Effect of N and Zn Fertilization on the Uptake Pattern and Protein Content in *T-aman* Rice

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Abstract

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during *T-aman* season of 2006 on BRRI Dhan 39 to study the effect of N and Zn fertilization on N and protein content by *T-aman* rice. Four rates of each of nitrogen (N_0=0, N_1=50, N_2=100 and N_3=150 kg ha^{-1}) and zinc (Zn_0=0, Zn_1=5, Zn_2=10, and Zn_3=15 kg ha^{-1}) in all possible combinations were applied following a randomized block design with three replications. Application of N and Zn fertilizers caused an increase in concentration of N and protein in rice grain with increasing level of the fertilizers over the control. However, N and Zn fertilizers showed a positive and significant effect on N and protein content of rice grain irrespective to the treatments applied. It is evident that nitrogen and protein content in rice grain increased with increasing level of N upto certain level. The highest N and protein content in rice grain and straw was found due to application of N at higher level (150 kg ha^{-1}). On the other hand, the highest N and protein content in rice grain and straw was observed in Zn_3 treatment. N and Zn uptake by rice grain significantly increased with increasing level of N upto 100 kg ha^{-1} and then decreased. However, the highest N uptake by straw was observed in N_3, N_2 treatment and Zn_3, Zn_2 treatment, respectively. The highest N and protein content in rice grain was recorded in N_3Zn_2 treatment. The treatment combination of N and Zn showed no significant variation in Zn content of rice grain. However, the highest uptake of N and Zn was observed in N_2Zn_2 and N_2Zn_3 treatment combinations.

1. Introduction

Food is the prime fundamental demand for human beings in the world. Bangladesh is a densely populated agro-based country where rice (*Oryza sativa* L.) is the most extensively cultivated cereal crop. Bangladesh has 8.65 mha of arable land of which 75% is devoted to rice cultivation (BBS, 2004). The climate and soils of Bangladesh are favorable for year round rice cultivation. Among three growing seasons of rice, transplanting-aman (*T-aman*) covers the largest area. Increased rice production in this country is essential to meet the food demand of the teeming population. Unfortunately, the average yield of rice is very low in Bangladesh (3.34 t ha^{-1}). Nutritional deficiency in soil is one of the major constraints which may lead to yield decrease by many folds. Higher crop yields naturally have higher demands of nutrients and more pressure on the soil for available forms of nutrients. Nutrient stresses in Bangladesh soils are increasing day by day. One of the major reasons is that nutrient removals far exceed than nutrient additions in most of the situations, as a result nutrient balances in the soil are negative (Abedin, 1990). Depletion of soil fertility has been identified as a major constraint for higher crop yield. Deficiencies of five nutrients such as N, P, K, S and Zn are now widespread in Bangladesh (Islam et al., 1990; Mondal et al., 1992; Islam and Hossain, 1993; Islam et al., 1996). Presently, the need for micronutrient fertilization in soil is increasing, yet the proportion of different fertilizer used in the country is not quite balanced. Nitrogen alone constitutes about 80% of the total nutrients used in the country which can not help to improve crop productivity unless other limiting nutrients are supplemented along with nitrogen (N). Zinc (Zn) deficiencies are widespread throughout the world, especially in the rice land of Asia and deficiencies occur in neutral and calcareous soils (Tisdale et al., 1997). It was reported that about 2 mha of agricultural land are Zn deficient in Bangladesh under different Agro Ecological Zones. Zn is essential for numerous enzyme systems and is capable of forming many stable bonds with N and S ligands. It plays an important role in many physiological functions in plants. It is involved in biosynthesis of tryptophene, a precursor of auxin which is essential for elongation. It also has been found to be essential for normal chlorophyll formation in plants. A survey of Zn nutrition in rice in Bangladesh shows that soils with high pH and calcareous soils of north- western districts and also the soils which have been intensively cultivated with transplanted rice have Zn deficiency problem. Among many factors, deficiency of N and Zn is now considered as one of the major reasons for low yield of rice in Bangladesh. In the recent years, efforts are being made to increase the ha^{-1} yield of rice in Bangladesh by using nitrogenous fertilizers at proper dose in the cultivation of high yielding varieties. The application of proper doses of N in rice crop along with P, K, Zn and S increased the grain yield upto 5.7 t ha^{-1} (BRRI, 1987).

