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Evaluation of effectiveness of foliar application of urea fertilizer on growth, development and yield of BRRI Dhan 84 in barind tract, Bangladesh

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ABSTRACT

As a component of enzymes, hormones, amino acids, nucleic acids, nucleotides, and chlorophyll, nitrogen is a vitally important nutrient for plants. It encourages quick plant growth and enhances grain quality and production through increased protein synthesis, tillering, leaf area development, grain formation and filling. Urea is one of the greatest and popular sources of nitrogen. Rice production is hampered when nitrogen fertilizer, particularly urea, is unavailable during crucial times (flood, sowing season, drought). Studies in different literature have shown that applying nitrogen fertilizer as foliar application in addition to the soil application increases its efficiency. A study was carried out to observe the theme "Evaluation of effectiveness of foliar application of urea fertilizer on growth, development and yield of BRRI Dhan 84 in Rajshahi region'' in the field of Agronomy and Agricultural extension Department Field, University of Rajshahi, Bangladesh from December 2023-April 2024. Six different percentage of urea as foliar application with BRRI Dhan-84 rice variety were used for this study. 1. T_1= N0% Control, 2. T_2= 65% of recommended dose (N 50% as SA + 15% as FA), 3. T_3= 70% of recommended dose (N50% as SA + 20% as FA), 4. T_4= 75% of recommended dose (N50 % as SA + 25 % as FA), 5. T_5= 80% of recommended dose (N60% as SA + 20% as FA), 6. T_6= N100% Soil application (Traditional practice). A randomized complete block design with three replications was applied in this study. Almost all the parameters under this study showed significant results of foliar application of urea. Treatment T_4 showed the highest result of phenological and growth parameters than the traditional practice and T_1 (control) the lowest. Foliar fertilizer improves crop quality, regulate nutrient deficiencies. It is a fertilizer saving and an economical technique than others. This study adds to the body of knowledge by providing actual data on the dynamics of rice production's profitability, productivity and fertilizer saving.

Keywords: Nitrogen; Plant; Production; Grain quality; Fertilizer; Foliar application; Treatment; Growth parameters; Profitability; Productivity.

1. Introduction

Agriculture is the spirit of human civility (Akter M. *et al*., 2024). In Bangladesh, approximately 80% of the population is either directly or indirectly employed in agriculture, particularly in rice production (Monira S. *et al*, 2023). Rice (*Oryza sativa* L) is consumed as staple food and widely grown as important cereal crop in Asia (Monira S. *et al*., 2017). Population is increasing day by day in our country. We have to feed the people. Here, BRII Dhan 84 may plays a significant role. The most notable characteristics of this variety is its red grain and yield than the check variety BRRI Dhan 28. The protein level of the rice is 9.7%, the zinc concentration is 27.6 mg/kg, and the amylose content is 25.9% (Kader M.A. *et al*., 2020). A good crop production depends in large part on this variety. Farmers use different techniques for applying fertilizer on rice production. Fertilizer application should be smart as applied nitrogen fertilizer is not used 100% in agricultural field. A certain amount of nitrogen is wasted due to de-nitrification, volatilization (atmospheric evaporation), runoff, and leaching (Belal *et al.*, 2020). Fertilizer application through soil has been found to be less successful than applying it through foliage to plants especially for urea (Mosluh *et al*., 1978). One of the main issues with sustainable agriculture is the over use of nitrogen fertilizer, which results in increased nitrogen release into the environment and decreased crop utilization efficiency, which pollutes the water systems, soil and atmosphere (Zhu *et al*. 1997). Researchers have even observed that applying nitrogen as foliar has a greater recovery than applying it in the soil (Shim *et al*., 1972, Klein & Weinbaum 1985). This research aims to assess the appropriate proportion of urea fertilizer application for rice plant growth and development.

1.1. Study Objectives

(1) To evaluate the effectiveness of foliar fertilizer of urea, (2) To recommend the appropriate dose of urea fertilizer, (3) To save the fertilizer, (4) To assess the actual data of growth and development, and (5) To save farmers cost of production.

2. Methods and Materials

2.1. Ethical Approval

The Department Field of Agronomy and Agricultural Extension, University of Rajshahi served as the experiment's location from December 2023-April 2024.

2.2. Location

At the western side of the Department of Agronomy and Agricultural Extension, University of Rajshahi, the experimental field was located. Geographically it was located at 24°22′36″ N latitude and 88°38′27″ E longitude at an elevation of 20m above the sea level to High Ganges River Flood Plain AEZ-11. The land was flat, medium in height and properly drained.

2.3. Soil

The soil of experimental plot was properly drained and permeability was moderately slow. The top soil was slightly alkaline in reaction and silty loam.

