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Effect of different irrigation intervals on the performance of wheat (*Triticum aestivum* L.) in ecological zone of Rahim Yar Khan

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Abstract

A field experiment was conducted to study the response of wheat to different irrigation intervals on the performance of wheat at Adaptive Research Farm, Rahim Yar Khan during 2020-2021 and 2021-2022 in Randomized Complete Block Design (RCBD). Five irrigations intervals were checked out i.e (1 irrigation at crown stage, 2 irrigations at crown and tillering stage, 3 irrigations at crown, tillering and booting stage, 4 irrigations at crown, tillering, booting and milking stage and 5 irrigations at crown, tillering, booting, milking and grain filling stage. Results revealed that application of different irrigation intervals to wheat crop affected the number of tillers (m^{-2}), plant height (cm), 1000 grain weight (g), and grain yield (kg ha^{-1}) significantly, while non-significant effect was observed on other parameters i.e germination count (m^{-2}). From the two years average results, maximum grain yield (4365.7 kg ha^{-1}), number of tillers (380.5m^{-2}), plant height (105.2cm) and 1000 grain weight (44.5g) were recorded from the plots where 4 irrigations at crown, tillering, booting and milking stage was applied.

Key words: *Irrigation, wheat, grain yield and thousand grain weight.*

Introduction

Wheat (*Triticum aestivum L.*) is an important cereal crop of the world. Due to its high demand and adaptability, wheat is grown on a large area of the world all round the year. A healthy wheat crop is not a symbol of prosperity but also an important source of strength for the nation. It ranks 1st among the cereal crops and is the staple food in Pakistan. Wheat is the most important crop of "Rabi", which showed growth of 8.1 percent and reached record high production level of 27.293 million tonnes compared to 25.248 million tonnes last year (Anonymous, 2020-21). The water availability per capita has reduced to 1200 m^3 and is seemed to reduce 800 m^3 by the year 2025 (Schahbazian *et al*., 2007). The optimum use of irrigation water should be an important strategy for increasing agricultural production in Pakistan. Seasonally about 250 – 350 mm water is required for wheat production with 1.5 – 4.0 mm as daily evapo-transpiration (Sattar, 2004). Proper time of irrigation especially in crown root initiation stage is very important for successful growth of wheat and it has a great impact on higher grain yield (Randhawa *et al*., 2004). Irrigation frequency has a significant influence on the growth and yield of wheat with the increase of irrigation frequencies the grain yield of wheat can be increased (Khajanij and Swivedi, 2007). Ali and Amin (2007) reported that significant effects were observed on number of effective tillers $hill^1$ where two irrigations were more effective. Ngwako and Mashiqa (2013) found that irrigation throughout the growth stages affect on grain yield. Mubeen *et al*. (2013) also reported that irrigation at tillering, stem elongation stage, booting and grain filling stage recorded the higher yield of wheat. Water needs of crop are of paramount importance in determining the time of irrigation during the crop growing season in irrigation programs (Passioura, 2007). While imposition of water stress at booting stage caused a greater reduction in plant height and number of tillers (Gupta *et al*., 2001). Islam (1997) who reported that plant height increased with increasing number of irrigations. 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. 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

