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Impact of Stage-Specific Irrigation on the Growth and Yield of Wheat

Ronzon Chandra Das[1*], Anup Ghosh[2], Syed Aflatun Kabir Hemel[3], S.M. Shahriar Parvej[4], Muhammad Tanvir Rahman[5] and Md. Imran Ali[6]

[1]Scientific Officer, Department of Soil Science, Agronomy Division, Bangladesh Jute Research Institute, Bangladesh, Email: ronzonbjri2020@gmail.com
[2]Scientific Officer, Jute Research Substation, Monirampur, Jashore, Bangladesh Jute Research Institute, Bangladesh. Email : anupghosh041194@gmail.com
[3]Scientific Officer, Jute Research Substation, Kalapara, Patuakhali, Bangladesh Jute Research Institute, Bangladesh, Email: himelaflatun@gmail.com
[4]Senior Scientific Officer, Department of Soil Science, Agronomy Division, Bangladesh Jute Research Institute, Bangladesh, Email: sparvej60@gmail.com
[5]Senior Scientific Officer, Department of Soil Science, Agronomy Division, Bangladesh Jute Research Institute, Bangladesh, Email: tanvir2511@gmail.com
[6]Scientific Officer, Jute Research Regional Station, Kishoreganj, Bangladesh Jute Research Institute, Bangladesh. Email : imran.cstru@gmail.com

*Correspondence: ronzonbjri2020@gmail.com

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Abstract: Stage-specific irrigation is essential for ensuring optimal water use at critical growth stages in wheat (*Triticum aestivum*), leading to increased yield and improved grain quality. Therefore, determining an appropriate irrigation schedule for wheat is crucial for enhancing productivity**.** Keeping this view in mind, an experiment was conducted at the farmer's fields of Dinajpur Sadar Upazila, Dinajpur, Bangladesh from November 2020 to April 2021, aimed to evaluate the impact of irrigation schedules on the growth and yield of wheat (BARI Gom-33). A randomized complete block design (RCBD) with seven treatments and three replications was implemented. Treatments included varying irrigation timings: T_0 (no irrigation), T_1 (one irrigation at maximum tillering), T_2 (one irrigation at booting), T_3 (one irrigation at heading), T_4 (two irrigations at maximum tillering and heading), T_5 (milking dough), and T_6(two irrigations at booting and milking dough). Key metrics assessed included plant height, leaf count, tiller number, dry matter, growth stages, grain number, thousand grain weight, and overall yield at different days' intervals. Results indicated that irrigated treatments (T_1-T_6) significantly improved the parameters for growth and yield compared to the control (T_0). Notably, T_4, with two irrigations, yielded the highest grain production at 5.20 t/ha, followed closely by T_6. These findings highlight the significance of proper irrigation scheduling for optimizing wheat yield, indicating that applying two irrigations at the maximum tillering and heading stages can significantly enhance agricultural productivity.
Keywords: Irrigation schedule; *Triticum aestivum*; Irrigated treatments; Growth; Yield; Tillering.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is among the most extensively cultivated cereal crops globally. It ranks as the largest crop in the world in terms of both cultivated area, covering 21,360 thousand hectares, and production, totaling 576,317 thousand metric tons. (FAO, 2014). Cereal crops are a staple food for approximately 10 billion people in as many as 43 countries globally, making up 30% of all cereal food produced worldwide. According to (Roy and Pandit, 2007), wheat consumption is rising at a pace of 3% annually. By 2050, the need for wheat in developing nations would rise by 60% (Rosegrant and Agcaoili, 2010). Wheat grain possesses high nutritional value, containing 12% protein, 1.72% fat, 69.60% carbohydrates, and 27.20% minerals (BARI, 2006). Rice serves as the staple food in Bangladesh; however, its total production falls short of meeting the needs of the country's growing population. In

