

## RESEARCH PAPER

# Effect of irrigation regimen on growth and yield of two corn hybrids (*Zea mays* L.)

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### ABSTRACT:

In this study, we investigated the effect of irrigation regimen on the growth and yield of summer corn (*Zea mays* L.) at grain-filling stages. The experimental study was conducted during the summer season of the Iraqi Kurdistan region in 2021, in two sites in the Erbil governorate (Gueer and Qushtapa). A factorial experiment within a Randomized Complete Block Design was conducted, with three replicates, including five irrigation treatments, irrigation treatments were created as water levels of pan evaporation (Ep) applied via drip irrigation, I1= Irrigated plant until full maturity. I2 = Irrigated plants until 20 days after flowering (silking) then stopped. I3 = Irrigated plants two times after 20 days of flowering then stopped irrigation. I4 = irrigated plants four times after 20 days of flowering then stopped irrigation, and I5 = irrigated plants six times after 20 days of flowering then stopped irrigation. And two corn hybrids (H1= DKC6050 and H2= DKC6777). The results revealed that the Water stress during grain – filling stage caused a significant reduction in 300- grain weight, grain yield, and moisture content of grain at harvesting in both sites. The reduction of irrigation in the I2 treatment had a significant effect, not a difference Which differed from I3 and I4. moreover, I3 and I4 were different from I1 and I5. While at all irrigation treatments was no effect on ear length, number of ears/plant, number of rows/ear, number of grain/rows, plant height, and ear height. interaction between (H x I) was a significant effect on grain yield. the result of this study, the best interaction between (H2 x I1, I5) at both sites recorded a maximum value of grain yield, which is 14377 Kg. ha-1 and 14559 Kg. ha-1 in the Gueer site, while in the Qushtapa site 13859 Kg. ha-1 and 13922 Kg. ha-1. The highest value of chlorophyll content was recorded at both sites were recorded for I1 and I5. while I3 and I2 recorded the lowest Soil Plant Analysis Development (SPAD) values. The chlorophyll content was decreased with increasing irrigation reduction time. Maximum water use efficiency (WUE) values were obtained for the I2 of deficit irrigation. the increased amount of water in I1 treatment (full irrigation) led to increasing grain yield. but reduced the WUE in both sites.

KEY WORDS: reducing irrigation, irrigation efficiency, corn yield, water requirement, and crop coefficient

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## 1. INTRODUCTION

Corn (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice, grown mainly for grain and secondly for fodder (Peykarestan et al., 2018). It is a multipurpose crop with wide adaptability to different agro-climatic conditions and is one of Iraq's major crops during the summer season. This crop is preferred by farmers due to its grain production potential being the highest among cereals (Monjardino et al., 2019).

It is grown for its grain which contains 65 % carbohydrates, 10-12 % protein, and 4-8 % fat (Utanovna, 2022). Moreover, Corn grain yield is determined by the plant growth and development it can be considered to be the result of the interaction of genotype, management, and environmental factors (Islam and Sebetha, 2020). Corn is a cross-fertilized plant, so it is considerably more sensitive to drought and high-temperature during flowering than other cereals, as the male and female flowers develop separately, at a distance of as much as 1m from each other; in addition, both the pollen and the

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pistils are directly exposed to environmental effects. In the case of Corn, the kernels develop at the same time on a single ear, so stress at flowering may result in the simultaneous abortion of all the kernels (Tollenaar and Daynard, 1978). The United Nations Environment Program's report (UNEP, 2007) provides useful background information on Iraq's geographical and environmental context. Precipitation in Iraq is limited and the majority of the country is arid to semi-arid. Annual precipitation in the northern hills and mountain ranges varies from 300-1000mm, while in the extreme south and west, it is in the order of 100-200mm, and highly irregular. Evaporation rates in arid areas are much higher than precipitation and natural recharge rates, resulting in the natural salinization of groundwater. Irrigation is a critical practice for sustainable agriculture, particularly in arid and semi-arid regions. The rainfall from June to September is rare in Iraq, irrigation is needed during the growing season to maintain and subsequently enhance crop growth and yield. Irrigated agriculture is the primary user of water resources globally and consumes 70–80% of total diverted water in the arid and semiarid zones (Araújo et al., 2022). Some of the reasons for this decrease include extended drought periods, and the decline in groundwater levels (McGuire et al., 1999). Water deficit is a major factor of abiotic stress which diminishes the grain yield of many crops (Aslam et al., 2015). Corn plants are sensitive to water shortage due to extraordinary evaporation and weak root structure (Abayomi et al., 2012). Globally 20-25% of the total planting area of corn is affected by drought stress (Golbashy et al., 2010). Water shortage at the flowering stage in corn causes 40-85% yield loss (Bänziger et al., 2002) and at anthesis to grain filling 40-80% yield losses are caused. The deficiency of water reduces photosynthesis, turgor in phloem cells, and the flow of sucrose from

conducting cells to sink (grain) (Sevanto et al., 2014). Grain yield can be analyzed in terms of three yield components, namely the number of ears per area, the number of grains per ear and mean grain weight. Compensation for components occurs as a result of competition for water and nutrients, particularly nitrogen (Miralles et al., 2000). The development of the components is sequential, later developing components are under the control of earlier ones. First-order yield components of corn consist of the number of ears m<sup>-2</sup> (or ears plant<sup>-1</sup>), kernels ear<sup>-1</sup>, and kernel weight. First-order yield components are sometimes referred to as primary components and have a direct effect on final yield as well as indirect effects through later developing yield components (Fageria et al., 2006). The most critical period for yield determination in the life cycle of corn begins approximately 2 weeks before silking and continues until 2 to 3 weeks after silking (Frey, 1981). The specific objectives of this study are to determine the amount of consumptive water used from the corn under full and deficit irrigation, determine the number of irrigation after 20 days of flowering (silking), and their effect on growth and grain yield.

