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Effect of irrigation frequency on growth and yield of wheat (*Triticum aestivum* L. var. Chonte 1) under Kabul agro-climatic conditions, Afghanistan

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ABSTRACT

A field experiment was conducted under Kabul agro-ecological conditions at the Agriculture faculty research farm and Botanical garden, Faculty of Agriculture, Kabul University to study the effects of different irrigation frequency on growth, yield and yield components of wheat (*Triticum aestivum* L.) during 2018-2019, wheat cultivar (Chonte 1) was grown with different irrigation intervals in every 5, 7, 9, 11 days. The experimental design was Randomized Complete Block Design (RCBD) with three replications. The parameters studied were plant height, dry matter, number of tillers per m^2, number of spikes per m^2, number of spikelets per spike, number of grains per spikelet and spike, 1000-grain weight, grain yield and spike length. The results showed that there were highly significant differences in the studied parameters due to irrigation intervals, where the irrigation in every seven days recorded higher values. Hence seven days' irrigation interval (T_2) treatment would be the most advantageous for finding better growth and higher yield in spring wheat production in the studied region and among the morphological and yield attributing characters. Through the treatment 4, the minimum values in the traits like grains per spike, shortest spike, the lowest weight of 1000-seed, the lowest yield of grain and dry matter content were obtained.

Key words: Growth, irrigation frequency, wheat variety Chonte 1, yield

INTRODUCTION

Wheat is one of the oldest and most vital of the cereal crops for the majority of world's population. In 2019, the world's main wheat-producing countries were China, India, Russian Federation, United States, France, Australia, Canada, Pakistan, Ukraine and Germany. According to the statistics of Food and Agriculture Organization (FAO, 2010), the cultivated land of wheat equals 217 million hectares, with production amounted to 653 million tons and about 44% of its production is in Asian countries. This staple crop is grown each year under irrigated and rainfed conditions. More than 85% of the population of Afghanistan is dependent on agriculture and related activities for livelihood. About 12% of the country's total land is arable, 3% is under forest cover, 46% under permanent pastures, and the remaining 39% is mountainous and habitable (Anonymous, 2019). Afghanistan's wheat production has ranged from 2.6 to 5.2 million tons during the last decade (FAO, 2016).

Agricultural production in Afghanistan is highly dependent on rain and snowfall. Approximately 45 per cent of Afghanistan's wheat area in a normal year is irrigated, while the remaining 55 per cent depends entirely on rainfall. The timing and quantity of the annual snowmelt is a key factor in determining the quantity and duration of water availability for irrigation throughout the cultivated areas of Afghanistan. The productivity of wheat differs significantly between irrigated and rain-fed areas (Asian Development Bank, 2003; Ahmad and Mahwash, 2004). 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 (Khajanij and Swivedi, 1988).

MATERIALS AND METHODS

This experiment was carried out at two locations, in the Agriculture faculty research farm and in the Botanical garden, Faculty of Agriculture, Kabul University during 2018-2019. The total area for each location was 48 m^2. The experiment was consisting of four treatments T_1 (Irrigation every 5 days), T_2 (Irrigation every 7 days), T_3 (Irrigation every 9 days) and T_4 (Irrigation every 11 days) and laid out in Randomized Complete Block Design (RCBD) with three replications. There were 12 plots for each location of the experimental area, having the size of each plot 2 m × 2 m. This area falls under the semi-arid climatic zone. The Faculty research farm is situated between 34° 31' 0.61" N latitude and 69° 08' 21.7" E longitude, whereas the Botanical Garden is lying between 34° 30' 44.5" N latitude and 69° 0.8' 08.8" E longitudes. The soil of the experimental area was sandy loam to clay loam and the pH range was 8-8.5. The elevation of the site ranges between 1791 to 1800 m above sea level and the depth of water table was 10 - 11 m from the soil surface.

