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Effect of Split Application of Urea on Growth, Yield Attributes, and Yield of Wheat (*Triticum aestivum* L.)

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Article info	Abstract
Received: 24 April, 2025 Accepted: 30 May, 2025 Published: 05 June, 2025 Available in online: 10 June, 2025 *Corresponding author:  mesba@ru.ac.bd 	Wheat (<i>Triticum aestivum</i> L.) is a major cereal crop belonging to the family <i>Poaceae</i>, ranking second after rice in global consumption. A field experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, Bangladesh, from December 2019 to March 2020, to evaluate the effect of split urea application on the growth, yield-contributing characters, and yield of wheat. The experiment comprised two varieties—BARI Gom-26 (V_1) and BARI Gom-28 (V_2)—and four urea application schedules: T_1 (full dose as basal), T_2 (two equal splits at basal and 20 DAS), T_3 (three equal splits at basal, 20, and 40 DAS), and T_4 (four equal splits at basal, 20, 40, and 60 DAS). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Results indicated that split application of urea had a significant effect on all growth and yield parameters. The highest performance was recorded under T_4 treatment, which produced the maximum number of effective tillers per plant (6.28), spike length (10.56 cm), number of spikelets per spike (20.61), number of grains per spike (51), 1000-grain weight (46.01 g), grain yield (2.59 t ha^{-1}), straw yield (3.32 t ha^{-1}), biological yield (5.91 t ha^{-1}), and harvest index (43.78%). The interaction between V_2 (BARI Gom-28) and T_4 exhibited superior results in all yield parameters, achieving a grain yield of 2.64 t ha^{-1} and biological yield of 6.01 t ha^{-1}. It may be concluded that BARI Gom-28, when fertilized with urea in four equal splits (basal + 20 DAS + 40 DAS + 60 DAS), enhances growth and yield performance of wheat under the agro-climatic conditions of Rajshahi, Bangladesh. Keywords: Wheat; <i>Triticum aestivum</i> L.; Split urea application; Growth; Yield attributes; BARI Gom-28; Nitrogen management; RCBD.

Introduction

Wheat (*Triticum aestivum* L.) is the world's second most widely produced and consumed cereal crop after rice and maize. During 2022–2023, global wheat production reached 783.8 million metric tons, while maize production stood at 1.151 billion tons (Statista, 2023). Wheat is cultivated across temperate, tropical, and subtropical regions and serves as a staple food for a large portion of the global population (Jan et al., 2023). It provides essential nutrients such as proteins, dietary fiber, vitamins, minerals, and phytochemicals, in addition to being a major source of starch and energy (Shewry & Hey, 2015). Wheat holds a vital position in human diets due to its adaptability, ease of storage, and suitability for diverse food products (Alnaass et al., 2023; Xie et al., 2023). The proximate composition of wheat flour consists of 69.4% carbohydrates, 12.1% protein, 1.7% fat, 2.7% minerals, 1.9% fiber, and 12.2% moisture, containing approximately 48 mg calcium, 355

mg phosphorus, 11.5 mg iron, and trace amounts of vitamin B complex. The grain protein content and its composition—both genetically and environmentally determined—are key quality attributes influencing wheat's nutritional value.

In Bangladesh, wheat production in 2022–2023 was about 1.16 million metric tons (Statista, 2023). However, national production has shown a consistent decline over the past two decades, mainly due to declining soil fertility and improper agronomic practices. Among the locally adapted cultivars, BARI Gom-26 and BARI Gom-28 are widely grown, yet their responses to specific fertilizer management strategies remain underexplored.

Nitrogen (N) is an essential macronutrient crucial for plant growth and yield formation. However, substantial nitrogen losses occur through volatilization, leaching, and denitrification, contributing to environmental degradation. The concept of 4R nutrient stewardship—right source, right rate, right time, and right place—

emphasizes efficient nutrient management (Hamani et al., 2023; Gawdiya et al., 2023). Split application of urea, a common nitrogenous fertilizer, enhances nitrogen use efficiency (NUE) and synchronizes nitrogen supply with crop demand, minimizing losses and improving productivity. Splitting nitrogen into several doses throughout the growing period also improves grain quality and yield.