## 2- Materials and Methods

### 2.1. Description of the study site:

The experimental study was conducted during the summer season in Iraqi Kurdistan Region in 2021 at two sites in Erbil governorate, the first site, in the experimental farm Gueer (ARD company farm) with GPS reading (Latitude = 36°07'46"N, Longitude =43°42'38 E and altitude =409m), the second site, Qushtapa farm with GPS reading (Latitude= 36o4'4.4"N, Longitude =44o 38'0.7" E and altitude =570m). The soil sample was taken from both fields before tillage at (0-30cm) depth. Some physical and chemical soil properties were analyzed at (Ankawa Research Station/ Erbil) as shown in (table 1).

Table 1. Some physical and chemical properties for the upper 30 cm of the soil at the experimental site.

sites	Ec mm/c	pH	N %	P (ppm)	K (ppm)	O.M %	Soil texture			
							Clay %	Silt %	Sand %	Texture
Guar	0.5	7.65	0.11	21.5	320	0.8	25.8	52.1	22.1	Silty loam
Qushtapa	0.7	7.85	0.7	10	142	1.8	49.6	47.1	18.3	Silty clay

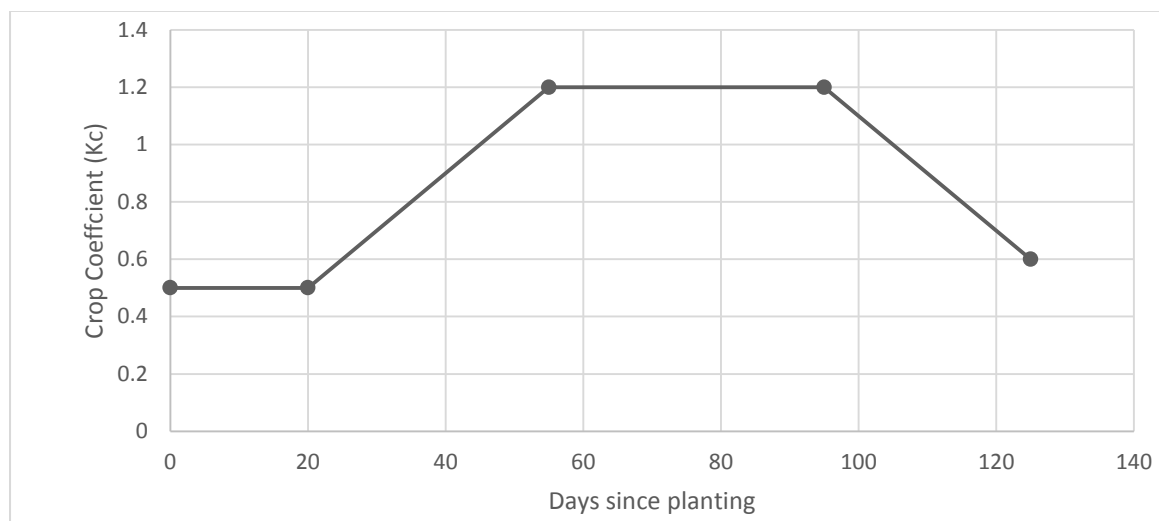


Fig.1. Crop coefficient for corn (Corn) through its growth season

## 2.2. Experimental design and treatments identify.

The experiment was conducted using Randomized Completely Block Design (RCBD) with ten plots in three replications, five irrigation regimes were used, I1= Irrigated plant until full maturity. I2 = Irrigated plants until 20 days after flowering (silking) then stopped. I3 = Irrigated plants two times after 20 days of flowering then stopped irrigation. I4 = irrigated plants four times after 20 days of flowering then stopped irrigation, and I5 = irrigated plants six times after 20 days of flowering then stopped irrigation. and all irrigation regimes treatments were conducted on two different hybrids of corn, the first hybrid (DKC 6050), and the second hybrid (DKC 6777). The area of each field was 11.40 × 39m at both sites. The plot dimensions were 2.80 x 3m. The distance between plots was 1m and between replications 1.5 m. Each Plot contains 5 lines, the distance between the line is 70 cm, and between plants within the row was 20cm which is equivalent to 71429 plant/ha-1.

## 2.3 Land Preparation and Cultural Practices.

The fields were irrigated on 1st July for softening land and after 10 days the fields of both sites were plowed with moldboard plow then clods were crushed and leveled by a rotator. The grain was sown on 15 and 16 July 2021 in Gueer and Qushtapa respectively. Corn grains were sown at depth of 3-4cm, and the first dose of N-P-K (20-20-20) fertilizer was applied three weeks after the sowing, but the second dose of N-P-K (20-20-20) was added before the flowering stage. This fertilizer soluble in water was used at the rate of 25 kg ha<sup>1</sup>. The insecticide with a trading name (Daltaplant) was used with a rate of 0.5L/1donm

and applied two weeks after sowing. Weeding was done for both sites.