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well as the reduction of seed yield. The effects of irrigation amount and irrigation frequency on water utilization and crop evapotranspiration of winter wheat is influenced by regional climate, soil properties, crop type and other factors (Asmamaw *et al*., 2023, Dhayal *et al*., 2023, *Zhang et al*., 2023b). During the stage of wheat growth when it undergoes simultaneous nutritional and reproductive growth, water deficit negatively affects tillering and floret development, ultimately leading to a reduction in the number of spikes and grains per spike (Liu *et al*., 2021, Xu *et al*., 2018). Flag leaves are highly sensitive to water availability, and drought stress after anthesis accelerates chlorophyll decomposition, resulting in premature leaf failure, slowing down grain filling rate and ultimately reducing grain weight (Lv *et al*., 2017, Wang *et al*., 2020). Achieving increased wheat yield necessitates the harmonization of three yield components. Grain weight, which is formed at the end of the reproductive period, exhibits greater plasticity (Paolo *et al*., 2022). Numerous studies have shown that irrigation significantly affects crop growth and yield (Si *et al*., 2020). Moreover, there is considerable inter annual variability in precipitation and its distribution during the jointing and anthesis periods of winter wheat in this region (Li *et al*., 2023). Grain weight is a crucial factor in determining the final yield of wheat. Once the number of spikes and grains in a spike are determined, further increasing grain weight becomes essential to fully utilize the yield potential of wheat (Bustos *et al*., 2013). Water consumption in wheat is influenced by three components: irrigation water, soil water storage, and rainfall. Wheat is a deep-rooted plant with a root system up to 2.0 m deep, which allows it to effectively absorb and utilize water from deeper soils (Feng *et al*., 2017). Surface and groundwater interactions and their quantification at basin scale are not well understood, but underpin the long term sustainability of irrigated agriculture in the region (Ahmad *et al.*, 2005. Since surface water supplies are not only used directly in the field, but also provide a substantial, but unquantified portion of groundwater recharge (Ahmad *et al*., 2009). (Johnson and Schmidt, 1968; Lee and Kaltsikes, 1973) recorded the effect of various irrigation regimes to maximize wheat crop yield. Information on the optimum time to apply limited amounts of water to obtain the maximum yield of high quality crops is essential for efficient use of irrigation water (Matsunaka *et al.*, 1992). Chaudhary and Kumar (1980) reported that maximum reduction of productive tillers was obtained when moisture stress occurred at the tillering stage. Grain yield of wheat was significantly increased with increasing irrigation frequency. Soil moisture conditions affect nutrient availability to the crops. Optimum irrigation increases N absorption by the crop, leading to a greater number of wheat tillers and a greater yield (Matsunaka *et al.*, 1992). The objective of this study is to determine the best irrigation intervals or levels to get maximum yield from wheat crop.

Materials and method:

Physical environment of the study area

The study was conducted during the Rabi seasons of 2020-21 and 2021-22 at the Adaptive Research farm, Rahim Yar Khan. It lies in the southern part of Pakistan between 160110 – 170450N latitudes and 760030 – 770300E longitudes, with a geographical area of 16,174 sq km as shown in fig.1. The weather of the study area is sub-tropical. The climate of the district is hot and dry in summer and cold in winter. The maximum and minimum temperature ranges between 50°C and 28°C in summer. During winter, the temperature fluctuates between 21°C and 5°C. The average rainfall is about 120 mm. The topography of the study area is plain land and moderately well drained. The soil on the site is clayey loam.

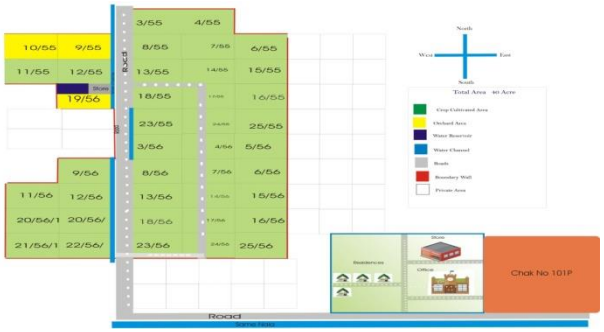

Figure 1: Experimental site at Adaptive Research Farm, Rahim Yar Khan

The experiment consisted of five irrigation intervals which were replicated three times in a randomized complete block design (RCBD). Treatment combination comprised 5 intervals of irrigation during wheat growth stages. The treatments were 1 irrigation at crown stage, 2 irrigations at crown and tillering stage, 3 irrigations at crown, tillering and booting stage, 4 irrigations at crown, tillering, booting and milking stage and 5 irrigations at crown, tillering, booting, milking and grain filling stage.

Cultural practices

Each treatment's plot had dimensions of 66 ft x 44 ft for the year 2020-21 and 63 ft x 42 ft for the year 2021-22. Replications were separated by a buffer zone 1 ft wide. Irrigation water was applied to the watercourse and within the plots, through diked water channels. A pre-sowing irrigation was applied for proper seed germination. A high yielding variety of wheat (*Triticum aestiuum L.*), Akbar-19 was sown in the experimental plots on 08 November, 2020 and 10 November, 2021 for the growing year 2020-21 and 2021-22 respectively. Planting was done with a seed drill at a row spacing of 9 inches and at a rate of 50 kg acre^{-1} for both seasons. Recommended NPK fertilizer @ 128-114-62 kg ha^{-1} was applied. Full dose of PK was applied at sowing and N was added in two splits i.e. half at first irrigation and remaining half at second irrigation.

