

Effect of Irrigation Levels on Growth, Yield Attributes and Yield of Wheat

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Abstract

The experiment was conducted during November 2012 to March 2013 in experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out the consequence of irrigation levels on growth, yield attributes and yield of wheat (BARI Gom-26). Four different irrigation levels viz. I_0 : No irrigation i.e. control; I_1 : Irrigation at 20 days after sowing (DAS) at crown root initiation stage; I_2 : Irrigation at 55 DAS at flowering stage) and I_3 : Irrigation at 75 DAS at grain filling stage were used in the experiment using Randomized Complete Block Design with three replications. Results revealed that maximum dry matter content (18.8 g/plant), crop growth rate (CGR) ($13.5 \text{ g m}^{-2}\text{day}^{-1}$), relative growth rate (RGR) ($0.024 \text{ g m}^{-2}\text{day}^{-1}$) were found from I_1 which was statistically identical with I_2 whereas minimum from I_0 . Plant height (80.7 cm), number of tiller (4.9/hill), number of spike (4.7/hill), number of spikelets (18.5/spike), spike length (19.2 cm), filled grains (29.3/spike), total grains (31.3/spike), 1000-grains weight (44.4 g), yield (grain 3.4 t/ha, straw 5.7 t/ha and biological 9.1 t/ha) and harvest index were correspondingly showed higher results as of growth characters.

Key words: Wheat, irrigation levels, growth and yield

I. Introduction

In the environmental condition of Bangladesh wheat (*Triticum aestivum* L.) is a well adapted cereal crop for its vegetative growth and development. The popularity of wheat as staple food is increasing day by day in our country and wheat cultivation has been increased manifold to meet up the food shortage in the country. However, the yield of the crop in the context of our country is low (2.2 t ha^{-1}) in comparison to other countries of the world (FAO, 1997). The area, production and yield of wheat have been increasing dramatically based on the demand of over increasing population of Bangladesh during the last two decades, but its present yield is too low in comparison to some developed countries like Japan, France, Germany and UK producing 3.76, 7.12, 7.28, and 8.00 t ha^{-1} , respectively (FAO, 2000). At present about 706.33 thousand hectares of land in Bangladesh is covered by wheat with the annual production of 1,592 thousand tons (BBS, 2011). Irrigation plays a vital role in terms of bringing good growth and development of wheat. Insufficient soil moisture affects both the germination of seed and uptake of nutrients from the soil. Irrigation frequency also has a significant influence on growth and yield of wheat (Khajani and Swivedi, 1988). But in Bangladesh most of the farmers are not in a position to provide irrigation in different critical stages of wheat production because of the inadequate facility of irrigation devices and irrigation sources. These suggest that irrigation water should be supplied precisely at the peak period of crop growth, which may provide good yield of wheat. Shoot dry weight, number of grains, grain yield, biological yield and harvest

index decreased to a greater extent when water stress was imposed at the anthesis stage while imposition of water stress at booting stage caused a greater reduction in plant height and number of tillers (Gupta *et al.*, 2001). The lowest value corresponded to the treatment with irrigation during grain filling and under rainfed conditions (Bazza *et al.*, 1999). From a survey Ahmed and Elias (1986) reported that in Bangladesh, lack of irrigation facilities was found to be a major constraint for 38% wheat growers, and 25% of the farmers of Bangladesh could not grow wheat due to this problem. Information on the precise time of irrigation of wheat is inadequate in Bangladesh. Considering above circumstances the current study was undertaken to determine the effect of irrigation levels/times on growth, yield attributes and yield of wheat.

II. Materials and Method

This experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2012 to March 2013. Four different irrigation levels viz. I₀: No irrigation i.e. control; I₁: Irrigation at 20 DAS (Crown root initiation stage); I₂: Irrigation at 55 DAS (Flowering stage) and I₃: Irrigation at 75 DAS (Grain filling stage) was considered as three treatments following Randomized Complete Block Design with three replications. BARI Gom-26 was used as experimental material. Seeds were sown continuous with maintaining 20 cm line to line distance and plant to plant 5 cm. Cowdung was applied 10 t/ha and fertilizers N, P, K and S were applied in the form of Urea (220 kg ha⁻¹), TSP (180 kg ha⁻¹), MoP (50 kg ha⁻¹) and Gypsum (120 kg ha⁻¹) respectively. The entire amount of TSP, MoP and Gypsum, 2/3rd of Urea were applied during the final preparation of land. Rest of Urea was top dressed after first irrigation (BARI, 2006).