2.4. Climate

Under a subtropical climate, the experimental area saw high levels of rainfall from April to September during the kharif season, and low temperatures and little precipitation from October to March during the rabi season.

2.5. Variety and Treatment

Rice variety BRRI Dhan- 84 was used for this experiment. Seeds of this variety were collected from Agronomy and Agricultural Extension Department, Rajshahi University, Bangladesh. It is widely cultivated and popular in this area. BRRI Dhan-84 rice with six different levels of urea as foliar application was used: 1. T_1= N0% Control; 2. T_2= 65% of recommended dose (N 50% as SA + 15% as FA); 3. T_3= 70% of recommended dose (N50% as SA + 20% as FA); 4. T_4= 75% of recommended dose (N50 % as SA + 25 % as FA); 5. T_5= 80% of recommended dose (N60% as SA + 20% as FA); 6. T_6= N100% Soil application (Traditional practice); *SA=Soil Application *FA=Foliar Application.

2.6. Experimental Design and Field Management

An RCBD (randomized completely block design) with three replications was used to set up the experiment. First, the field was split into three sections. In this experiment, every replication stood in for a block. After then, every block was split up into six units. There were eighteen unit plots in all, with a 10 m^2 (4 m × 2.5 m) plot size. The units used for plots and replications were kept at a distance of 0.5 and 1.0 meters, respectively. On December 7, 2023, the sprouting seeds were evenly sown in a prepared seedbed. Ultimately, on January 27, 2023, the

experimental plot was prepared for transplantation. On January 28, 2023, the experimental field's layout was completed.

2.7. Fertilizer Management

TSP, MoP, Gypsum, and ZnS04 were applied to the experimental field at rates of 90 $kgha^{-1}$, 112 $kgha^{-1}$, 75 $kgha^{-1}$, and 7.5 $kgha^{-1}$, equally (Source: Soil Resources Development Institute Regional Laboratory, Rajshahi. SRDI, Rajshahi). As per the experiment, urea fertilizer was used. At the last stage of land preparation, whole TSP, MoP, and gypsum were added, and the soil was well mixed with them.

All plots, with the exception of the control plots, received foliar application of urea at three distinct time intervals (20 DAT, 45 DAT, and 60 DAT) following transplant (DAT).

2.8. Preparation of Seedbed

Healthy seeds were collected following standard method. 24 hours water soaked seeds were taken out and spread on polythene sheet thickly. For sprouting, a covering was necessary with wet gunny bags under dark condition. After 48 hours the sprouting was started and after 72 hours seeds were sown in the seedbed.

2.9. Raising and Transplanting of Seedling

A piece of perfectly puddled medium high and weed free land was selected. Necessary irrigation, pest and disease infestation were done timely. Two or three seedlings were planted $hill^{-1}$ where hill to hill distance was 20cm and plant to plant 20cm respectively. The size of plot was $10m^2$.

2.10. General Observation

To monitor the crop growth stages, regular observations were conducted. The field looked nice with normal, vigorous and fresh green plants. Tiller growth was satisfactory with all treatment.

2.11. Harvest

When 80–85% of the grains turn golden yellow, the crop is considered mature. For recording necessary data ten hills (excluding border hill) were randomly selected from each plot and tagged carefully. On 12 May 2023 the whole plot was harvested. The harvested crop of each plot was bundled, tagged and taken to the threshing floor for threshing, cleaning and sun drying to record the data perfectly.

2.12. Recording of Data at Harvest and Statistical Analysis

From any side of the plot three $plants\ plot^{-1}$ were taken randomly for measuring the total dry matter.

At 600 ^oC for 72 hours the samples (with an envelope) were dried in an oven, weighed separately by using an electric balance for leaf, stem, root dry weight as well as panicle dry weight. The compilation and tabulation of recorded data of different parameters was done for statistical analysis. The “Analysis of variance” (ANOVA) was done with the help of computer package program SPSS 20 version. The mean differences were adjudged by using Duncan’s Multiple Range Test.

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3. Results

3.1. Effectivity of urea fertilizer as foliar treatments on Plant Height at Different Days after Transplanting

The effectivity of foliar fertilizer of urea on plant height was significant at different DAT (Table 1). The height of the plants increased gradually over time. Plant height increased slowly at first, then on subsequent DAT, it quickened. Among different treatments, T_4, T_5, T_6 showed the highest plant height and the lowest was observed in T_0 (control) treatment at all DAT. Similar result was also observed by Karim, M. *et al*. (2019) and reported that nitrogen increase plant height through cell division and cell elongation.