In Bangladesh, wheat ranks second in terms of total land area (328,924 ha) and production (1,085,368 tons), following rice. The average yield of wheat is currently only 3.30 t/ha (BBS, 2019), highlighting considerable opportunities to increase production per unit area through the implementation of modern agronomic practices, such as optimal seed rates, timely sowing, and the careful application of irrigation, fertilizers, and other inputs. From a nutritional perspective, wheat is superior to rice due to its higher protein content. However, various factors contribute to the low grain yield of wheat, including temperature fluctuations, inadequate irrigation water and plant nutrients, weed competition, insect infestations, and disease infections. The scarcity of irrigation water accounts for approximately 30% of wheat production losses, while deficiencies in soil nutrients and metals, along with their availability and the pollution status of other environmental parameters, contribute to an additional 40% yield loss (Uddin et al. 2016, Islam et al. 2016, Sarker et al. 2018). Nonetheless, a sufficient supply of nutrients and irrigation water can boost our nation's productivity by up to 70% (Uddin et al. 2016, Ahmed 2006). During the rabi season, many lands, particularly in the northwestern region of Bangladesh, remain fallow due to insufficient irrigation facilities, despite favorable climatic and soil conditions for wheat cultivation. Effective irrigation timing and management are crucial for successful wheat production, as supplemental irrigation enhances grain development and overall yield (Singh and Singh 2005). The frequency of irrigation significantly affects wheat growth and yield, with increased irrigation frequency capable of enhancing wheat grain production (Khajanji and Swivedi, 2007). A better grain production can be achieved by watering wheat at the right time, which is crucial for healthy growth, particularly during the crown root initiation stage (Randhawa et al. 2004).

Thus, the judicious application of irrigation water during critical growth stages is a key approach to irrigation scheduling in wheat cultivation, potentially leading to optimal crop yields. In light of the aforementioned context regarding wheat cultivation in Bangladesh, this study was conducted to investigate the effect of irrigation on the growth and yield of wheat.

MATERIALS AND METHODS

The experiment was carried out from November 2020 to March 2021 to evaluate the impact of irrigation scheduling on the growth and yield of wheat. The following sections present the details of the materials and methods used in the study:

Location and duration

The experiment was conducted at a research farm in Dinajpur from November 2020 to April 2021. The site is located in the Dinajpur Sadar Upazila at a latitude of 25º39′ N and a longitude of 88º41′ E, with an elevation of 37.58 meters above sea level (Fig 1).

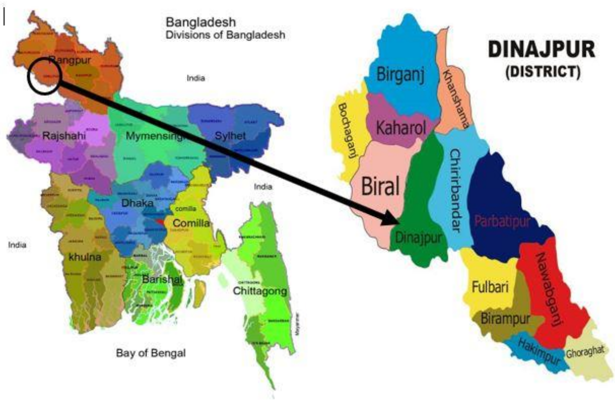

Figure 1: Map of the study area

Soil and climate

The experimental field was designated as medium high land, comprising non-calcareous dark gray floodplain soil within the agro-ecological zone of the Old Himalayan Piedmont Plain (AEZ-1). This sandy loam soil is classified under the inceptisol order. The site is situated in a subtropical region, characterized by substantial rainfall from May to September and minimal precipitation during the rest of the year.

Experimental design and treatments

The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications, each consisting of seven-unit plots per block. The size of each unit plot was 2 m × 2 m, with a 0.5 m gap between plots and a 1.0 m distance between blocks. The treatments were-

T_0 = No irrigation
T_1 = One irrigation at maximum tillering stage
T_2 = One irrigation at booting stage
T_3 = One irrigation at heading stage
T_4 = Two irrigations, one at maximum tillering stage and another one at heading stage
T_5 = One irrigation at milk dough stage
T_6 = Two irrigations, one at booting stage and another one at milk dough stage

Cultivation Procedure

The land was ploughed by a power tiller and was leveled by harrowing and laddering carefully. A fertilizer application rate of 140-35-75-18-2-0.5 kg ha^{-1} of N, P, K, S, Zn, and B was used, provided in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc, and boric acid, respectively. Following land preparation, the full doses of P, K, S, Zn, B, and two-thirds of the N were thoroughly incorporated into the soil as a basal application. The remaining nitrogen was applied 22 days after seedling emergence. Seeds of the BARI Gom 33

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variety were sown on November 25, 2020, in rows spaced 20 cm apart within the experimental plots, at a seeding rate of 140 kg ha^{-1}. A light irrigation was applied after sowing to ensure uniform germination. For the first 15 days, precautions were taken to protect the seedlings from birds. The crop was maintained weed-free, and to control diseases, Tilt 250 EC was sprayed as needed to prevent stripe rust.