Data were collected on plant height, number of tillers, dry matter content, Crop Growth Rate (CGR), Relative Growth Rate (RGR), days required from sowing to flowering, days required from sowing to maturity, number of spikes, number of spikelets, spike length, number of filled grains, number of unfilled grains, number of total grains, weight of 1000-grains, grain yield, straw yield, biological yield and harvest index.

Data from five sample plants from each plot were collected and gently washed with tap water, thereafter soaked with paper towel. Fresh weight was taken immediately after soaking by paper towel. After taking fresh weight, the samples were oven dried at 70°C for 72 hours. These oven-dried samples were transferred into a desiccator and allowed to cool down to room temperature. Finally, dry weight was taken and expressed in grams.

Using the data on the leaf area and dry matter from each specific treatment, the following growth parameters were derived with the following mentioned calculation (Hunt, 1978).

- $CGR = [(1 \div GA) \times \{(W_2 - W_1) \div (T_2 - T_1)\}] \text{ g m}^{-2} \text{ day}^{-1}$

Where, GA = Ground area (m²), W₁ = Total dry weight at previous sampling date (T₁), W₂ = Total dry weight at current sampling date (T₂), T₁ = Date of previous sampling and T₂ = Date of current sampling

- $RGR = \{(\text{Ln}W_2 - \text{Ln}W_1) \div (T_2 - T_1)\} \text{ g g}^{-1} \text{ day}^{-1}$

Where, W₁ = Total dry weight at previous sampling date (time T₁), W₂ = Total dry weight at current sampling date (time T₂), T₁ = Date of previous sampling, T₂ = Date of current sampling, Ln = Natural logarithm

Grains and straw obtained from 1 m² from each unit plot were sun-dried and weighed carefully. Dry weight of central 1 m² area used to record grain yield m⁻² and converted this into t ha⁻¹.

Biological yield was calculated with the following formula

$$\text{Biological yield} = \text{Grain yield} + \text{Straw yield}$$

Harvest Index was calculated using the following formula-

$$\text{HI (\%)} = \left[\frac{\text{Economic yield (grain weight)}}{\text{Biological yield (Total dry weight)}} \right] \times 100$$

Collected data were statistically analyzed using MSTAT-C computer package program. Mean were calculated and significance of difference among treatment means was estimated by Duncan Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

III. Results and Discussion

Statistically significant variation for plant height of wheat at different days after sowing (DAS) and at harvest was due to different irrigation levels. Tallest plant was found in I₁ (80.7 cm) while shortest in I₀ (68.4 cm) at harvest (Figure 1a). This result is in good agreement with the result of Islam (1997) who reported that plant height increased with increasing number of irrigations. Number of tillers of wheat showed major variation at different DAS due to different irrigation levels. Maximum number of tillers was found in I₁ (4.9 hill⁻¹) which was statistically identical with I₂ (4.6 hill⁻¹) and I₃ (4.5 hill⁻¹) minimum in I₀ (3.9 hill⁻¹) at harvest (Figure 1b). Application of two irrigations at crown root initiation stage and pre flowering stage ensured the optimum vegetative growth of the wheat with highest number of tillers hill⁻¹ as referred by Meena et al, (1998). Gupta et al. (2001) reported that when water stress was imposed at the booting stage caused a greater reduction in number of tillers. Significant difference for dry matter content of wheat was found at diverse DAS due to different irrigation levels. Maximum dry matter content was found in I₁ (18.8 g plant⁻¹) which was statistically similar with I₂ (18.4 g plant⁻¹) and I₃ (17.9 g plant⁻¹) while minimum in I₀ (15.8 g plant⁻¹) at harvest (Figure 1c).