## 2.4. Estimating the water requirement of corn:

### 2.4.1. Irrigation and water application.

Irrigation was applied by the method of drip irrigation. The gross and net quantities of water applied to each treatment were recorded at the time of irrigation. The irrigation treatments started 20 days after the flowering (silking) of a plant. The corn plants were irrigated according to the calculated irrigation requirements. Calculation of irrigation water requirements the daily reference evapotranspiration (ET<sub>o</sub>) was estimated using FAO Penman–Monteith's modified equation

### 2.4.2. Evaporation pan (ET<sub>pan</sub>).

The principle of the evaporation pan is the following: the pan is installed in both fields, the pan is filled with a known quantity of water (the surface area of the pan is known, and the water depth is measured), It is a modified version of Class a Pan. ISI Standard Pan has a diameter of 1200 mm and a depth of 250 mm. This type of Pan is made of a copper sheet 1mm thick, tinned inside, and painted white outside. The pan is placed on a square wooden platform with on width and length of 1100 \* 1100 mm and a height of 150 mm above ground level to allow free air circulation below the pan. The water is allowed to evaporate during a certain period (usually 24 hours). For example, each morning at 8 o'clock a measurement is taken. Pan evaporation: E<sub>pan</sub> (mm/24 hours). A fixed-point gauge indicates the level of that water is added to or removed from the pan to maintain the water level at a fixed mark using a calibrated cylindrical measure The top of the pan is covered with a hexagonal wire net to protect water in the pan from bird presence of the

water wire-mesh making the temperature of water more uniform during the day and night. the temperature meter is installed in both fields, daily temperatures were received during 24 hours the device was saving the maximum and minimum air temperatures at 24 hours. Table 2. shows Pan evaporation (Ep), and maximum and minimum air temperatures determined for both sites.

#### 2.4.3. Reference crop evapotranspiration (ET<sub>o</sub>).

Values were estimated using the FAO Penman-Monteith method. Reference Crop evapotranspiration ET<sub>o</sub> estimated according to the equation:

$$ET_o = ET_{pan} \times 0.7 \text{ mm/day}$$

#### 2.4.4. Crop Coefficient (K<sub>c</sub>)

The effects of characteristics that distinguish the cropped surface from the reference surface are integrated into the crop coefficient (K<sub>c</sub>). multiplying ET<sub>o</sub> by the crop coefficient (K<sub>c</sub>), ET<sub>c</sub> is determined. To estimate ET<sub>c</sub>, FAO (1998). K<sub>c</sub> values used for corn were 0.5, 0.6, 0.8, 1, 1.2 for the growth stages initial, mid, and final.

#### 2.4.5. Crop evapotranspiration (ET<sub>c</sub>).

The crop water requirement is the quantity of water equivalent to what is lost from a cropped field by the ET and is represented by the rate of ET in mm/day. Crop evapotranspiration (ET<sub>c</sub>) is given by FAO (1998) equation:

$$ET_c = K_c \times ET_o$$

#### 2.4.5. Water use efficiency (WUE).

Crop water use efficiency is the yield harvested in kilograms per total water used. were calculated for different treatments after harvest using the equation according to Jensen (1983).

$$WUE = \frac{\text{Grain yield (kg.ha)}}{\text{Water applied (m}^3\text{.ha)}}$$

### 2.5 Data collection

All data was recorded for ten plants from two middle rows of each plot and two sites.

**2.5.1. Plant height (cm):** plant height was measured from the soil surface to the base of the tasseling nod.

**2.5.2. Ear height (cm):** Measured from the soil surface to the base of the upper ear.

**2.5.3. Number of ears/plant:** The number of ears/plant was counted and the average was recorded

**2.5.4. Ear length (cm):** The length of the ear was measured from base to tip of the ear.

**2.5.5 Number of rows/ears:** The number of rows/ears was counted and recorded.

**2.5.6 Number of grain/row:** The number of grain/rows was counted and the average was recorded.

**2.5.7. 300-grain weight (g):** The weight of 300-grain was recorded at 15% moisture content.

**2.5.8. grain yield (Kg. ha-1):** calculated as the total grain weight in one hectare.

**2.5.9. Grain moisture content at harvesting time:** weighting 100g of corn grain at the time of harvesting. Used air oven method to determine moisture, at temperature 80°C for 24 hours, then weighting sample after drying. The following formula calculated the moisture content.

$$\text{Moisture Content \%} = \frac{\text{samle weight befor drying} - \text{weight after drying}}{\text{samle weight befor drying}} \times 100$$

**2.5.10. Chlorophyll Content:** For every 10 days the (at LEAF) hand-held device has been used for recording chlorophyll content in leaves.

### 2.6. Statistical Analysis

The Collected data were subjected to analysis variance utilizing SAS version 9.1 (2003) Duncan's Multiple Range Test (Al-Rawi and Khalafallah, 1980) was used for means comparison at 0.05 level of significance.