Table 1. Effectivity of urea fertilizer as foliar application on plant height (cm)

Treatment	Plant height20DAT	Plant height40DAT	Plant height60DAT	Plant height80DAT	Plant height after harvest
T_0	21.28d	37.94f	56.33d	67.65e	78.13d
T_1	22.71d	44.58e	58.60cd	69.29e	92.47c
T_2	25.32c	47.60d	61.36c	72.95d	94.87b
T_3	26.90c	50.16c	69.31b	83.07c	97.07a
T_4	34.08b	53.21b	74.29a	90.97a	98.33a
T_5	36.00a	55.65a	76.35a	87.98b	96.97c
T_6	32.36b	50.91c	76.31a	88.89b	97.17c
LSD	0.05	0.05	0.05	0.05	0.05
CV (%)	3.78	2.05	2.38	1.36	1.30

Here, T for treatment, CV for co-efficient variance, LSD for least significant difference, a, b, c, d relates Duncan's multiple range test (MRT), DAT= Days after Transplanting.

3.2. Effectivity of urea fertilizer as foliar treatments on Plant Height at Different Days after Transplanting

The effectivity of liquid fertilizer of urea had significant effect on total number of tillers hill^{-1} at the observation of 20, 40, 60, 80 DAT and after harvest (Table 2). With the advancement of time total number of tillers hill^{-1} was increased progressively. The treatment T_4 showed the highest total number of tillers hill^{-1} (8.34a) and the lowest (3.69d) was found in the treatment T_0 at 20 DAT. After harvest, the treatment T_4 showed the highest total number of tillers (15.99a) and the lowest (12.33) was observed in the treatment T_0. Similar result was recorded by Ferdous H. (2013) on Boro rice cv. BRRI dhan29 from foliar application of 3% urea solution.

Table 2. Effectivity of urea fertilizer as foliar application on tiller number

Treatment	Tiller no. at 20DAT	Tiller no. at 40DAT	Tiller no. at 60DAT	Tiller no. at 80DAT	Tiller at after harvest
T_0	3.69d	9.08c	10.91d	12.20d	12.33d
T_1	4.63c	9.83c	11.32d	13.29c	13.89c
T_2	5.03c	9.83c	11.63d	13.38c	13.98c
T_3	6.60b	11.67b	12.68c	14.28b	14.98b

T_4	9.34a	13.28a	14.88a	15.33a	15.99a
T_5	9.03a	11.32b	13.66bc	14.91ab	15.66a
T_6	9.28a	12.33ab	14.08ab	15.57a	15.98a
LSD	0.05	0.05	0.05	0.05	0.05
CV (%)	6.54	5.58	4.59	3.57	10.14

3.3. Effectivity of urea fertilizer as foliar treatments on non- effective tillers at Different Days after Transplanting

The liquid fertilizer had significant effect on total number of non-effective tillers hill^{-1} at the observation of 20, 40, 60, 80 DAT and days after harvest (Table 3). At every DAT, T_0 showed the highest number of non -effective tillers as there was no application of fertilizer. T_1 and T_2 also showed higher number of non- effective tillers as there was less amount of fertilizer application.

Table 3. Effectivity of urea fertilizer as foliar application on non-effective tiller

Treatment	Non-effective Tiller no. at 20DAT	Non-effective Tiller no. at 40DAT	Non-effective Tiller no. at 60DAT	Non-effective Tiller no. at 80DAT	Non-effective Tiller at after harvest
T_0	7.75a	4.99a	4.20b	13.70ab	13.95a
T_1	7.61a	3.00bc	4.01bc	13.25ab	13.33ab
T_2	5.33b	3.68b	3.69bc	13.33ab	13.27ab
T_3	3.45c	2.57cd	4.99a	13.02ab	13.09ab
T_4	3.95c	2.13d	2.49d	8.39a	10.01ab
T_5	7.65a	2.75cd	3.36c	12.38b	13.79ab
T_6	6.87a	3.67b	3.66bc	13.56ab	12.12b
LSD	0.05	0.05	0.05	0.05	0.05
CV (%)	21.91	12.64	11.06	11.64	10.93

3.4. Effectivity of urea fertilizer as foliar treatments on panicle length and spikelet no. after harvest

Liquid fertilizer as a plant nutrient contributes in panicle formation as well as panicle elongation and increases spikelet number. Panicle length was elongated by spraying liquid fertilizer. Nitrogen and liquid fertilizer had significant influence on panicle length and spikelet number (Table 4). The highest panicle length (26.43a) was observed in T_4 and the lowest panicle length (21.13d) was found in control. The similar result was consistent with Patrick and Hoskins (1974). Liquid fertilizer also helpful for increasing spikelet number. After harvest the highest spikelet number (12.00a) was recorded in T_4 and lowest (8.00c) in T_0.