Crop Growth Rate (CGR) of wheat was not varied significantly among the different irrigation levels at different DAS. Maximum CGR was found in I₁ (13.5 gm²day⁻¹) which was statistically identical with I₃ (13.0 gm²day⁻¹) followed by I₂ (12.8 gm²day⁻¹) and I₃ (9.9 gm²day⁻¹) at 65-85 DAS (Figure 2a). Similarly Relative Growth Rate (RGR) of wheat was also not varied meaningfully among the different irrigation levels at different DAS. Maximum RGR was found in I₁ (0.024 gm²day⁻¹) followed by I₂ and I₃ (0.021 gm²day⁻¹) while minimum in I₀ (0.019 gm²day⁻¹) at 65-85 DAS (Figure 2a).

Early flowering was found in I₁ (65.6 days) whereas late in I₀ (70.7 days) which was statistically undistinguishable with I₃ (68.9 days) (Table 1). Early maturity was found in I₁ (115.3 days) while late in I₀ (121.6 days) which was statistically identical with I₂ and I₃ (Table 1). Maximum number of spikes was found in I₁ (4.7 hill⁻¹) which was statistically similar with I₂ and I₃ (4.2 hill⁻¹) while minimum was recorded from I₀ (3.7 hill⁻¹) (Table 1). Maximum number of spikelets was found in I₁ (18.5 spike⁻¹) which was statistically similar with I₂ (17.4 spike⁻¹) and I₃ (17.0 spike⁻¹) whereas minimum in I₀ (14.4 spike⁻¹) (Table 1). Longest spike was found in I₁ (19.2 cm) which was statistically identical with I₂ (18.7 cm) and I₃ (18.6 cm) while shortest in I₀ (16.9 cm) (Table 1). Naser (1996) reported that the highest number of grains per spike were recorded when two irrigations were applied.