Data collection

Plant height

Plant height was measured in centimeters (cm) at 30, 50, 70, and 90 days after sowing (DAS). The data were collected as the average height of five randomly selected plants from the inner rows of each plot, which were tagged in advance. Measurements were taken from the ground level to the tip of the plant using a meter scale.

Number of leaves plant^{-1}

The number of leaves per plant was recorded at 30, 50, 70, and 90 days after sowing (DAS). Data were collected by counting the leaves of five randomly selected tagged plants from each plot, and the mean value was calculated.

Number of tillers plant^{-1}

The number of tillers per hill was recorded at 30, 50, 70, and 90 days after sowing (DAS). Data were obtained by counting the tillers on each plant and calculating the average from five randomly selected plants in the inner rows of each plot.

Total dry matter m^{-2}

Plant samples from five hills per square meter of each unit plot were collected and gently washed with tap water, then dried with paper towels. Fresh weight was recorded immediately after drying. Subsequently, the samples were oven-dried at 70°C for 72 hours. Once dried, the samples were placed in a desiccator to cool to room temperature, after which the dry weight was measured and expressed in grams. Dry matter content per plant was recorded at 30, 50, 70, and 90 days after sowing (DAS), and the data were converted to g m^{-2} using a calculator.

Days required to crown root initiation stage

Days required to attain crown root initiation from sowing were recorded through looking at the number of days required to attain crown root initiation from sowing seeds by acute inspection of the research plots at the time of research period.

Days required to booting stage

The number of days from seed placement to the onset of booting was recorded through careful monitoring of the research plots throughout the study period.

Days required from sowing to flowering

The number of days from sowing to the onset of flowering was recorded by calculating the duration from sowing to flowering, based on careful observation of the experimental plots throughout the study period.

Days required from sowing to maturity

Days required from sowing to starting of maturity were recorded by calculating the number of days from sowing to starting of maturity as spikes become brown color by keen observation of the experimental plot.

Weight of 1000-grain (g)

A thousand clean, sun-dried grains were randomly counted from each plot and weighed using an electronic balance, with the weight expressed in grams.

Grain yield (t ha^{-1})

Grains harvested from a 1 m^2 area in each unit plot were sun-dried and carefully weighed. The dry weight of grains from the central 1 m^2 area was used to determine the grain yield per square meter, which was then converted to tons per hectare (t ha^{-1}).

Straw yield (t ha^{-1})

Straw harvested from a 1 m^2 area in each unit plot was sun-dried and weighed carefully. The dry weight of straw from the central 1 m^2 area was used to determine the straw yield per square meter, which was then converted to tons per hectare (t ha^{-1}).

Statistical analysis

The data were analyzed by partitioning the total variance using the MSTATC software. Treatment means were compared employing Duncan's Multiple Range Test (DMRT) at a significance level of $P \leq 0.05$.

RESULTS AND DISCUSSION

Plant height

This study examines the impact of various irrigation treatments on the plant height of wheat at different growth stages: 30, 50, 70, and 90 days after sowing (DAS). Results indicate that irrigation significantly influences plant height across all measured time points. At 30 days after sowing (DAS), the tallest plants, measuring 34.90 cm, were recorded in T6 (two irrigations at the booting and milk dough stages), whereas the shortest plants, measuring 28.77 cm, were found in T0 (no irrigation).This trend continued at

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50 DAS, with T_6 reaching 60.57 cm. At 70 DAS, T_6 plants measured 77.03 cm, and by 90 DAS, they peaked at 83.77 cm (Fig. 2). Overall, T_6 consistently produced the tallest plants, demonstrating the critical role of targeted irrigation in enhancing wheat growth, especially compared to treatments with limited or no irrigation. Similar study was also obtained by (Islam, 1997) who reported that plant height increased with increasing number of irrigations (Fig. 2).