So, balanced N application to the rice crop is a prerequisite condition for obtaining optimum potentiality of rice. Hence, there is an urgent need to maximize the rice production by applying different nutrients like N and Zn to the soil. Thus, an attempt was made in a field trial to observe the effects of N and Zn on the N, Zn and protein content and uptake by *T-aman* rice (BRRI Dhan 39).

2. Materials and Methods

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the period from July 5, 2006 to October 29, 2006 using the rice variety BRRI Dhan 39 as a test crop. Four levels of each of nitrogen (N_0=0, N_1=50, N_2=100 and N_3=150 kg ha^{-1}) and zinc (Zn_0=0, Zn_1=5, Zn_2=10 and Zn_0 =15 kg ha^{-1}) in a full factorial combinations were applied following a randomized block design with three replications. A blanket dose of 36.6 kg P_2O_5, 72 kg K_2O, and 10 kg S ha^{-1} was applied at standard rates to all plots during final land preparation.

All Zn was applied as per treatment on the day of transplanting. N was applied as per treatment in three equal splits. The first split was applied after 7 days of transplanting, the second split after 30 days of transplanting, i.e. at active vegetative stage and the third split was applied after 60 days of transplanting, i.e. at panicle initiation stage. The normal cultural practices including weeding and insecticides spray were done as and when necessary.

At harvesting stage rice grain and straw were collected and preserved for analysis of the nutrient content and uptake (N and protein). Grain and straw samples were digested with a mixture of 4% $HClO_4$ and concentrated H_2SO_4 acid. The digest was used to determine N (Kjeldhal method) content. Protein content was estimated by multiplying the percent N with the conventional factor 6.25. N uptake was estimated from the N content and yield of rice crop using the following formula:

Uptake=Content (%) x Yield (kg ha^{-1})/100

Statistical analysis for different character including the nutrient content and uptake were done following the ANOVA technique and the mean results in case of significant F-values were adjusted by the Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1. N content in grain and straw

N content in grain was influenced by different levels of N fertilization. The effect of different doses of N on total N content in grain was found positive and statistically significant (Table 1). The highest N content (1.40%) in grain was found in N_3 treatment, which was statistically similar with N_1 and N_2 treatments. The lowest N content (1.30%) was recorded in control treatment. The result revealed that N content in rice grain increased with increasing rate of N. N content in grain was also statistically increased with increasing level of Zn upto the highest level (Table 2). The maximum content of N (1.41%) was observed in Zn_3 treatment, which was statistically higher than the control treatment. Jahiruddin, 1983 observed that application of Zn (6 kg ha^{-1}) increased N concentration over control. The combined effect of N and Zn on total N content in grain was statistically significant (Table 3). The highest concentration of N was obtained with N_3Zn_2 treatment (1.51%), which was statistically similar with N_2Zn_3 treatment. The minimum (1.28%) was found in the treatment combination of N_0Zn_3, which was statistically identical with N_0Zn_1, N_0Zn_2, N_1Zn_0, N_3Zn_0, and N_3Zn_1 treatments.