The seed sown rate was 150 kg ha^{-1}, the plant to plant distance was 3 cm and row to row distance was 30 cm. Phosphorus (DAP) fertilizer was used at 175 kg ha^{-1} and the nitrogen (urea) fertilizer at the rate of 200 kg ha^{-1} was applied in three split doses (at times of sowing, tillering and heading stage). All the phosphorus fertilizer and one third of urea were applied in each plot at final land preparation and were mixed thoroughly with the soil. The rest two thirds of urea were top-dressed in two equal splits, one at the active tillering stage and the other at the heading stage.

RESULTS AND DISCUSSION

Generally, the results indicated that the growth and yield attributes of wheat variety Chonte 1 under different irrigation intervals were the highest when irrigation intervals were short. The statistical analysis data showed a significant effect on plant height due to different irrigation intervals in both the locations.

Plant height

The plant height in centimetre was compared between the treatments at the faculty farm and at the botanical garden that the treatment 1 produced the highest plant height and treatment 4 had the lowest plant height (Fig. 1; Table 1). This is in agreement with Moursi et al. (1979) in Egypt who reported that, the shorter the irrigation interval, leads to taller the plant. On the other hand, increased irrigation amount, irrespective of interval showed a highly significant difference in plant height. These results agreed with the studies of Thompson and Chase (1992), who reported that irrigation treatments significantly influenced plant height. Several investigations from different parts of the world reported that plant height increased with more frequent irrigation and decreased with less irrigation frequency (Elmonyeri et al., 1982). Haikle and Melegy (2005) reported that the positive effect of irrigation on plant height may be attributed to the effect of irrigation on the activities of cell elongation, cell division and consequently increased meristematic growth.

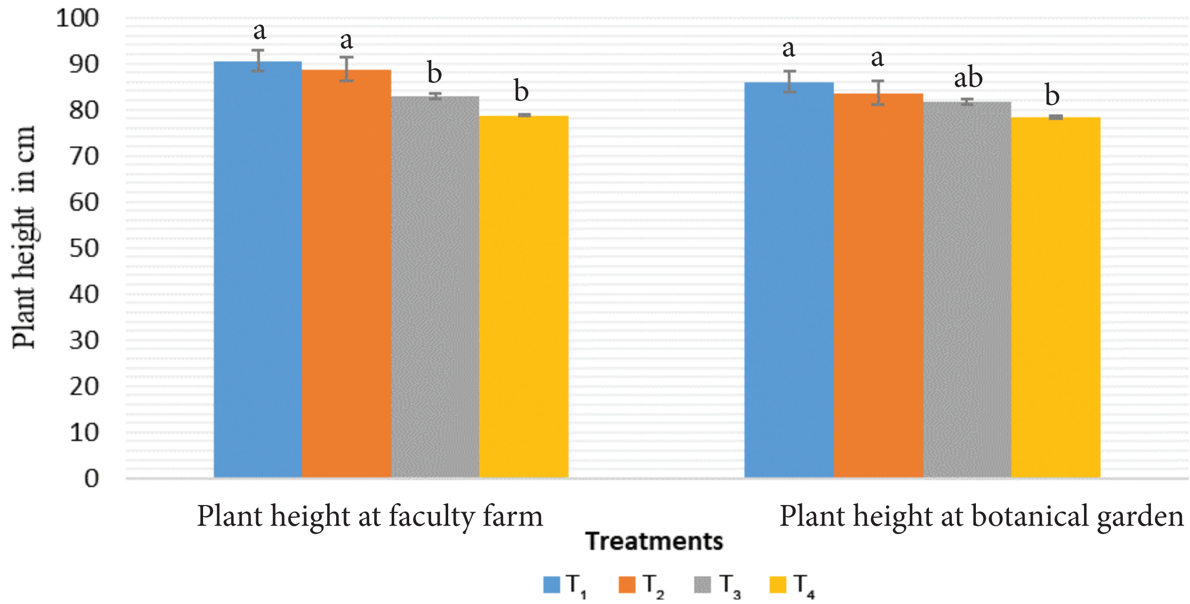

Fig. 1. Effect of different irrigation frequency on plant height (cm) of wheat at harvest time at faculty farm location and botanical garden

Table 1. Effect of irrigation frequency on plants height per cm and tillers per m^2 of wheat at faculty farm and botanical garden