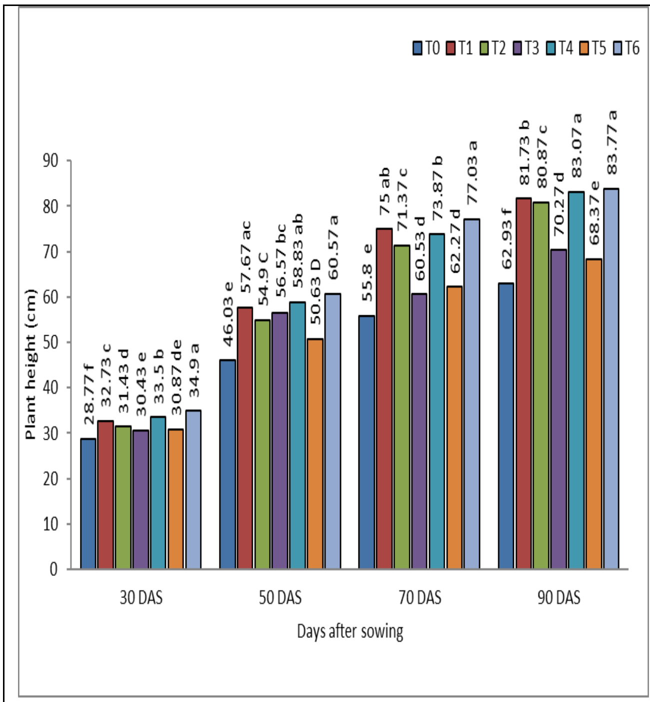

Fig.2. Effect of irrigation on plant height at different days after sowing

Number of leaves per plant

The results demonstrate that various irrigation treatments significantly influenced the number of leaves per wheat plant at different growth stages (30, 50, 70, and 90 DAS). At 30 DAS, the highest leaf count of 8.73 leaves was recorded in T6 (two irrigations at the booting and milk dough stages), which was statistically comparable to T4. In contrast, T0 (no irrigation) produced the lowest leaf count of 6.33, highlighting the crucial role of irrigation in early leaf development. By 50 DAS, T_4 showed the highest leaf number (14.03), followed closely by T_6. This highlights that timely irrigation during critical growth phases, such as maximum tillering and heading, significantly enhances leaf proliferation (Fig. 3). Additionally, T0 exhibited the lowest leaf count of 10.37, further confirming the negative impact of inadequate water supply. At 70 days after sowing (DAS), T6 recorded the highest leaf count of 16.23, which was statistically comparable to T4, T3, T1, and T2. The trend continued with T_4 at 90 DAS, yielding the highest leaf count (17.70), while T_0 remained the lowest (11.37). Overall, the data demonstrate that the number of leaves increases with both time and irrigation application, particularly with treatments involving two irrigations. These findings are consistent with previous studies, such as those by Alsohaibani (2007), which emphasize the positive correlation between irrigation and leaf growth in wheat. Proper irrigation strategies can therefore play a crucial role in maximizing wheat productivity by enhancing leaf development (Fig. 3).

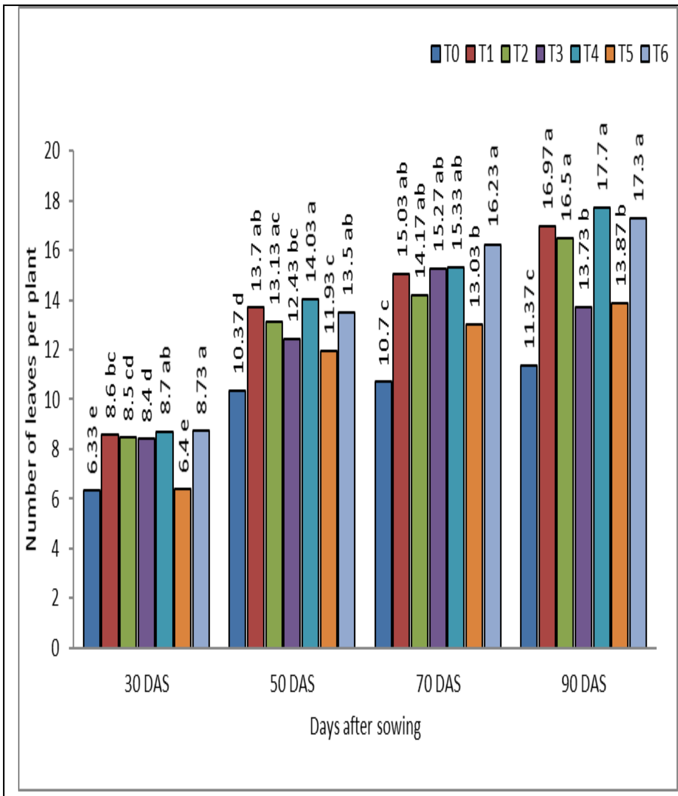

Fig.3. Effect of irrigation on the number of leaves per plant on different days after sowing