Observed data

The data regarding germination (count m^{-2}), number of tillers (m^{-2}), plant height (cm), 1000 grain weight (g), number of grains spike^{-1}, spike length (cm) and grain yield (kg ha^{-1}) were recorded during the course of experimentation. Data on plant characteristics such as germination count m^{-2}, number of fertile tillers m^{-2}, plant height (cm), no. of grains/spike,

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1000grain wt (g), and grain yield were recorded from each of the experimental plot and were subjected to analysis of variance, regression and correlation to sort out significant difference among treatments. MSTAT-C was used to find least significant difference (LSD) at 5% for the treatment means.

Results and discussion

Germination counts (m^{-2})

Data concerning number of germination counts is shown in Table-1 and 2. Statistical analysis of the data revealed that the different irrigation intervals had no significant results on germination counts for the growing seasons because the data for germination counts was recorded before first irrigation. Average maximum germination counts m^{-2} were recorded as 202 in T_4 (4 irrigations at crown, tillering, booting and milking stage) for the Rabi 2020-21 and 204 in T_4 (4 irrigations at crown, tillering, booting and milking stage) for Rabi 2021-22. On the other hand, lowest value for Rabi 2020-21 was recorded as 190 in T_1 (1 irrigation at crown stage) and 191 in T_1 (1 irrigation at crown stage) for the Rabi 2021-22.

Number of fertile tiller (m^{-2})

Tillering is also very sensitive to water stress, being almost halved if conditions are dry enough (Peterson *et al*., 1984; Rickman *et al*., 1983). Different irrigation intervals had significant effect on tillering counts. Data regarding number of tillers m^{-2} are presented in table 1 and table 2. Average maximum tillering counts m^{-2} were recorded as 385 in T_4 (4 irrigations at crown, tillering, booting and milking stage) for the Rabi 2020-21 and 376 in T_4 (4 irrigations at crown, tillering, booting and milking stage) for Rabi 2021-22. On the other hand, lowest value for Rabi 2020-21 was recorded as 302 in T_1 (1 irrigation at crown stage) and 304 in T_1 (1 irrigation at crown stage) for the Rabi 2021-22. Ali and Amin (2007) reported that significant effects were observed on number of effective tillers $hill^1$ where two irrigations were more effective. This result is in accord with that of Ngwako and Mashiqa (2013) who found that irrigation throughout the growth stages affect on grain yield. Gupta *et al*., 2001 reported that imposition of water stress at booting stage caused a greater reduction in plant height and number of tillers. As referred by Meena *et al*, (1998) that 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 $hill^{-1}$. Gupta *et al.* (2001) reported that when water stress was imposed at the booting stage caused a greater reduction in number of tillers. Islam *et al*. (1993)

Plant height (cm)

Data concerning plant height is shown in Table 1 and 2. Statistical analysis of the data showed that plant height has non-significantly ($P \leq 0.05$) affected by the different intervals of irrigations. Similarly, average value of the data (2020-21) indicated that taller plants were produced 105.7 (cm) where 4 irrigations at crown, tillering, booting and milking stage was applied. While during the year 2021-22 the taller plants 104.5 (cm) were produced where also 4 irrigations at crown, tillering, booting and milking stage was applied. The lowest height 99 and 98 (cm) was observed during both years where only 1 irrigation was applied at crown stage. The possible reason for this variation could be the availability of more space, light and nutrients to wheat plants and more water applied. While imposition of water stress at booting stage caused a greater reduction in plant height and number of tillers (Gupta *et al*., 2001). With the result of Islam (1997) who reported that plant height increased with increasing number of irrigations.