Treatments	Faculty farm location		Botanical garden location	
	Plant height (cm)	No of tillers m^{-2}	Plant height (cm)	No of tillers m^{-2}
T_1	90.62_a	322.22_b	86.08_a	377.78_a
T_2	88.75_a	474.07_a	83.67_a	403.70_a
T_3	83.04_b	440.74_a	81.85_{ab}	392.59_a
T_4	78.75_b	311.48_b	78.38_b	268.81_b
CV (%)	3.02	5.84	2.61	12.20
SE	2.10	18.46	1.76	35.93
LSD	5.14	45.17	4.29	87.92

Means followed by the same letter in each column are not significantly different according to (LSD) test

T_1=irrigation every 5 days, T_2 = irrigation every 7 days, T_3=irrigation every 9 days and T_4=irrigation every 11 days

Number of tillers per m^2

The number of tillers per m^2 were compared between the treatments that the treatments 2 and 3 produced the highest number of tillers per m^2 compared to all and the treatment 4 obtained the lower number of tillers per m^2 in both locations (Table 1). The beneficial effect of frequent irrigation may be due to availability of nutrients in the upper surface of the soil where the nodal roots and rootlets usually spread. The higher number of tillers may be attributed to adequate moisture supply, particularly at the tillering stage. The survival of productive tillers was reported to be positively correlated with grain yield (Shanahan et al., 1985). However, the different irrigation treatments in this study showed different effects on the components of yield. So, Bajwa et al. (1993) observed a significant effect on varying levels of irrigations on the number of tillers per m^2. The final yield of wheat is the product of the number of spikes per m^2 × spikelets per spike × grains per spike × weight of grains.

Number of spikes per m^2

The crops produced a greater number of spikes per m^2 under treatment 2 (irrigation interval 7 days) and the treatment 4 produced a lower number of spikes per m^2 in the faculty farm (Table 2). So, at Botanical Garden location, it was observed that the highest number of spikes per m^2 was obtained by 7 days' irrigation interval, however, 11 days' irrigation interval produced the lowest number of spikes per m^2 (Table 2). These results are in agreement with the Matsunaka et al. (1992) and Ghazal et al. (1998), who reported that the number of spikes per m^2 increased as irrigation increased.

Number of spikelets per spike

There was a significant difference of irrigation intervals on spikelets per spike in both the locations and the treatment 2 (Irrigation interval 7 days) produced greater number of spikelets per spike (11.50) at the faculty farm location and after that (T_3 and T_1) treatments gave the highest number of spikelets per spike and treatment 4 produced the lower number of spikelets per spike (Table 2). Moreover, at botanical garden location lower number of spikelets per spike were recorded by irrigation interval 11 days (Table 2). These results are in agreement with those obtained by Dencic et al. (2000).

Number of seeds per spikelet

The number of seeds per spikelet were compared between the treatments. The treatment -T_2 (Irrigation interval 7 days) gave the highest number of seed per spikelet at faculty farm and botanical garden locations, while 11 days' irrigation interval produced lowest number of seed per spikelet but the varying levels of irrigations have no significant effect on the number of seeds per spikelet (Table 2).

Spike length (cm)

The length of the spike was significantly influenced by different irrigation treatments. At the faculty farm the treatment 2 and 3 produced a greater length of the spike but followed the (T_1 and T_4) treatments revealed the lowest length of spike and also at the Botanical Garden. It has appeared that the longest spike (11.06 cm) was obtained by 7 days' irrigation interval (Table 2), so many workers have reported similar effect of irrigation on spike length in wheat (Swati et al., 1985).