Number of tillers per hill

The number of tillers per hill exhibited significant variation among the different irrigation treatments at 30, 70, and 90 days after sowing (DAS). At 30 DAS, T6 (two irrigations at the booting and milk dough stages) yielded the highest tiller count of 2.00, whereas T0 (no irrigation) recorded the lowest count of 1.00. By 70 DAS, T_6 maintained its advantage with 5.33 tillers, and at 90 DAS, T_4 reached the peak with 7.00 tillers. The trend indicates that irrigation positively influences tiller development, enhancing moisture and nutrient availability. These findings align with Ali and Amin (2007), who noted that effective tillering is significantly enhanced by timely irrigation. Overall, appropriate irrigation practices are crucial for maximizing wheat yield potential through improved tiller production (Fig. 4).

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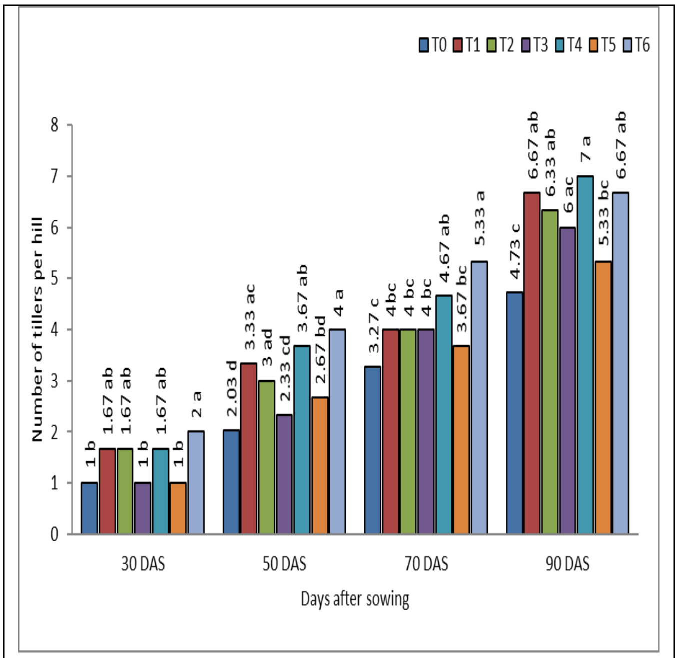

Fig.4. Effect of irrigation on number of tillers per hill at different days after sowing

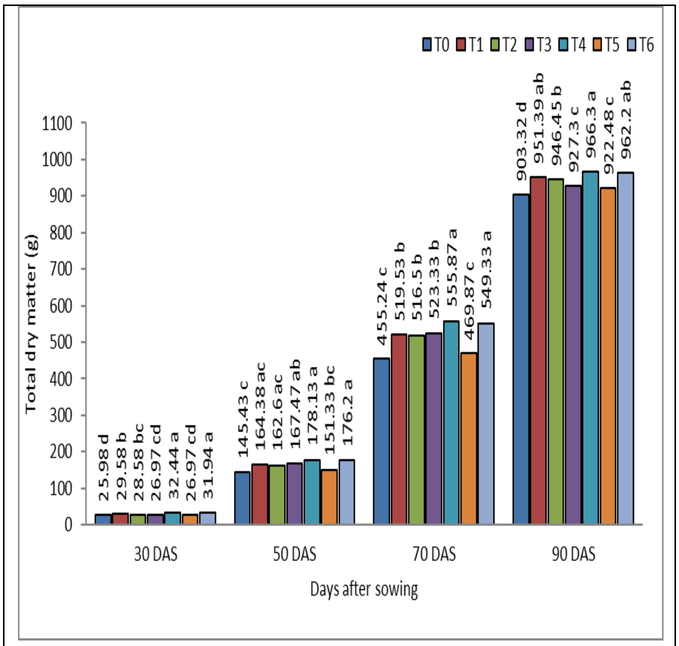

Fig.5. Effect of irrigation on total dry matter per square meter on different days after sowing