## 3. RESULTS

### 3.1 Effect of deficit irrigation, hybrids, and their interaction on plant height.

Table (2) illustrates the effect of insufficient irrigation on plant height in both sites and for both hybrids. In the Gueer site, the highest plant height recorded for H2 was 274.16cm opposite to H1 which was recorded minimum value of 214.50 cm, in the same context at the Qushtapa site we notice that the maximum plant height was recorded for H2 at 225.86cm compared to H1 it was less than where reached to 182.62 cm. The reason is that the H2 is late in maturing. It is also evident from table (4) there was a significant difference between irrigation treatments at the Gueer site on plant height, maximum plant height of 245.78cm recorded in the I2 treatment while the minimum plant height was recorded in full irrigation treatment (I1 as a control) 243.13cm. While the differences were not significant in the Qushtapa site between all irrigation treatments. Although the difference between the treatments was clear on this site it did not reach the

significance, which may be due to errors either during sampling or temperature and soil fertility. because there was no drought stress on the plants at the growth stage until they reached the post-pollination and fertilization stage. As is known that corn plants are among the plant with limited growth. Growth ceases as soon as the flowering process occurs. Interaction between corn hybrids and irrigation treatments was also found to be significant. H2 at all irrigation treatments and in both sites recorded the greatest plant height because hybrid 2 is from the late hybrid group that is characterized by the length of its plants.

### **3.2 Effect of deficit irrigation, hybrids, and their interaction on Ear height.**

according to the present data in table (2) a significant difference was observed in the ear height due to the differences between hybrids. H2 overcome H1 in-ear height traits at both sites, in Gueer and Qushtapa sites H2 recorded 135.64 cm and 111.86cm sequentially, while H1 recorded a minimum ear height of 105.85cm and 90.72cm for Gueer and Qushtapa site respectively. In the Gueer site, stopping irrigation 20 days after flowering led to increasing ear height and the effect was significant but the lowest plant height was observed in full irrigation treatment. While the I4 treatment at the Qushtapa site recorded d maximum value for ear height of t 105.98cm, whereas the minimum ear height again notices in full irrigation treatments. On the other hand, the ear height was significantly affected by the treatment combination between (hybrid x irrigation treatment) for both sites The highest ear was height recorded in all treatments with H2 while the minimum ear height was obtained when irrigation treatments combined with H1. This is due to the dominance of hybrids and the absence of the effect of all irrigation treatments after complete flowering. As tice, there is no stress on plants during the vegetative growth stage, the water stress occurred after completing flowering.

### **3.3 Effect of deficit irrigation, hybrids, and their interaction on Ear Length.**

Table (2) shows that there was a signification difference between both hybrids for both sites in ear length. Again we notice the superiority of hybrid 2 over hybrid 1 in the characteristic of ear length by recording 24.44cm and 23.64cm in both sites respectively, while H1 recorded 22.21 and 21.41cm in the same organization. The average ear length was not affected by irrigation treatment

at both sites. The two-factor interaction (H x I) was found to be significant (H2 x I3 and I4) recorded maximum ear length 24.60cm and 24.60cm in the Gueer site while in the Qushtapa site, we found that (H2 x I2 and I4) recorded main value 23.86, 24.13cm respectively. Minimum ear length obtained in treatment combination (H1 x most irrigation treatments).

### **3.4 Effect of deficit irrigation, hybrids, and their interaction on the Number of ears/plants.**

Table (2) present the ear number/plant of the studied corn hybrids in response to different irrigation treatment at both sites, the hybrids 2 significantly ranked first to produce the highest number of ear/plant 1.20 and 1.18 for both sites Gueer and Qushtapa respectively, while hybrid1 ranked second in many ear plant 1.00 and 1.01 for both sites respectively. Contrary to the above results, the number of ear plants was not affected significantly by the irrigation treatment at both sites. Interaction between (H x I) was found to have a significant effect on this trait the highest number of ear 1.30 represented in (H2 X I4) in the Gueer site while in the Qushtapa site (H2 X I3, I4, I5) recorded the highest value 1.23,1.24 and 1.23 ear plant it means that the H2 have more than one ear per each plant's this trait is favorable for farmer and grain producer. All irrigation treatments did not affect this trait, because the plant did not expose to any stress at ear initiation, and also this trait was considered one of the genetic traits that didn't affect any environmental factors.

### **3.5 Effect of deficit irrigation, hybrids, and their interaction on the number of rows/ear.**

It is evident from table (2) that the number of rows per ear was not influenced statistically by irrigation treatment at both sites. While the number of rows/ears was affected significantly by the type of hybrids. Here as we see H1 recorded a greater number of rows/ears 16.42 and 15.84 row/ears in both sites Gueer and Qushtapa sequentially, but the number of rows/ears in H2 decreased it recorded 14.28 and 14.08 row/ear in Gueer and Qushtapa sites. Also, the result of interaction between (H x I) was a significant effect on the number of rows/ears and we find that the (H1 x all irrigation treatments) recorded the maximum number of rows/ear for both sites.

