dhan28 up to 97% increase over control was reported with the application of USG (Islam et al., 2014). Based on grain yield, the treatments may be ranked in the order of T_3>T_4>T_2>T_1. The rate of 80 kg ha^{-1} and at the rate 100 kg ha^{-1} performed better in increasing grain yield of rice compared to 40 kg ha^{-1} applied nitrogen in BRRI dhan50. Thus, 120 kg ha^{-1} of N fertilizers demonstrated the most positive effect on grain yield in BRRI Hybrid Dhan4.

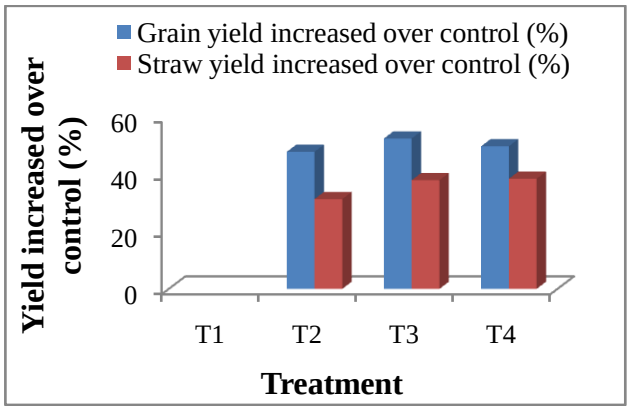

Figure 1: Grain and straw yield increased over control due to N fertilization for BRRI Hybrid Dhan4 during aman season.

Straw yield

Straw yield was increased with increasing the fertilizer rates. Grain yield varied from 5.25 to 8.52t ha^{-1}. The highest straw yield was observed 8.52t ha^{-1} for treatment $T_4$when rice plants were fertilized with 100 kg N ha^{-1} which was statistically similar to T_3 and T_2 and the lowest straw yield 5.25t ha^{-1} in treatment T_1 (control).Figure 1 shows the percent increase of straw yield over control for all

treatments. The straw yield increased over control varied from 31% to 43%. The highest straw yield was observed 43% for treatment T_3 (N_{80}) and the lowest was recorded 31% in treatment T_2 (N_{40}). Based on straw yield, the treatments may be ranked in the order of $T_3>T_4>T_2>T_1$. The rate of 80 kg ha^{-1} and the rate 100 kg ha^{-1} performed better in increasing straw yield of rice compared to40 kg ha^{-1} applied nitrogen in BRRI Hybrid Dhan4. Thus, 80 kg ha^{-1} of N fertilizers demonstrated the most positive effect on straw yield in BRRI Hybrid Dhan4.

N Uptake

Figure 2 showed thatBRRI Hybrid dhan4 influenced significantly with the application of different nitrogen rates for both N uptake and N uptake increased over control during the aman season. N uptake varied 62.45 to 134.16 kg ha^{-1}. The highest N uptake was recorded 134.16 kg ha^{-1} for treatment $T_3$when rice plants were fertilized with 80 kg N ha^{-1} which was statistically similar to T_4 and the lowest 62.45 kg ha^{-1} in treatment T_1(control). N uptake increased over control varied from 33 to 54%. The highest was found 54% for treatment $T_3$when rice plants were fertilized with 80 kg N ha^{-1} which was statistically similar to T_4 and the lowest 33% in treatment $T_2$when rice plants were fertilized with 40 kg N ha^{-1}. The trend of N uptake conforms with the published work (Jahan et al. 2014).The total N uptake by BRRI dhan46 due to different treatments may be ranked in the order of $T_3> T_4> T_2> T_1$. The result revealed that the rate of N fertilizers (N_{80}) increases the total N uptake by rice plant.