Table 4. Effectivity of urea as foliar application on panicle length and spikelet no. after harvest

Treatment	Panicle length (cm)	Spikelet No.
T_0	21.13d	8.00c
T_1	23.57c	11.67ab

T_2	25.17ab	11.67a
T_3	24.13bc	11.33a
T_4	26.43a	12.00a
T_5	24.13bc	11.67a
T_6	26.43a	8.33c
LSD	0.05	0.05
CV (%)	3.03	13.75

3.5. Effectivity of urea fertilizer as foliar treatments on total grain number and non- grain seed after harvest

Liquid fertilizer showed significant variation in term of number of filled grain. Highest number of filled grain panicle^{-1} (216.67a) was recorded from T_4, while the lowest (101.33c) was in control treatment (Table 5). Non -grain seed number also recorded. Highest number of non-grain seed (27.00b) was recorded in control treatment. T_1, T_3 and T_4 (18.33a) showed the same results. Alston (1979), Strong (1982) and Gooding and Devies (1992) also reported increased grain yield from foliar application of N and P, individually or in combination.

Table 5. Effectivity of urea as foliar application on total grain no. and nongrain seed after harvest

Treatment	Total grain no.	Non grain seed no.
T_0	101.33c	27.00b
T_1	182.00b	18.33a
T_2	205.33ab	17.33a
T_3	209.67ab	18.33a
T_4	216.67a	18.33a
T_5	194.67ab	20.33a
T_6	198.33	21.33
LSD	0.05	0.05
CV (%)	9.00	12.04

3.6. Effectivity of urea fertilizer as foliar treatments on total grain weight and 1000 grain weight after harvest

Total grain weight from 10m^2 was observed. T_4 showed the highest (394.33a) whereas T_0 showed the lowest (195.67d). The 1000 grain weight was significantly influenced by the nitrogen liquid fertilizer. The results shown in Table 6 show that T4 treatment produced the largest 1000-grain weight (27.67a), whereas the control treatment produced the lowest weight (22.67c). Grain yield significantly varied as a result of the nitrogen liquid fertilizer.

Table 6. Effectivity of urea as foliar application on total grain weight and 1000 grain weight after harvest

Treatment	Total grain weight from 10m^2 (gm)	1000 grain weight (gm)
T_0	195.67d	22.67c

T_1	306.67c	24.27bc
T_2	378.33b	24.82abc
T_3	359.67b	26.89ab
T_4	394.33a	27.67a
T_5	346.67bc	24.61bc
T_6	380.33b	26.92ab
LSD	0.05	0.05
CV (%)	7.36	6.09

3.7. Effectivity of urea fertilizer as foliar treatments on total straw weight (ton/ha) and yield (Ton/ha) after harvest

Due to nitrogen liquid fertilizer Straw yield of rice differed significantly (Table-7). Highest straw yield was showed in T_4 (6.92bc) whereas, the lowest one (4.67e) was obtained from control treatment. Similar result was observed by Patrick and Hoskins (1980). The most important parameter of this paper was yield which was highest in T_4 (6.36a) and lowest was in control (4.13c) treatment.

Table 7. Effectivity of urea as foliar application on total straw weight (ton/ha) and yield (Ton/ha) after harvest

Treatment	Straw weight (ton/ha)	Yield (ton/ha)
T_0	4.67e	4.13c
T_1	5.00d	5.56bc
T_2	6.67c	5.83ab
T_3	6.49b	5.97ab
T_4	6.92bc	6.36a
T_5	6.44b	6.03ab
T_6	6.49b	5.93b
LSD	0.05	0.05
CV (%)	2.63	5.25

4. Conclusion

With a few exceptions, the liquid fertilizer had significant effect on almost all the parameters under study. In most cases, the highest value for plant phenological characteristics like plant height, total number of tiller hill^{-1} was observed from the treatment T_4 (liquid fertilizer) and the lowest value was found in the treatment T_1 (control or non- nitrogenous fertilizer) at different DAT. Almost all the plant, growth, yield and yield components were observed significant by liquid fertilizer. Among six treatments T_4 performed the best for almost all the plant height, tiller number, panicle length, spikelet number, and growth, yield and yield components and consequently it produced the highest grain yield and showed the highest growth and yield performance. It is advisable to advise farmers to use BRRI dhan 84 as it is superior to the current zinc-enriched rice varieties for Bangladesh, appropriate for the country's arid environment (Boro season). Application of liquid fertilizer instead of applying nitrogen

fertilizer just to the soil in order to achieve optimal growth and yield performance in rice farming. Farmers should adopt this technique as it saves money, time and extra use of fertilizer. Foliar application saves irrigation water and it is cost effective technique.

Declarations

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Competing Interests Statement

The authors have not declared any conflict of interest.

Authors' contributions

All the authors show the heartiest responsibility to fulfil the manuscript.

Consent for publication

The authors declare that they consented to the publication of this study.

Availability of data and materials

Data will be provided by the corresponding author upon a reasonable request.

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