### **3.6 Effect of deficit irrigation, hybrids, and their interaction on the Number of grains per row.**

In table (3) we found that the number of grain/rows was not affected significantly by irrigation treatment at both sites. While the significant difference has appeared between both hybrids in the number of grains/rows. Hybrid 2 again recorded the highest number of grain/rows 46.19 and 43.68 grain/row in the Gueer and Qushtapa sites, whereas the minimum number of grain/row was noted in hybrid1 35.56 and 33.92 grain/row for both sites respectively (Guar, Qushtapa). In general, the interaction between (H x I) we found that H2 at all irrigation treatments and both sites again recorded the highest number of grain/row. The reason behind this result is the completion of the process of pollination, fertilization, and the water stress that occurred later.

### **3.7 Effect of deficit irrigation, hybrids, and their interaction on grain moisture content at harvesting.**

Table 3. represents the impact of irrigation on the moisture percent at harvesting time for both hybrids and both sites. The readings of the recording data for both hybrids in Gueer sites was 35.80 % for H2 which was higher than H1 at 33.50%. Furthermore, the lowest value for H2 recorded was 28.33% which was higher than the lowest recorded value of 24.78% for H1. In the Qushtapa site again the recordings were different from each other for both hybrids. H2's highest recorded value was 33.86 and it was higher than the highest recorded value of H1 (31.86) %. The lowest recorded value of H2 was 25.86% and it was higher than the lowest recorded value of H1 in the same location which was 23.73%. Gueer sites, the mean value, in the same way, was higher for H2 which was 32.70% compared to the mean value of H1 which was 30.85%. However, the mean value of H2 has recorded a higher value of 29.88% compared to 28.22% for H1 in Qushtapa sites. The outcome of the experiment showed that the value of H2 is higher than the value of H1 in Gueer while the value of H1 is higher than the value of H2 in the Qushtapa site. There is a difference in all irrigation stages' influences on humidity, which decreased during reducing irrigation humidity. For this reason, the humidity of H2 was higher than H1 because H2 was in a delayed irrigation stage compared to H1's relatively earlier stage.

### **3.8 Effect of deficit irrigation, hybrids, and their interaction on the weight of 300 grains.**

As indicated in the table (3) there is an improvement in the weight of 300 grains based on

the differences between irrigation treatments at both sites. Where we observe a clear gradient in the weight of 300 grains by increasing the length of the period of water stress. So, this trait is more affected by water stress during the period of stopping the irrigation process (after 20 days from flowering) than other traits that preceded it. It recorded a minimum value of 300-grain weight 97.33 and 94.33g at both sites according to table organize Gueer then Qushtapa. while the maximum value was recorded from full irrigation and I5 (6 irrigations after 20 days from flowering), 117.86 and 115.68g at the Gueer site and 111.11g and 104.159g at the Qushtapa site. As for the hybrids, we notice that there are significant differences between hybrids in 300-grain weight traits, hybrid2 recorded the highest weight of 112.88g and 106.98g for both sites while hybrid1 recorded the lowest weight of 103.46g and 96.67g also for Gueer and Qushtapa respectively. In the same context of hybrids, the interaction between (H x I) was significant. Again (H2 x I1 and I5) at both sites recorded a maximum value of the 300-grain weight, while the minimum value of 300-grain weight was observed in (H1 x I2) for both sites but if we focused on the value we notice that the interaction between H1 and I1, I5 recorded height value and the effect was positive on 300-grain weight.

### **3.9 Effect of deficit irrigation, hybrids, and their interaction on grain yield.**

The representation of the influence of the irrigation treatment on the yield for both hybrids in both sites is in table (3). In Gueer sites and this experiment, the highest grain yield recorded from H2 which was 14.559 Kg/ha-1 was higher than the value recorded from H1(13601 Kg. ha-1). The lowest value recorded for H2 was 12435 Kg. ha-1 and it was higher than the H1 which was 11439 Kg. ha-1. However, In Qushtapa sites the highest grain yield was 13.922 Kg. ha-1 and it was higher than H1 of 12581 Kg. ha-1. So, the humidity at a time harvest of H2 was higher than H1 because H2 was in a later irrigation stage compared to H1, which was relatively in an earlier stage. This led to a higher weight of H2 compared to H1 during harvest.

In irrigation treatments I2, I3, and I4, there is the impact of reducing irrigation on the yield of corn. For instance, when irrigation was reduced, the product's weight was also reduced. However, in the treatment of I1 and I5, there is no difference. Gueer sites the mean value of H2 13.893 Kg. ha-1 was higher than the mean value of H1 which was

12.923 Kg. ha<sup>-1</sup>. While the mean value of H2 (13.082 Kg. ha<sup>-1</sup>) was higher than the mean value of H1 (11.612 Kg. ha<sup>-1</sup>) in Qushtapa sites, the mean value of both hybrids was higher in Gueer sites than in Qushtapa.

### **3.10 Effect of deficit irrigation, hybrids, and their interaction on chlorophyll content in Gueer location.**

The data in table (5) shows the portrayal of SPAD values as an index of chlorophyll content as influenced by two corn hybrids (DKC6777 and DKC6050) with reduction irrigation treatment (I1, I2, I3, I4, I5).