Therefore, the present study was undertaken to assess the comparative yield performance of two wheat varieties (BARI Gom-26 and BARI Gom-28) in response to different split applications of urea under the agro-climatic conditions of Rajshahi, Bangladesh.

- **T₂**: Two equal splits (basal and 20 DAS)
- **T₃**: Three equal splits (basal, 20, and 40 DAS)
- **T₄**: Four equal splits (basal, 20, 40, and 60 DAS)

The experiment followed a **Randomized Complete Block Design (RCBD)** with three replications, comprising 24 unit plots of 10 m² each.

Cultivation Techniques

The experimental land was ploughed using a tractor-drawn disc plough on 25 November, followed by laddering to achieve a fine tilth. Weeds and stubbles were removed, and large clods were broken manually. Seeds were sown plot-wise after proper land preparation. Standard agronomic practices and intercultural

Table-1: Varietal differences, split urea application and their interaction on plant height, total dry matter production and SPAD value of wheat at different day's after sowing (DAS)

Varieties	Plant height (cm)				TDM(g plant ⁻¹)				SPAD value	
	30 DAS	60 DAS	90DAS	120DAS	30 DAS	60DAS	90 DAS	120 DAS	30 DAS	60 DAS
V ₁	40.92	66.46b	83.22	91.14b	86.4	9.27b	13.49b	21.28b	25.49b	20.68b
V ₂	44.63	75.02a	90.63	120.10a	86.4	12.63a	15.55a	24.22a	37.24a	38.93a
Split urea application levels										
T ₁	39.35b	61.70b	81.60b	99.96b	2.08 d	7.42 d	11.75d	19.54c	19.84d	13.998d
T ₂	41.16b	66.95b	85.59ab	104.17ab	2.63c	9.60 c	13.90c	21.95b	27.29c	22.81c
T ₃	42.58ab	74.58a	87.04ab	106.94ab	3.86 b	12.27 b	15.38b	23.98a	35.02b	35.69b
T ₄	48.00a	79.73a	93.46a	111.33a	4.87 a	14.52a	17.03a	25.52a	43.29a	46.73a
Interactions between varieties and split urea application										
V ₁ T ₁	37.63b	57.50e	78.67	86.40b	1.60f	6.03e	11.33e	18.46e	15.76f	4.697g
V ₁ T ₂	39.66b	62.35de	82.22	90.23b	2.07ef	7.43de	12.54de	20.68de	21.04e	12.47f
V ₁ T ₃	41.82b	69.47bcd	81.28	91.95b	2.97cd	10.80c	13.63cd	22.04cd	27.97d	28.84d
V ₁ T ₄	44.56ab	76.51abc	90.7	95.996b	3.63c	12.83bc	16.43ab	23.93bc	37.16c	36.71c
V ₂ T ₁	41.10b	65.90cde	84.53	113.52a	2.57de	8.80d	12.17de	20.63de	23.92de	23.30e
V ₂ T ₂	42.67ab	71.55bcd	88.96	118.098a	3.20cd	11.77bc	15.27bc	23.22bcd	33.53c	33.14cd
V ₂ T ₃	43.33ab	79.68ab	92.8	121.93a	4.76b	13.73b	17.13ab	25.92bc	42.06b	42.54b
V ₂ T ₄	51.44a	82.95a	96.22	126.65a	6.10a	16.20a	17.632a	27.11a	49.43a	56.74a
CV(%)	11.44	8.13	10.69	8.76	12.83	10.43	7.57	7.28	8.94	9.84

Mean followed by different letter (s) differed significantly as per DMRT. CV= Coefficient of variation; DAS= Day's after sowing; V₁= BARI Gom-26, V₂= BARI Gom-28, T₁=Fertilizer applied at basal dose, T₂= Fertilizer applied at basal and 20 DAS, T₃= Fertilizer applied at basal, 20 and 40 DAS, T₄= Fertilizer applied at basal, 20, 40 and 60 DAS.

Materials and Methods

Location and Site

The experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, Bangladesh, from December 2019 to March 2020. The soil of the experimental site was sandy loam with a pH of 7.6.