Table 2. Effect of irrigation frequency on yield components of wheat at Faculty farm location and Botanical garden

	Faculty farm location				Botanical garden location			
Treatments	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)
T_1	322.22_{c}	8.33_{bc}	2.33	7.83_{b}	344.56_{a}	11.33_{ab}	2.47	9.26_{b}
T_2	461.22_{a}	11.50_{a}	2.83	10.62_{a}	394.48_{a}	12.67_{a}	3.00	11.06_{a}
T_3	407.41_{b}	10.33_{ab}	2.40	8.88_{b}	378.67_{a}	12.50_{a}	2.46	10.12_{ab}
T_4	257.70_{d}	7.67_{c}	2.33	7.83_{b}	266.67_{b}	9.67_{b}	2.42	9.79_{b}
CV (%)	5.67	13.27	19.48	9.23	8.42	7.47	18.15	5.27
SE	16.77	1.03	0.39	0.66	23.79	0.70	0.38	0.43
LSD	41.03	2.50	1.62	58.21	1.72	1.05		

Means followed by the same letter in each column are not significantly different according to (LSD) test

T_1= irrigation every 5 days, T_2 = irrigation every 7 days, T_3 = irrigation every 9 days and T_4=irrigation every 11 days

Number of grains per spike

The treatment 2 through 7 days' irrigation interval revealed the highest number of grains per spike at the Faculty farm location (55.67) and also at the Botanical Garden (53.92) (Table 3). Hence Ngwako and Mashiqa (2013) found that irrigation throughout the growth stages recorded the more grains per spike. A similar observation was also found by Mubeen et al. (2013). Many workers reported a range of grain number varying from 40 to 59 grains per pike among various genotypes of wheat (Musaddique et al., 2000).

1000-grain weight

At Faculty farm location 1000-grain weight was significantly influenced by irrigation frequency. The heaviest grain weight of 1000 grains (45.77 g) was weighed in (T_2) at the faculty farm and also at Botanical Garden (36.13 g) was obtained with 7 days' irrigation interval (Table 3). These results are in agreement with Singh et al. (1980), Ibrahim (1980, 1995) and Martin (1982) who reported increased grain weight (1000-grain weight) with frequent irrigation.

Grain yield (kg ha^{-1})

At the faculty farm, the treatment (T_2) revealed the highest yield (4160.67 kg ha^{-1}) but treatment (T_4) produced the lowest grain yield (2989.67 kg ha^{-1}) Similarly at the botanical garden the (T_2) treatments revealed the highest yield (3658.00 kg ha^{-1}) and treatment (T_4) produced the lowest grain yield (2841.33 kg ha^{-1}), (Fig. 2 and Table 3). Grain yield was significantly reduced under longer irrigation intervals due to lower number of tillers per plant, number of spikes per m^2, number of spikelets per spike, number of grains per spike and 1000-grains weight and these results were in agreement with the Khajanij and Swivedi (1988), who reported that increase of irrigation frequencies can be increased the grain yield of wheat.

Dry matter (g)

The present finding at the sites of faculty farm and the botanical garden locations showed that dry matter accumulation was consistently greater with shorter irrigation intervals (5 days) than the longer ones (11 days), (Fig. 3 and Table 3). This result showed that the increased growth is due to frequent irrigation and decreased growth is with less irrigation frequency. Increasing soil moisture depletion by decreasing the amount of irrigation progressively from ear-emergence to harvest, reduces the straw and grain yields. This was in conformity with the findings of Omer and Aziai (1993), Gajri and Prihar (1983) and Talukder (1985) who reported that water stress at any stage of crop growth and development reduced the dry matter. Wang et al. (2012) also found a significant irrigation effect on straw yield.