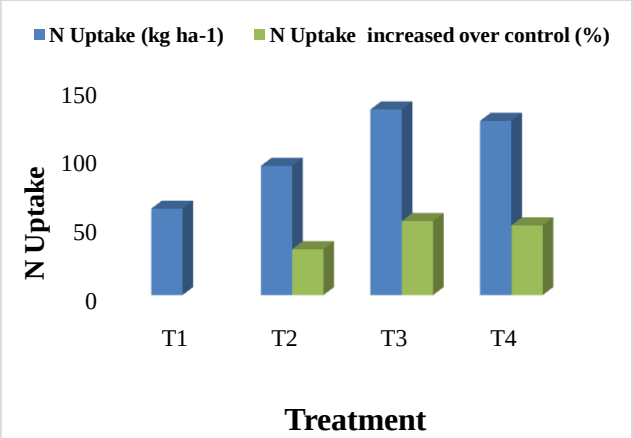

Figure 2: N uptake and N uptake increased over control during the aman season

Table 3: Effect of N and P on nutrient content of post-harvest soil

Treatment	pH	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g soil)	Available S (ppm)
T_1	6.2b	1.22b	0.11b	2.86c	0.11b	11.74c
T_2	6.4ab	1.5a	0.16ab	2.95b	0.125ab	11.82b
T_3	6.48a	1.52a	0.17a	2.97a	0.135a	11.89a
T_4	6.42ab	1.55a	0.16ab	2.97a	0.128ab	12.03a
*CV%	4.66	2.06	3.57	4.12	1.92	5.85
LSD	2.72	2.68	1.56	3.95	1.82	1.09

Post-harvest soil

Soil pH

Soil pH of post-harvest soil showed statistically significant with different treatments (Table 3). The highest soil pH (6.48) was found from T_3 treatment, whereas the lowest in (6.2) T_1 treatment. Data revealed that soil pH in post-harvest soil was slightly changed.

Organic carbon

Organic carbon content in post-harvest soil showed statistically significant among different treatments (Table 3). The highest organic carbon content (1.55%) in soil was recorded in T_4treatment and it was followed by (T_3, T_2) while the lowest organic carbon was found in T_1 (1.22%) treatment. It was observed that chemical fertilizer has no significant effects on organic carbon contents.

Total N

Total N in post-harvest soil varied significantly due to different treatments (Table 3). The highest total N (0.17%) was recorded in T_3 treatment which was statistically closely similar to T_4 and T_3 treatment, while the lowest total N (0.11%) was found in T_1 treatment.

Available P

Available P in post-harvest soil varied significantly due to different treatments (Table 3). The highest available P (2.97 ppm) was recorded in $T_4$and T_3treatment. The second highest available P was (2.95 ppm) obtained in T_2 treatments, while the lowest available P (2.86 ppm) was found in T_1 treatment. Data revealed that available P (ppm) on post-harvest soil of BRRI Hybrid Dhan4.

Exchangeable K

Exchangeable K in post-harvest soil varied significantly due to different treatments (Table 3). The highest exchangeable K (0.135meq/100 g soil) was obtained from T_3 treatment which was statistically similar to T_4 treatment (0.128 meq/100 g soil) and T_2 treatment (0.125 meq/100 g soil). The lowest exchangeable K (0.11 meq/100 g soil) was found in T_1 treatment.

Available S

Available S showed significant variation in post-harvest soil due to different treatments (Table 3). The highest value was found in T_3 (18.45 ppm) which was statistically similar to treatment (17.40 ppm) T3. The minimum Available S was found in T_1 (11.80 ppm) treatment.

Conclusion

In present study, treatment T_3 (N_{80}) appeared better than the other treatments. T_1 (N_0) gave significant reductions in growth and yields in most of the experiments. It gave the lowest grain N content in experiments. Thus, in this series of experiments, T_3 (N_{80}) had little effect on the quality of the growth and grain yield for BRRI Hybrid dhan4. It may be concluded that nitrogen fertilizers, applications of N_{80} were found to be optimum for better growth and maximum yield of T. Aman rice (BRRI Hybrid dhan4).

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