As per the finding, a considerable difference was found between early hybrid H1 and late hybrid H2 for producing SPAD value at the Gueer location it can observe that on average H2 offered superiority to H1 at all growth stages. As is clear from table (4) there was a gradual increase in SPAD value in the first stage for both hybrids. Reached the highest between 40 – 60 DAS and then declined in the same content to record the lowest SPAD value at 80 DAS to 100. As for reduction irrigation treatment, which was applied 30 DA flowering, the SPAD value was statistically at par from 30 DAS to 60 DAS. after the implementation of reduction irrigation. found that the I3 and I2 recorded the lowest SPAD value after 70 and 80 DAS. 70.75 and 62.11 units respectively. While I1, I4, and I5 recorded the highest value of SPAD at both stages. But after 90 days of sowing both treatment I1 and I5 recorded a sharp decline in SPAD value of 32.66 units, dramatically. After 100 days of sowing found that the SPAD value increased recording a maximum value of 56.55 and I5 recorded at 52.05 unite. the interaction between hybrids and irrigation treatments, similarly, it was noted that the SPAD value affected by the interaction between (H \* I) was similar to those obtained in a lone effect of each factor. The highest value was recorded under the interaction between H2 and I3 (H2, I2, I3, and I5) until 50 DAS that ranged between 75.07 to 76 SPAD unite. While the lowest SPAD value was obtained after 80 – 100 DAS. Except for the interaction between both hybrids with I1, I5 was increased in this period. Data presented in Table (4) show that the irrigation treatment at (I3) significantly decreased the value of chlorophyll fluorescence compared to (I1) in both seasons. This result supports that of Munne-Bosch and

Alegre, (2000) who found that the chlorophyll was decreased with decreasing the irrigation water.

### **3.11 Effect of deficit irrigation, hybrids, and their interaction on chlorophyll content in Qushtapa location.**

The information in table (6) illustrates how two corn hybrids (DKC6777 and DKC6050) with reduced irrigation treatment (I1, I2, I3, I4, I5) individually and collectively at 20 days to 100 days after planting affected SPAD values as a measure of chlorophyll content.

According to the results, a significant difference between the early hybrid H1 and the late hybrid H1 was discovered for creating SPAD value at the Qushtapa site. It can be shown that on average, H1 showed superiority over H2 at every growth stage. The SPAD value for both hybrids gradually increased in the first stage. As seen in the table (5) reached its peak between 40 and 60 DAS, fell in the same content, and then peaked between 80 and 100 DAP, when the lowest SPAD value was recorded. Regarding the decrease irrigation method, which was used 30 days after blooming, the SPAD value was statistically equal from 40 DAS to 60 DAS. following the start of reduced irrigation. after 70 and 80 DAS, it was discovered that the I1 and I2 recorded the lowest SPAD values. 62.11 and 70.75 SPAD units respectively. While I1 recorded the greatest unit of SPAD at both stages, I4 and I5 did as well. However, 90 days after planting, a drastic decrease in the SPAD value, 32.66 units, was observed for both treatments I1 and I5. SPAD value rose after 100 days after seeding, with I1 recording a maximum value of 56.55 and I5 recording 52.05 units. Similar to the interaction between hybrids and irrigation treatments, it was observed that the SPAD value affected by the interaction between (H \* I) was comparable to those obtained in a lone influence of each component. The greatest value, which varied between 75.07 and 76 SPAD units, was discovered in the interaction between H2 and I3 (H2, I2, I3, and I5) till 40 DAS. The lowest SPAD value, however, was discovered between 70 and 90 DAS. Except for this period's increasing interaction between both hybrids and I1, and I5.

### **3.12. Effect of deficit irrigation on a total number of irrigation, reference crop evapotranspiration (ET<sub>o</sub>), seasonal crop evapotranspiration (ET<sub>c</sub>), seasonal irrigation water applied, grain yield, and water use efficiency (WUE) for both sites.**

Different irrigation treatments in Gueer and Qushtapa sites have different values of reference crop evapotranspiration (ET<sub>o</sub>), crop evapotranspiration (ET<sub>c</sub>), seasonal irrigation water applied, grain yield, and water use efficiency (WUE), from July to October (Table 7). The total ET<sub>o</sub> values in the Gueer site of different treatments differed from the ET values in the Qushtapa site, where ET<sub>o</sub> in Gueer was lower than the ET<sub>o</sub> value in Qushtapa site of about (227.43) mm, the differences were about 6.01, 5.23, 5.57, 0.71 and 5.53 mm between each treatment for each site. As for the values of ET<sub>c</sub> they were in the same context as ET<sub>o</sub> they were also less in the Gueer site. Due to the low values of ET<sub>o</sub>, ET<sub>c</sub> in the Gueer site, we notice that the amount of seasonal irrigation water applied (kg.m<sup>3</sup>) also was less than in the Qushtapa site and for all treatments. Also, The results in table 6 indicate that the decrease of ET<sub>o</sub>, ET<sub>c</sub> value and

increase in the number of irrigations (after 20 days from the silking stage) led to increases in total grain yield. at the same time, the amount of seasonal irrigation water applied (kg.m<sup>3</sup>) was increased. The differences in WUE under different irrigation treatments were not equal to the total grain yield, the highest WUE value was obtained from the I2 and the lowest value from the full irrigation I1 for both sites. In general, the grain yield and WUE in the Qushtapa site were lower than in the Gueer site. Whereas, WUE values ranged from 4.19 and 4.55 (Kg.m<sup>3</sup>) 1 treatment (full irrigation), and T2 treatment (deficient irrigation). WUE changed when the irrigation amount increased. To support this result, the results of Bozkurt, S. and Yazar, A., (2011) and Mengü and Özgürel, (2008) reported that the irrigation water use efficiency values increased with the decreasing seasonal irrigation amounts.