Total dry matter

The total dry matter per square meter exhibited significant differences across various irrigation treatments at 30, 50, 70, and 90 DAS. At 30 DAS, the highest total dry matter (32.44 g) was recorded in T_4 (two irrigations at maximum tillering and heading stages), closely followed by T_6. In contrast, T_0 (no irrigation) produced the lowest dry matter (25.98 g), highlighting the critical role of irrigation in early plant development. By 50 DAS, T_4 continued to show superior performance with 178.13 g of total dry matter, maintaining a statistically similar output to T_6 and other irrigated treatments. The lowest recorded dry matter remained in T_0 at 145.43 g, reinforcing the negative impact of inadequate irrigation on biomass accumulation. At 70 DAS, T_4 peaked at 555.87 g, with T_6 again showing comparable results, while T_0 fell behind at 455.24 g. By 90 DAS, the trend persisted, with T_4 achieving the highest total dry matter (966.30 g), statistically similar to T_6 and T_1. The consistent superiority of T_4 across all stages underscores the importance of timely irrigation in optimizing plant growth and biomass accumulation. Overall, these results emphasize that effective irrigation not only enhances dry matter production but also contributes significantly to the overall yield potential of wheat. Adequate water management strategies are essential for maximizing crop performance and ensuring food security (Fig.5).

Effect of irrigation on phenological characteristics of wheat

Table 1. Impact of Irrigation on the Phenological Stages of Wheat

Treatments	Days to crown root initiation	Days to Booting	Days to anthesis	Days to physiological maturity
T_0	26.33 c	41.28 g	60.67 c	94.33 e
T_1	27.67 b	50.65 c	66.00 ab	103.00 b
T_2	27.00 bc	43.28 f	64.27 b	103.67 b
T_3	25.33 d	48.66 d	64.47 b	102.00 c
T_4	28.33 a	53.47 a	67.73 a	105.33 a
T_5	25.33 d	45.28 e	64.13 b	101.00 d
T_6	26.33 c	51.47 b	67.60 a	104.67 a
Level of significance	**	**	**	**
CV (%)	11.12	9.78	13.31	12.65

When comparing treatment means using Duncan's Multiple Range Test (DMRT) at a significance level of $P \leq 0.05$, it allows you to identify which means are significantly different from each other after an ANOVA test.

Table 1 displays the effects of different irrigation treatments on the phenological characteristics of wheat, specifically focusing on days to crown root initiation,

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booting, anthesis, and physiological maturity. Significant differences were observed across treatments, indicating that irrigation practices play a crucial role in the timing of key developmental stages. The data shows that T_4 (two irrigations at critical growth stages) resulted in the longest duration for days to crown root initiation (28.33 days) and booting (53.47 days), suggesting that adequate water availability positively influences early root and shoot development. In contrast, T_0 (no irrigation) exhibited the shortest durations for both crown root initiation (26.33 days) and booting (41.28 days), highlighting the negative impact of water stress on these early phenological phases. According to (Ahmed and Jamil,2016) the study highlights how different irrigation regimes significantly affect the phenological stages of wheat, including sowing to flowering duration, which in turn influences overall yield.

Table.2 Effect of irrigation on TGW, GY& SY of Wheat

Treatments	Thousand grain weight	% increase over T_0	Grain yield (t/ha)	% increase over T_0	Straw yield (t/ha)	% increase over T_0
T_0	31.73 d		3.74 c		4.72 f	
T_1	40.17 ab	26.60	4.93 b	31.82	7.43 b	57.42
T_2	39.07 b	23.13	4.89 b	30.75	6.24 d	32.20
T_3	39.32 b	23.92	4.84 b	29.41	6.61 c	40.04
T_4	40.60 a	27.95	5.20 a	39.04	7.75 a	64.19
T_5	35.97 c	13.36	4.79 bc	28.07	5.84 e	23.73
T_6	40.25 a	26.85	5.09 ab	36.10	7.69 a	62.92
LSD	**		**		**	
CV (%)	6.12		11.32		13.22	

Effect of irrigation on thousand grain weight, grain yield and straw yield of wheat