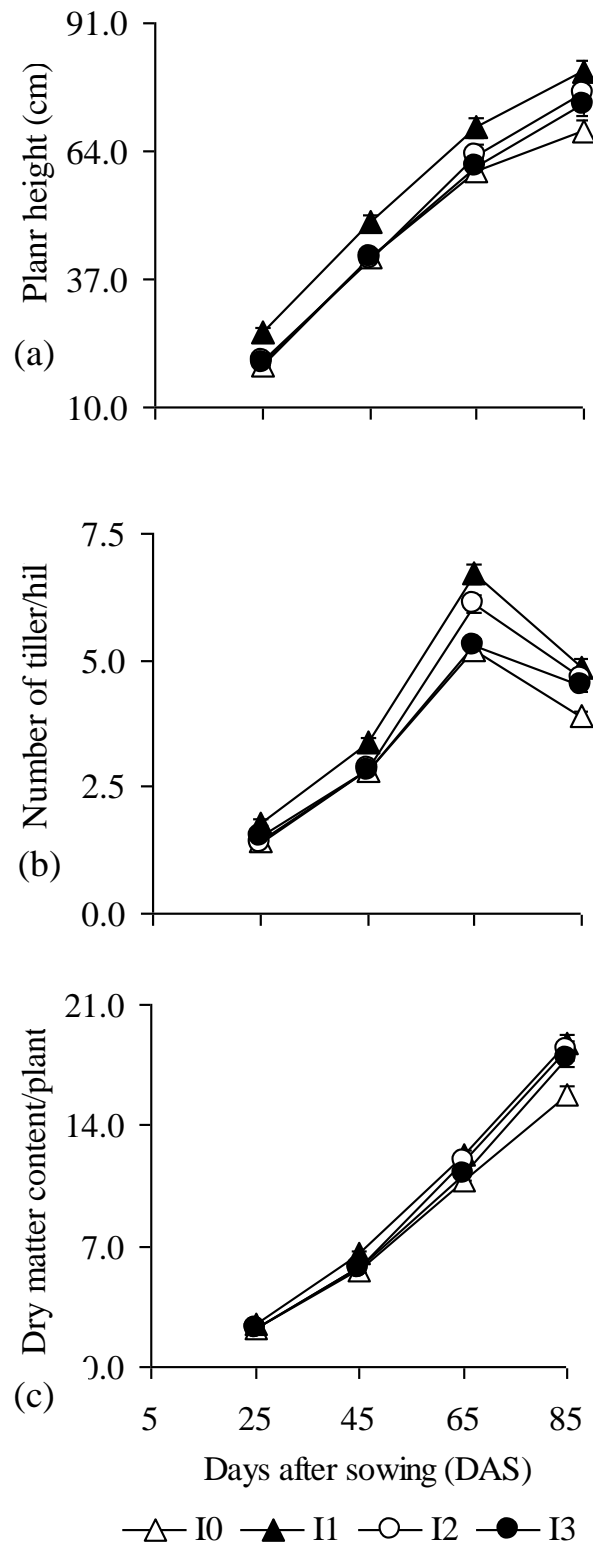


Figure 1. Effect of different irrigation level (I₀, I₁, I₂, I₃) on (a) plant height, (b) number of tillers and (c) dry matter content of wheat

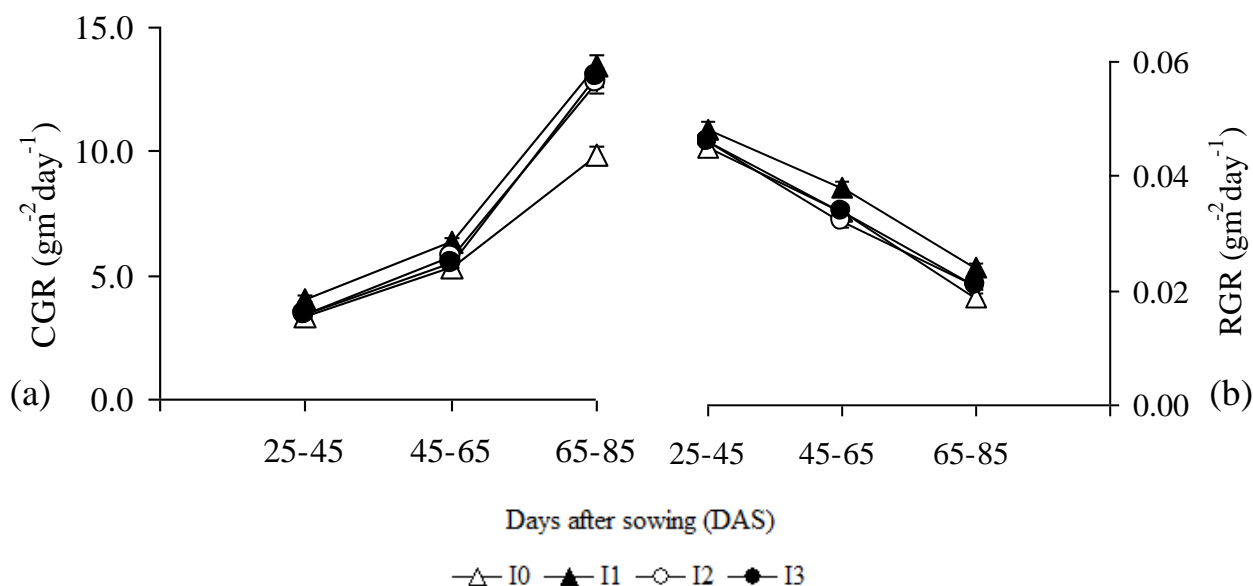


Figure 2. Effect of irrigation levels on (a) CGR and (b) RGR to wheat

Table 1. Effect of seed irrigation levels on duration and spike related characters

Treatment	Days required from sowing to		Number of				Spike length (cm)
	flowering	maturity	Spikes hill ⁻¹		Spikelets spike ⁻¹		
I ₀	70.7 a	121.6 a	3.7 B	14.4 B	16.9 b		
I ₁	65.6 c	115.3 b	4.7 A	18.5 A	19.2 a		
I ₂	68.4 b	118.9 ab	4.2 A	17.4 A	18.7 a		
I ₃	69.4 ab	118.2 ab	4.2 A	17.0 A	18.6 a		
LSD 0.05	1.3	3.7	0.7	1.9	1.2		
CV (%)	5.8	4.8	4.7	8.5	5.4		