Climate

The study area falls under a subtropical climate, characterized by moderately high temperatures and heavy rainfall during the Kharif season (April–September) and low rainfall with cool to mild temperatures during the Rabi season (October–March).

Experimental Treatments

Two wheat varieties—BARI Gom-26 (V₁) and BARI Gom-28 (V₂)—were obtained from the Regional Wheat Research Station, Shyampur, Rajshahi. Four levels of urea application were tested:

- **T₁**: Full urea dose as basal application

operations were carried out uniformly. Crops were harvested at full maturity, and yield data were recorded accordingly.

Data Collection

Growth parameters (plant height, total dry matter, and SPAD value) were recorded from randomly selected tagged plants. At harvest, yield and yield-contributing traits were measured from each plot.

Statistical Analysis

All collected data were analyzed using the STATVIEW statistical package, and mean differences among treatments were compared using Duncan's Multiple Range Test (DMRT) at the 5% level of significance.

Results

Plant Height

Significant differences in plant height were observed among treatments and between varieties. BARI Gom-28 exhibited greater plant height than BARI Gom-26 (Table 1). At 30 DAS, the tallest

plants (48.00 cm) were recorded in T_4 , which decreased by 11.29%, 14.25%, and 18.03% in T_3 , T_2 , and T_1 , respectively. Similar trends were observed at 60, 90, and 120 DAS, with T_4 consistently producing the highest plant height values. The interaction effect between variety and split urea application was significant, with the tallest plants recorded under V_2T_4 and the shortest under V_1T_1 .

Discussions

Split application of nitrogen proved highly effective in enhancing growth and yield attributes of wheat. The increase in plant height observed in T_4 aligns with findings of Goudar et al. (2023), who reported that frequent nitrogen application promotes auxin synthesis, leading to greater internode elongation (Davies, 1995). Split application ensures a steady nitrogen supply, promoting

Table-2: Varietal differences, split urea application and their interaction on yield contributing characters and yield of wheat

Varieties	No. of effective tillers plant ⁻¹	Length of spike (cm)	No. of Spikelets spike ⁻¹	No. of grains spike ⁻¹	1000 grains weight(g)	Grain yield (tha ⁻¹)	Straw yield (tha ⁻¹)	Biological yield (tha ⁻¹)	Harvest index (%)
V_1	5.01b	9.48	18.33	41.83b	41.88	2.11b	2.88	4.99b	42.24
V_2	5.87a	10.11	19.81	48.33a	44.18	2.43a	3.17	5.596a	43.49
Split urea application levels									
T_1	3.72c	8.88d	17.06c	36.67c	40.68c	1.88c	2.66c	4.55c	41.37c
T_2	5.06b	10.09b	19.61b	47.00b	43.08b	2.33b	3.11b	5.44b	42.82b
T_3	4.67b	9.66c	19.00b	45.67b	42.34bc	2.27b	3.01b	5.27b	42.97ab
T_4	6.28a	10.56a	20.61a	51.00a	46.01a	2.59a	3.32a	5.91a	43.78a
Interactions between varieties and split urea application									
V_1T_1	3.44f	8.63e	16.22f	33.33e	40.34e	1.72g	2.51f	4.23f	40.55d
V_1T_2	4.00e	9.14d	17.89e	40.00d	41.03de	2.05f	2.81e	4.86e	42.18c
V_1T_3	4.55d	9.86c	19.11cd	46.00bc	42.51bcde	2.25de	3.02d	5.27d	42.61bc
V_1T_4	5.55bc	10.32b	20.11ab	48.00b	43.64bc	2.41bc	3.19bc	5.60bc	43.02abc
V_2T_1	4.22de	9.30d	18.44de	43.67cd	41.67cde	2.17ef	2.87e	5.03de	43.05abc
V_2T_2	5.11c	10.02c	19.55bc	47.67b	43.01bcd	2.36cd	3.15c	5.51c	42.88abc
V_2T_3	6.00b	10.44ab	20.33ab	50.00ab	44.54b	2.54ab	3.28ab	5.82ab	43.63ab
V_2T_4	6.55a	10.67a	20.89a	52.00a	47.47a	2.64a	3.37a	6.01a	43.94a
CV (%)	7.09	11.18	10.62	9.97	10.19	3.94	11.92	8.34	5.04