Table 2 illustrates the impact of various irrigation treatments on thousand grain weight, grain yield, and straw yield of wheat. The results indicate significant differences among treatments, highlighting the importance of irrigation in enhancing wheat productivity. The highest thousand grain weight was recorded in T_4 (40.60 g), which is statistically superior to T_0 (31.73 g). This reflects a 27.95% increase, suggesting that proper irrigation positively influences grain development and quality. The increase in thousand grain weight observed in treatments T_4 and T_6, which achieved values of 40.60 g and 40.25 g respectively, is consistent with findings by Daryanto et al. (2016), who noted that improved irrigation practices lead to enhanced grain weight due to better moisture availability during critical growth stages. Similar trends were observed in grain yield, where T_4 achieved the highest yield (5.20 t/ha), marking a 39.04% increase over T_0. This indicates that effective water management significantly boosts overall productivity. The significant increase in grain yield, especially in treatment T_4 (5.20 t/ha), aligns with the work of Sial et al. (2019), who reported that appropriate irrigation management can increase wheat yields substantially by optimizing water supply during flowering and grain filling periods. This is critical, as the grain yield is heavily influenced by both genetic and environmental factors, including soil moisture (Pang et al., 2019). The results of this study emphasize that proper irrigation not only boosts yield but also ensures that plants reach their genetic potential. Straw yield also varied considerably, with T_4 yielding 7.75 t/ha, representing a 64.19% increase compared to T_0. The enhanced straw yield may contribute to improved soil health and organic matter return, further benefiting future crop cycles. This finding is corroborated by the research of Ali et al. (2020), who noted that irrigation positively influences biomass accumulation, which in turn supports better soil health and nutrient cycling. Other treatments like T_1 and T_6 also showed notable increases in grain and straw yields, reinforcing the benefits of timely irrigation (Table 2). The coefficients of variation (CV) suggest moderate variability, indicating consistent treatment effects across the trials. Overall, these findings indicate that strategic irrigation significantly improves key yield parameters in wheat, emphasizing its essential role in optimizing crop performance and sustainability. This aligns with Ngwako and Mashiqa (2013), who found that consistent irrigation positively affects grain yield, and Mubeen et al. (2013), who reported that targeted irrigation during critical growth phases enhances wheat yields. These studies reinforce the importance of strategic water management in maximizing crop productivity, highlighting that optimal irrigation practices are essential for achieving better grain development and overall yield in wheat cultivation. The results of the current study align with those of Qi Wang et al. (2012), who noted a significant effect of irrigation on straw yield. Furthermore, Zeidan et al. (2009) found that irrigating wheat at different growth stages results in variations in both grain and straw yields. These studies collectively underscore the crucial role of irrigation in enhancing not only grain production but also straw yield, emphasizing its importance in achieving overall crop performance and sustainability in wheat cultivation.

CONCLUSION

The application of various irrigation treatments, such as: T_0 (no irrigation), T_1 (one irrigation at maximum tillering), T_2 (one irrigation at booting), T_3 (one irrigation at heading), T_4 (two irrigations at maximum tillering and heading), T_5

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(milking dough), and T_6 (two irrigations at booting and milking dough) significantly enhances growth parameters, yield components, and grain yields of wheat compared to the control (no irrigation). Among the treatments, T4, which involved two irrigations during the maximum tillering and heading stages, was found to be the most effective. It was closely followed by T_6, which involved irrigations at the booting and milk dough stages. These findings highlight the critical role of strategic irrigation in optimizing wheat cultivation and maximizing yield potential.

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Conflict of Interest

The authors declare no conflicts of interest.

REFERENCE

Ahmed, F., & Jamil, M. (2016). Impact of irrigation regimes on phenology and yield of wheat. *Agricultural Water Management*, 168, 1–10.

Ahmed, M. (2006). Maximizing yield of wheat under sufficient water using nitrogen fertilizer dose splitting. *Australian Journal of Science*, 26(2), 113–125.

Ali, M. A., & Amin, S. (2007). Effect of irrigation frequencies on yield and yield attributes of wheat cultivar (Triticum aestivum) 'Shatabdi'. *Journal of Food Technology*, 2(3), 145–147. Medwell Online.

Alsohaibani, A. (2007). The effects of irrigation on leaf growth and yield of wheat. *Journal of Agricultural Science*, 5(3), 123–130.