Table 1: Effect of different levels of N on N and protein content of BRRI Dhan 39 at harvesting stage

Treatment	Total N (%)		Protein (%)	
	Grain	Straw	Grain	Straw
N_0	1.30b	0.74b	8.12b	4.61c
N_1	1.38a	0.95a	8.59a	5.96a
N_2	1.38a	0.93a	8.65a	5.79b
N_3	1.40a	0.95a	8.76a	5.97a
LSD (p=0.05)	0.046	0.037	0.242	0.124

Similar letter(s): Non-significant to each other; Dissimilar letter(s): Significant to each other

Table 2: Effect of different levels of Zn on N and protein content of BRRI Dhan 39 at harvesting stage

Treatment	Total N (%)		Protein (%)	
	Grain	Straw	Grain	Straw
Zn_0	1.32b	0.83c	8.23b	5.22c
Zn_1	1.34b	0.88b	8.36b	5.51b
Zn_2	1.39a	0.88b	8.70a	5.51b
Zn_3	1.41a	0.98a	8.84a	6.09a
LSD (p=0.05)	0.046	0.037	0.242	0.124

Similar letter(s): Non-significant to each other; Dissimilar letter(s): Significant to each other

N content in rice straw was increased significantly with increasing N level (Table 1). Similarly, N content in straw increased with increasing level of Zn (Table 2). N content in straw was also significantly affected by the combined effect of N and Zn (Table 3). The highest N content in straw was found in N_1Zn_3 treatment combination, which was statistically different from the others and the lowest was found in N_1Zn_0 treatment combination.

3.2. Protein content in grain and straw

Table 1 and 2 indicate that protein content in rice grain and straw was significantly influenced by the effect of different levels of N and Zn. The trend of variation in protein content was similar to that of N content because protein content was computed directly from the values of N content in grain and straw. The highest protein content of 9.43% (in grain) was recorded in N3Zn2 treatment combination and 7.68% (in straw) was recorded in N1Zn3 treatment combination. Protein content reduced remarkably in absence of either of the two nutrients (N and Zn). Even with the minimum dose of any one of the nutrients led to increase protein content. This suggests that N and protein content in rice grain and straw may be raised to the satisfactory level by addition of even minimum dose of N and Zn together.

Table 3: Interaction effect of different levels of N and Zn on N and protein content of BRRI Dhan 39 at harvesting stage

Treatment	Total N (%)		Protein (%)	
	Grain	Straw	Grain	Straw
N_0Zn_0	1.30d	0.74ef	8.12c	4.62f
N_0Zn_1	1.30d	0.77e	8.12c	4.81f
N_0Zn_2	1.32d	0.77e	8.25c	4.81f
N_0Zn_3	1.28d	0.67f	8.00c	4.18g
N_1Zn_0	1.33d	0.77e	8.31c	4.81f
N_1Zn_1	1.36cd	0.91cd	8.50bc	5.68de
N_1Zn_2	1.37bcd	0.91cd	8.56bc	5.68de
N_1Zn_3	1.44abc	1.23a	9.00ab	7.68a
N_2Zn_0	1.34cd	0.88d	8.37c	5.50e
N_2Zn_1	1.36cd	0.91cd	8.50bc	5.68de
N_2Zn_2	1.37bcd	0.87d	8.56bc	5.43e
N_2Zn_3	1.47a	1.05b	9.18a	6.56b
N_3Zn_0	1.30d	0.95cd	8.12c	5.93cd
N_3Zn_1	1.33d	0.94cd	8.31c	5.87cd
N_3Zn_2	1.51a	0.98bc	9.43a	6.12c
N_3Zn_3	1.46ab	0.95cd	9.18a	5.93cd
LSD (p=0.05)	0.091	0.075	0.483	0.247

Similar letter(s): Non-significant to each other; Dissimilar letter(s): Significant to each other

Table 4: Effect of different levels of N on N uptake by grain and straw of BRRI Dhan 39

Treatment	N uptake (kg ha^{-1})	
	Grain	Straw
N_0	34.63c	49.04d
N_1	47.72b	67.15c
N_2	50.99a	71.66b
N_3	48.31b	77.20a
LSD (p=0.05)	2.842	2.815

Similar letter(s): Non-significant to each other; Dissimilar letter(s): Significant to each other

3.3. N uptake by rice grain and straw

Statistically significant variations in N uptake by grain were found due to the application of different levels of N (Table 4). The highest significant N uptake (50.99 kg ha^{-1}) by grain was recorded in N_2 treatment comprising of 100 kg N ha^{-1} which was statistically different from all other N levels. The lowest N uptake (34.63 kg ha^{-1}) by grain was found from N_0 treatment. Duhan and Singh (2002) reported that uptake of N increased significantly with increasing N levels. A statistically significant difference was recorded for different levels of Zn in terms of N uptake by grain.