Table (2). The maximum and minimum air temperatures, ET<sub>pan</sub>, determined for both sites.

Sites	Monthly	Temperature(°C)for every 10 days		ET <sub>pan</sub> (mm)
		Max	Min	
Guar	July	45.5	32.7	12
		46.2	32	15
	August	45.6	33.1	14
		44.8	32.5	13
		44.3	31.9	12
	September	43.5	25.6	10
		43.2	23.0	9
		42.8	20.1	7
	October	39.0	18.3	5
		35.7	17.5	4
		28.0	15.5	4
	Qushtapa	July	45.6	33.2
45.9			32.5	14
August		44.5	33.0	15
		44.3	32.9	14
		43.6	30.9	12
September		43.0	26.1	11
		42.5	23.8	9
		40.0	21.0	6
October		39.3	18.6	5
		34.8	17.0	4
		27.9	16.4	5

Table 3. Effect of insufficient irrigation hybrids and their interactions on plant height (cm), Ear height (cm), Length of ear (cm), No. of ears/plant and No. of row/ ear for both sites

Locations	Gueer					Qushtapa				
Traits	Plant height (cm)	Ear height (cm)	Ear length (cm)	No. of ears/plant	No. of row/ear	Plant height (cm)	Ear height (cm)	Ear length (cm)	No. of ears/plant	No. of row/ear
<b>Treatments</b>	<b>Means</b>									
<b>H1</b>	214.50b	105.85b	22.21b	1.00b	16.42a	182.62b	90.72b	21.41b	1.01b	15.84a
<b>H2</b>	274.16a	135.64a	24.44a	1.20a	14.28b	225.86a	111.86a	23.46a	1.18a	14.08b
<b>I1</b>	243.13b	119.08c	23.16a	1.08a	15.40a	200.65a	98.00b	21.85a	1.03a	14.53a
<b>I2</b>	245.78a	122.51a	23.26a	1.13a	15.30a	210.95a	101.38ab	23.05a	1.06a	15.13a
<b>I3</b>	244.60ab	120.43bc	23.41a	1.08a	15.50a	197.16a	98.18b	22.21a	1.11a	15.00a
<b>I4</b>	244.36ab	121.35ab	23.40a	1.15a	15.26a	213.08a	105.98a	23.05a	1.11a	15.13a
<b>I5</b>	243.78ab	120.35bc	23.38a	1.06a	15.30a	199.35a	105.90ab	22.01a	1.15a	15.00a
<b>H1x I1</b>	213.50c	102.30d	22.20c	1.00c	16.66a	177.27b	86.26b	20.73b	1.00b	15.53a
<b>H1x I2</b>	215.46c	108.26b	22.10c	1.00c	16.33a	190.23b	94.36b	22.23ab	1.00b	16.06a
<b>H1x I3</b>	214.73c	106.26bc	22.26c	1.00c	16.73a	175.47b	88.26b	21.10b	1.00b	15.73a
<b>H1x I4</b>	214.30c	107.13bc	22.20c	1.00c	16.06a	190.33b	90.00b	21.96ab	1.00b	16.06a
<b>H1x I5</b>	214.53c	105.30c	22.30c	1.00c	16.33a	179.81b	89.70b	21.03b	1.06ab	15.80a
<b>H2x I1</b>	272.76b	135.86a	24.13b	1.16abc	14.13b	224.03a	109.73a	22.96ab	1.06ab	13.53b
<b>H2x I2</b>	276.10a	136.76a	24.43ab	1.26ab	14.26b	231.67a	108.40a	23.86a	1.13ab	14.2b
<b>H2x I3</b>	274.46ab	134.60a	24.56a	1.16abc	14.26b	218.87a	108.10a	23.33ab	1.23a	14.26b
<b>H2x I4</b>	274.43ab	135.56a	24.60a	1.30a	14.46b	235.83a	116.96a	24.13a	1.24a	14.20b
<b>H2x I5</b>	273.03b	135.40a	24.46ab	1.13bc	14.26b	218.90a	116.10a	23.00ab	1.23a	14.20b

Within the individual factor or their interaction, the value that share the alphabet do not differ significantly according to DMRT,1955at 5%.

Table 4. Effect of insufficient irrigation hybrids and their interactions on No. of grain/ row, 300 grain weight(g), grain yield (Kg.ha<sup>-1</sup>) and Moisture % at harvesting for both sites.