Bangladesh Agricultural Research Institute (BARI). (2006). *Annual report for 2005*. Joydebpur, Gazipur, Bangladesh.

Bangladesh Bureau of Statistics (BBS). (2019). *Statistical pocket book of Bangladesh*. Bureau of Statistics, Statistical Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Food and Agriculture Organization (FAO). (2014). *Statistics yearbook*. Rome, Italy.

Islam, M. M. (1997). Effect of irrigation on different growth stages of wheat cultivation. *Bangladesh Journal of Trends and Developments*, 6(1), 41–44.

Islam, S. T., Haque, M. Z., Hasan, M. M., Khan, A. B. M. M. M., & Shanta, U. K. (2018). Effect of different irrigation levels on the performance of wheat. *Progressive Agriculture*, 29(2), 99–106.

Khajanji, S. N., & Swivedi, R. K. (2007). Response of wheat (Triticum aestivum) to irrigation and fertilizer mixture under late condition. *Bhartiya Krishi Anisandhan Patrika*, 3(1), 37–42.

Mubeen, M., Ahmad, A., Wajid, A., Khaliq, T., Sultana, S. R., Hussain, S., Ali, A., Ali, H., & Nasim, W. (2013). Effect of growth stage-based irrigation schedules on biomass accumulation and resource use efficiency of wheat cultivars. *American Journal of Plant Sciences*, 4, 1435–1442.

Ngwako, S., & Mashiqa, P. K. (2013). The effect of irrigation on the growth and yield of winter wheat (Triticum aestivum L.) cultivars. *International Journal of Agricultural Crop Sciences*, 5(9), 976–982.

Randhawa, A. S., Jolly, R. S., & Arora, B. S. (2004). The effect of sowing time and rates and time of nitrogen application on dwarf wheat. *Journal of Research Punjab Agricultural University*, 13(2), 130–135.

Rosegrant, M. W., & Agcaoili, M. (2010). *Global food demand, supply, and price prospects to 2010*. Washington, DC: International Food Policy Research Institute.

Roy, K. C., & Pandit, D. B. (2007). Paper presented at Wheat Research Center (WRC), BARI, Nashipur, Dinajpur.

Sarker, R., Yeasmin, M., Rahman, M. A., & Islam, M. A. (2018). People’s perception and awareness on air pollution in rural and urban areas of Mymensingh Sadar upazila. *Progressive Agriculture*, 29(1), 22–32.

Singh, B., & Singh, C. P. (2005). Effect of nitrogen application in wheat in north hill condition. *Indian Journal of Agronomy*, 36(3), 326–328.

Uddin, N., Islam, M. A., & Baten, M. A. (2016). Heavy metal determination of brinjal cultivated in soil with wastes. *Progressive Agriculture*, 27(4), 453–465.

Wang, Q., Li, F., Enhe, Z., Guan, L., & Maureen, V. (2012). The effects of irrigation and nitrogen application rates on yield of spring wheat (Longfu-920), and water use efficiency and nitrate nitrogen accumulation in soil. *American Journal of Crop Science*, 6(4), 662–672.

Zeidan, E. M., Abd El-Hameed, I. M., Bassiouny, A. H., & Waly, A. A. (2009). Effect of irrigation intervals, nitrogen and organic fertilization on yield, yield attributes, and crude protein content of some wheat cultivars under newly reclaimed saline soil conditions. In *4th Conference on Recent Technologies in Agriculture* (No. 33).

Ali, S., Khan, M. S., & Yaseen, M. (2020). Effect of Irrigation Frequency on Wheat Biomass Production and Soil Nutrient Availability. *Journal of Agronomy*, 12(4), 123-130.

Daryanto, S., Wang, L., & Jacinthe, P. A. (2016). Global synthesis of drought effects on wheat and maize production. *PLOS ONE*, 11(2), e0152741.

Pang, J., Zhang, Y., & Li, X. (2019). Impact of Irrigation on Wheat Yield and Quality: A Review. *Frontiers in Plant Science*, 10, 947.

Sial, A. A., Majeed, A., & Iqbal, M. (2019). Irrigation Management for Sustainable Wheat Production: A Review. *International Journal of Agronomy*, 2019, 1-10.

DOI: https://doi.org/10.55706/jae1719