Table 5 shows that with increasing Zn level upto 10 kg ha^{-1} significantly increased N uptake by rice grain and thereafter decreased. The highest (54.30 kg ha^{-1}) N uptake by grain was recorded in Zn_2 treatment which was statistically higher from other Zn levels. On the other hand, the lowest (44.77 kg ha^{-1}) N uptake was recorded from the Zn_0 treatment, i.e. without any Zn, which was closely followed (49.55 kg ha^{-1}) by Zn_1 treatment comprising of 5 kg Zn ha^{-1}. Panda and Das (1970) showed that Zn application increased N uptake by rice grain and straw. The treatment combinations of N and Zn significantly influenced the N uptake by rice grain. The maximum uptake of N (72.58 kg ha^{-1}) by grain was obtained from the treatment N_2Zn_2, which was statistically identical with N_2Zn_3 and N_2Zn_1 treatment and

Table 5: Effect of different levels of Zn on N uptake by grain and straw of BRRI Dhan 39

Treatment	N uptake (kg ha^{-1})	
	Grain	Straw
Zn_0	44.77c	60.23c
Zn_1	49.55b	65.00b
Zn_2	54.30a	66.70b
Zn_3	50.02b	73.12a
LSD (p=0.05)	2.842	2.815

Similar letter(s): Non-significant to each other; Dissimilar letter(s): Significant to each other

the lowest N uptake was obtained in N_0Zn_0 treatment. This may be due to the positive interaction of N and Zn increase uptake of N by rice grain (Table 6). The highest N uptake by straw (87.41 kg ha^{-1}) was obtained from N_1Zn_3 treatment combination and the lowest one (45.50 kg ha^{-1}) was obtained from N_0Zn_3 treatment. Individually, N uptake increased with increasing rate of Zn and individual N treatment had also increasing effect of N uptake by rice grain and straw.

Table 6: Interaction effect of different levels of N and Zn on N uptake by grain and straw of BRRI Dhan 39

Treatment	N uptake (kg ha^{-1})	
	Grain	Straw
N_0Zn_0	28.61h	47.34hi
N_0Zn_1	35.69fg	51.47h
N_0Zn_2	40.49ef	51.85h
N_0Zn_3	33.72gh	45.50i
N_1Zn_0	40.82ef	53.18h
N_1Zn_1	45.79de	63.64g
N_1Zn_2	54.79bc	64.38fg
N_1Zn_3	49.46cd	87.41a
N_2Zn_0	59.87b	65.28fg
N_2Zn_1	67.99a	69.32efg
N_2Zn_2	72.58a	69.92def
N_2Zn_3	71.52a	82.12ab
N_3Zn_0	49.79cd	75.13cde
N_3Zn_1	48.75cd	75.58cd
N_3Zn_2	49.32cd	80.65bc
N_3Zn_3	45.38de	77.43bc
LSD (p=0.05)	5.683	5.631

Similar letter(s): Non-significant to each other; Dissimilar letter(s): Significant to each other

4. Conclusion

From the present study, it was clear that both N and Zn fertilization had the positive influences on protein content in *T-aman* rice. Solely 150 kg N ha^{-1} gave the highest N and protein content in rice grain and straw. On the other hand, 15 kg Zn ha^{-1} gave the highest N and protein content in rice grain and straw. N and Zn uptake by rice grain significantly increased with increasing level of N upto 100 kg N ha^{-1}. However, from statistical point of view among sixteen treatment combinations, 150 kg N ha^{-1} along with 10 kg Zn ha^{-1} was the best for maximum yield and highest protein content in *T-aman* rice.

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