Mean followed by different letter (s) differed significantly as per DMRT. CV= Coefficient of variation; DAS= Day's after sowing; V_1 = BARI Gom-26, V_2 = BARI Gom-28, T_1 =Fertilizer applied at basal dose, T_2 =Fertilizer applied at basal and 20 DAS, T_3 = Fertilizer applied at basal, 20 and 40 DAS, T_4 = Fertilizer applied at basal, 20, 40 and 60 DAS.

Total Dry Matter (TDM)

Split nitrogen application significantly influenced total dry matter production at all growth stages (30, 60, 90, and 120 DAS). The maximum TDM was observed in T_4 at each stage. At 120 DAS, T_4 recorded 25.52 g plant⁻¹, while T_3 , T_2 , and T_1 showed reductions of 13.98%, 23.43%, and 23.43%, respectively. The interaction V_2T_4 produced the highest TDM values across all sampling intervals.

SPAD Value

SPAD readings differed significantly among varieties and treatments. BARI Gom-28 consistently showed higher SPAD values than BARI Gom-26. The highest SPAD values (43.29 and 46.73 at 30 and 60 DAS, respectively) were recorded in T_4 , followed by T_3 . The lowest readings occurred in T_1 . The interaction V_2T_4 exhibited the highest SPAD values, confirming enhanced chlorophyll content due to effective nitrogen management.

Yield Components and Yield

Yield attributes and grain yield were significantly influenced by split urea application. T_4 produced the highest number of effective tillers per plant (6.06), spike length (10.49 cm), number of spikelets per spike (20.61), and grains per spike (51). The highest 1000-grain weight (44.18 g) was obtained from BARI Gom-28. Grain yield reached 2.52 t ha⁻¹ in T_4 , compared to 1.94 t ha⁻¹ in T_1 . The combination V_2T_4 yielded the maximum grain (2.64 t ha⁻¹), straw (3.37 t ha⁻¹), and biological yield (6.01 t ha⁻¹).

sustained vegetative growth and improved photosynthetic efficiency.

Total dry matter accumulation increased significantly with each additional nitrogen split. Similar findings were reported by Allart et al. (2023), who noted that split nitrogen applications enhance nutrient uptake, delay senescence, and ultimately increase biomass accumulation.

Higher SPAD values in split-applied treatments indicate improved chlorophyll synthesis and nitrogen assimilation (Gawdiya et al., 2023). Regular nitrogen availability prevents chlorophyll degradation and maintains photosynthetic activity (Martins et al., 2023).

The number of effective tillers per plant increased significantly with split nitrogen applications, consistent with Desta et al. (2023) and Tao et al. (2024), who observed that periodic nitrogen supply supports continuous tiller initiation. Splitting nitrogen also enhances nitrogen use efficiency (NUE) by reducing leaching and volatilization losses (Singh et al., 2023).

Overall, the superior performance of the four-split treatment (T_4) demonstrates that synchronizing nitrogen supply with crop demand optimizes physiological processes, resulting in higher yields and improved nitrogen efficiency.

Conclusions

The results clearly demonstrate that BARI Gom-28 outperformed BARI Gom-26 in terms of growth and yield parameters. Split

application of urea significantly influenced wheat performance, with the four-split treatment (T_4 : basal + 20 + 40 + 60 DAS) producing the highest number of effective tillers (6.28), spike length (10.56 cm), grains per spike (51), 1000-grain weight (46.01 g), grain yield (2.59 t ha^{-1}), straw yield (3.32 t ha^{-1}), and biological yield (5.91 t ha^{-1}). The combination of BARI Gom-28 with four urea splits (V_2T_4) yielded the best performance across all parameters.

Therefore, BARI Gom-28 with urea applied in four equal splits is recommended for maximizing wheat growth and yield under the agro-climatic conditions of Rajshahi or similar environments. Future research should integrate economic evaluation and environmental impacts of combined urea and irrigation management to ensure sustainable production.

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