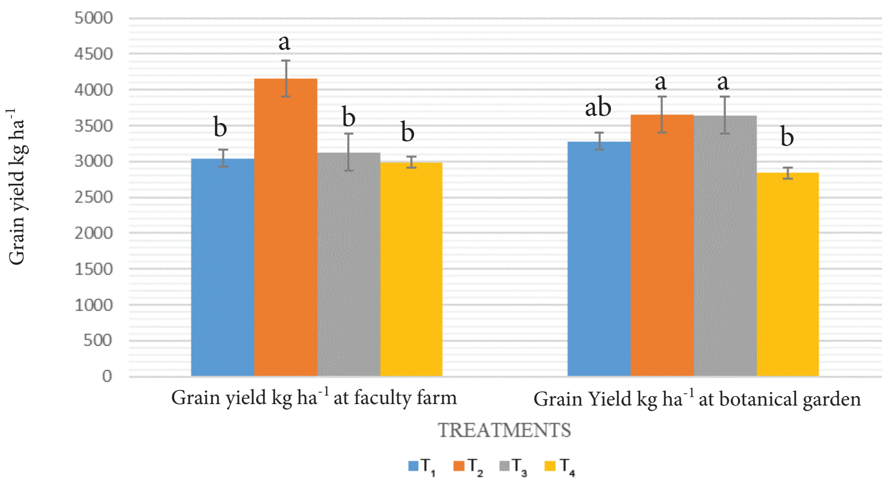

Fig. 2. Effect of different irrigation frequency on grain yield (kg ha^{-1}) at faculty farm location and botanical garden

Table 3. Effect of irrigation frequency on grains per spike and 1000 grain weight (g), grain yield kg ha^{-1} and dry matter gr m^2 of wheat at Faculty farm location and Botanical garden.

	Faculty farm location				Botanical garden location			
Treatments	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)	Spikes m^{-2}	Spikelets per spike	Seeds per spikelet	Spike length (cm)
T_1	43.50_{bc}	34.77_b	3045.67_b	1152.48 a	43.83_b	30.67_b	3282.33_{ab}	1418.89_a
T_2	55.67_a	45.77_a	4160.67_a	1127.78 ab	53.92_a	36.13_a	3658.00_a	1393.33_a
T_3	45.08_b	37.03_b	3127.33_b	969.55 bc	45.08_b	35.57_a	3645.00_a	1185.11_b
T_4	37.00_c	38.43_b	2989.67_b	926.30 c	45.42_b	29.63_b	2841.33_b	1122.22_b
CV (%)	8.41	7.33	9.82	8.57	4.45	5.13	7.82	6.98
SE	3.11	2.33	267.11	73.07	1.71	1.38	214.30	72.91
LSD	7.61	5.70	653.59	178.79	4.18	3.38	524.37	178.41

Means followed by the same letter in each column are not significantly different according to (LSD) test
T_1=irrigation every 5 days, T_2 = irrigation every 7 days, T_3=irrigation every 9 days and T_4=irrigation every 11 days

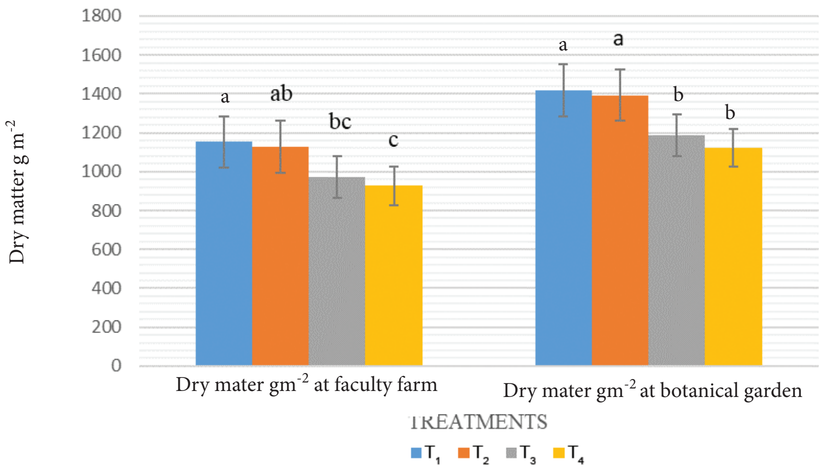

Fig. 3. Effect of different irrigation frequency on dry matter (g per m^2) at faculty farm location and botanical garden

CONCLUSION

Among the studied morphological and yield attributing characters, the lowest result was obtained by treatment 4 such as shortest plant height, minimum tillers, minimum grains per spike, shortest spike, lowest weight of 1000-seed, the lowest yield of grain and dry matter. From the aforementioned result, it is clear that irrigation frequency the whole morphological, growth and yield attributing traits where the treatment (T_2) (irrigation interval 7 days) performs better over other irrigation treatments. So, at seven days' irrigation interval it is infored that treatment (T_2) would be the most advantageous irrigation intervals for spring wheat production under the studied region.

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