1000 grain weight (g)

Data recorded on thousand-grain weight is shown in Table 1 and 2 for the two growing seasons. Analysis of the data revealed that thousand-grain weight was significantly ($P \leq 0.05$) affected by the different intervals of irrigation. The data also indicated that maximum thousand grain weights 45 and 44 in (g) was recorded where 4 irrigations at crown, tillering, booting and milking stage was applied. While minimum thousand grain weight 34 and 33 (g) was recorded where only 1 irrigation was applied at crown stage for both Rabi 2020-21 and 2021-22. Randhawa *et al*., 2004 reported that proper time of irrigation especially in crown root initiation stage is very important for successful growth of wheat and it has a great impact on higher grain yield. Liu et al., 2021 and Xu et al., 2018 reported that during the stage of wheat growth when it undergoes simultaneous nutritional and reproductive growth, water deficit negatively affects tillering and floret development, ultimately leading to a reduction in the number of spikes and grains per spike

Grain yield (kg ha^{-1})

The effect of irrigation level was found significant on grain yield (Table 1 and 2). It was observed that grain yield was increased with the more efficiently used water. Maximum grain yield 4435.7 and 4295.7 (kg ha^{-1}) was obtained from T_4 where 4 irrigations was applied at crown, tillering, booting and milking stage for the both Rabi 2020-21 and 2021-22 seasons. The lowest yield 3645.4 and 3355.3 (kg ha^{-1}) was obtained where only 1 irrigation was applied at crown stage during both years 2020-21 and 2021-22. These results indicated that wheat was quite responsive to increase yield in optimal or near optimal irrigation. The results are in line with Matsunaka *et al*., 1992 and Sattar, 2004. Mubeen *et al*. (2013) also reported that irrigation at tillering, stem elongation stage, booting and grain filling stage recorded the higher yield of wheat.

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Table 1: The effect of irrigation intervals on grain yield and yield components for the year 2020-21.

Treatments	Average germination counts (m^{-2})	Average Tiller counts (m^{-2})	Average plant height (cm)	Average 1000 grain weight (g)	Average grain yield (kg/ ha)
1 irrigation at crown stage	190e	302e	99e	34e	3645.4e
2 irrigations at crown and tillering stage	197d	325d	101d	38d	3967.5d
3 irrigations at crown, tillering and booting stage	200c	348c	103.2c	41c	4188.5c
4 irrigations at crown, tillering, booting and milking stage	202a	385a	105.7a	45a	4435.7a
5 irrigations at crown, tillering, booting, milking and grain filling stag	201b	371b	104.2b	42b	4309.8b
LSD(0.05)	Ns	3.25	0.42	2.132	88.7

Table 2: The effect of irrigation intervals on grain yield and yield components for the year 2021-22.

Treatments	Average germination counts (m^{-2})	Avg. Tiller counts (m^{-2})	Average plant height (cm)	Average 1000 grain weight (g)	Average grain yield (kg/ ha)
1 irrigation at crown stage	191e	304e	98e	33e	3355.3e
2 irrigations at crown and tillering stage	195d	329d	100d	37d	3867.4d
3 irrigations at crown, tillering and booting stage	199c	345c	101.2c	39c	4008.6c
4 irrigations at crown, tillering, booting and milking stage	204a	376a	104.5a	44a	4295.7a
5 irrigations at crown, tillering, booting, milking and grain filling stag	202b	362b	103.1b	41b	4135.8b
LSD(0.05)	Ns	2.99	0.57	1.734	95.4

Table 3 shows that the heighest yield was produced in T_4 (4 irrigations at crown, tillering, booting and milking stage) with 21.6% and 28.0 % yield increase in comparison with T_1 (1 irrigation at crown stage) which has produced the least yield ha^{-1} for Rabi 2020-21 and 2021-22 seasons respectively.

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Table 3: Percentage increase in wheat yield (kg/ha) in comparison of 1 irrigation at crown stage for the year 2020-21-11 and 2021-22

Treatments	Av. yield 2020-21 (Kg/ha)	Percent increase in wheat yield	Av. yield 2021-22 (Kg/ha)	Percent increase in wheat yield
T_1	3645.4e	-	3355.3e	-
T_2	3967.5d	8.8	3867.4d	15.2
T_3	4188.5c	14.8	4008.6c	19.4
T_4	4435.7a	21.6	4295.7a	28.0
T_5	4309.8	18.2	4135.8	23.2

Conclusions

The results concluded that four irrigation intervals which is applied (at crown, tillering, booting and milking stage) varied yield and yield components significantly ($p<0.05$) during the both years. Therefore 4 irrigations intervals can be recommended to get maximum yields of wheat in Rahim Yar Khan Zone.

Fig.1 irrigation at crown Root Initiation Stage

Fig. 2 irrigation at tillering Stage

Fig.3 irrigation at booting Stage

Fig.4 irrigation at heading Stage

Fig 5. Irrigation at grain Formation Stage

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