* In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Maximum number of filled grains was found in I₁ (29.3 spike⁻¹) which was statistically identical with I₂ (27.6 spike⁻¹) while minimum in I₀ (23.2 spike⁻¹) (Table 2). Gupta *et al.* (2001) reported that number of grains decreased to a greater extent when water stress was imposed at the anthesis stage. Minimum unfilled grains was recorded from I₁ (2.0 spike⁻¹) while maximum unfilled grains from I₀ (3.6 spike⁻¹) (Table 2). Different sowing date showed significant variation in number of grains. Maximum number of total grains was found in I₁ (31.3 spike⁻¹) which was statistically identical with I₂ (30.6 spike⁻¹) and I₃ (29.6 spike⁻¹) while minimum in I₀ (26.8 spike⁻¹) (Table 2). However, Islam (1996) observed that irrigation had no influence of grains per spike. Maximum 1000 grains weight of wheat was recorded from I₁ (44.4 g) followed by I₂ (42.1 g) and I₃ (41.5 g) while minimum from I₀ (39.0 g) (Table 2). Islam (1996) observed that irrigation had no influence of 1000-grains weight. Grain yield of wheat showed significant variation due to different sowing date. Maximum grain yield was recorded from I₁ (3.4 tha⁻¹) which was statistically identical with I₃ (3.3 tha⁻¹) and I₂ (3.2 tha⁻¹) while minimum from I₀ (2.6 tha⁻¹) (Table 2). Bazza *et al.* (1999) reported that one water application during the tillering stage allowed the yield to be lower only than that of the treatment with three irrigations However, Meena *et al.* (1998) reported that wheat grain yield was the highest with 2 irrigations (2.57 tha⁻¹ in 1993 and 2.64 tha⁻¹) at flowering and/or crown root initiation stages. Generally wheat sown in November to ensure optimal crop growth and avoid high temperature and after that if wheat sown in the field it faces high range of temperature for its growth and development as well as yield potential. Islam *et al.* (1993) reported that late planted wheat plants faced a period of high temperature stress during reproductive stages causing reduced kernel number spike⁻¹ as well as the reduction of seed yield.

Table 2. Effect of irrigation levels on yield related characters and yield of wheat

Treatment	Grains spike ⁻¹			Weight of 1000 grains (g)	yield (t ha ⁻¹)			Harvest index (%)
	filled	unfilled	total		grain	straw	biological	
I ₀	23.2 c	3.6 a	26.8 b	39.0 b	2.6 b	5.0 b	7.6 c	34.3 b
I ₁	29.3 a	2.0 d	31.3 a	44.4 a	3.4 a	5.7 a	9.1 a	37.7 a
I ₂	27.6 ab	2.9 b	30.6 a	42.1 ab	3.2 a	5.4 a	8.7 b	37.2 a
I ₃	26.9 b	2.6 c	29.6 a	41.5 ab	3.3 a	5.5 a	8.7 b	37.3 a
LSD0.05	2.5	0.2	1.9	3.1	0.5	0.3	0.4	1.3
CV (%)	7.2	7.6	6.8	4.8	6.8	6.2	4.8	5.9

* In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

I₁ showed maximum straw yield (5.7 t ha⁻¹) which was statistically similar with I₂ (5.4 t ha⁻¹) and I₃ (5.5 t ha⁻¹) while minimum from I₀ (5.0 t ha⁻¹) (Table 2). Maximum biological yield was found in I₁ (9.1 t ha⁻¹) which was statistically identical with I₂ and I₃ (8.7 t ha⁻¹) while minimum recorded from I₀ (7.6 t ha⁻¹) (Table 2). Gupta *et al.* (2001) reported that biological yield decreased to a greater extent when water stress was imposed at the anthesis stage. There was significant variation for harvest index of wheat due to different irrigation levels. Numerically, maximum harvest index was found in I₁ (37.7%) which was statistically identical with I₂ (37.2%) and I₃ (37.3%) while minimum in I₀ (34.3%) (Table 2). Gupta *et al.* (2001) reported that harvest index decreased to a greater extent when water stress was imposed at the anthesis stage.

IV. Conclusion

It may be concluded that irrigation at root initiation and flowering state has greater impact on crop growth rate, relative growth rate and dry matter content of wheat. As such, growth characteristics, yield attributes and yield of wheat were related to irrigation levels as found in this experiment. When irrigation in wheat field is limited to once, then it should be given at crown root initiation stage to obtain better growth and development of wheat to achieve higher yield.

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