Locations	Gueer				Qushtapa			
Traits	No. of grain/row	Grain Moisture % at harvesting	300 grain weight(g)	Grain yield Kg.ha <sup>-1</sup>	No. of grain/row	grain Moisture % at harvesting	300 grain weight(g)	grain yield Kg.ha <sup>-1</sup>
<b>Treatments</b>	<b>Means</b>							
<b>H1</b>	35.56b	30.85b	103.46b	13893a	33.92b	29.88a	103.46b	11612b
<b>H2</b>	46.19a	32.70a	112.88a	12923b	43.86a	28.22b	112.88a	13082a
<b>I1</b>	40.93a	34.98a	117.86a	13989a	37.13a	32.86a	117.86a	13220a
<b>I2</b>	41.10a	26.55e	97.33c	11937d	39.70a	24.80e	97.33c	10700d
<b>I3</b>	40.80a	30.75d	103.60b	13222c	38.80a	27.15d	103.60b	11847c
<b>I4</b>	40.80a	32.26c	106.40b	13818b	40.05a	29.51c	106.40b	12777b
<b>I5</b>	40.76a	34.33b	115.68a	14075a	38.76a	30.93b	115.68a	13191a
<b>H1x I1</b>	35.53c	34.16b	110.90b	13601d	33.43b	31.86b	110.90b	12581cd
<b>H1x I2</b>	35.73c	24.76f	92.40e	11439h	34.46b	23.73g	92.40e	10024g
<b>H1x I3</b>	35.86c	29.83d	100.20d	12640f	33.30b	26.60f	100.20d	10802f
<b>H1x I4</b>	35.23c	32.00c	104.50cd	13346e	34.90b	28.66d	104.50cd	12194d
<b>H1x I5</b>	35.46c	33.50b	109.33b	13595d	33.50b	30.23c	109.33b	12460d
<b>H2x I1</b>	46.33ab	35.80a	124.83a	14377ab	40.83a	33.86a	124.83a	13859a
<b>H2x I2</b>	46.46a	28.33e	102.26d	12435g	44.93a	25.86f	102.26d	11377e
<b>H2x I3</b>	45.73b	31.66c	107.00bc	13804c	44.30a	27.70e	107.00bc	12893c
<b>H2x I4</b>	46.36a	32.53c	108.30bc	14290b	45.20a	30.36c	108.30bc	13361b
<b>H2x I5</b>	46.06ab	35.16a	122.03a	14559a	44.03a	31.63b	122.03a	13922a

Within the individual factor or their interaction, the value that share the alphabet do not differ significantly according to DMRT,1955at 5%.

Table 5. Effect of insufficient irrigation hybrids and their interactions on chlorophyll content in Gueer location

	Gueer Locations								
	Chllo. after 20 days	Chllo. after 30 days	Chllo. after 40 days	Chllo after 50 days	Chllo. after 60 days	Chllo. after 70 days	Chllo. after 80 days	Chllo. after 90 days	Chllo. after 100 days
<b>treatments</b>	<b>Means</b>								
<b>H1</b>	71.45b	71.96b	72.91b	72.88b	72.76b	70.18b	66.36b	53.17a	40.79b
<b>H2</b>	74.77a	74.93a	75.68a	75.36a	75.78a	72.92a	68.54a	54.50a	41.49a
<b>I1</b>	73.03ab	72.91c	74.48a	73.79a	74.39a	71.82ab	69.76a	32.66c	56.55a
<b>I2</b>	73.02ab	73.25bc	73.96a	74.11a	74.57a	71.01bc	62.11c	54.83b	25.41e
<b>I3</b>	72.64b	73.73ab	74.48a	74.26a	74.91a	70.75c	66.60b	57.32b	30.72d
<b>I4</b>	73.54a	73.99a	74.27a	74.26a	74.21a	72.06a	69.62a	61.14a	40.97c
<b>I5</b>	73.32ab	73.35abc	74.29a	74.44a	74.39a	72.12a	69.17a	32.66c	52.05b
<b>H1x I1</b>	70.95cd	71.82d	73.26b	72.76cd	72.89d	69.86ef	67.91b	62.67ab	55.45b
<b>H1x I2</b>	71.90bc	71.42d	72.41bc	72.87cd	72.65d	69.74f	61.78d	32.73d	25.71g
<b>H1x I3</b>	70.44d	71.94d	73.28b	72.62cd	73.11d	69.60f	66.48c	54.57c	30.95f
<b>H1x I4</b>	72.26b	72.89c	72.55bc	72.34d	73.30d	70.60ef	68.08b	55.23c	40.54e
<b>H1x I5</b>	71.68bc	71.72d	73.55bc	73.81bc	71.85d	71.12ed	67.55bc	60.66ab	51.35d
<b>H2x I1</b>	75.10a	74.01b	75.70a	74.81ab	75.90abc	73.79a	71.62a	63.76a	57.66a
<b>H2x I2</b>	74.14a	75.07a	75.51a	75.35a	76.49ab	72.28bcd	62.44d	32.60d	25.11g
<b>H2x I3</b>	74.85a	75.52a	75.67a	75.91a	76.72a	71.90cd	66.71c	55.10c	30.49f
<b>H2x I4</b>	74.82a	75.09a	76.00a	75.65a	75.12bc	73.52ab	71.16a	59.41b	41.40e
<b>H2x I5</b>	74.96a	74.98a	75.54a	75.08ab	74.66c	73.13abc	70.79a	61.61ab	52.78c

Within the individual factor or their interaction, the value that share the alphabet do not differ significantly according to DMRT,1955at 5%.

Table 6. Effect of insufficient irrigation hybrids and their interactions on chlorophyll content in Qushtapa location.

	Qushtapa Locations								
	Chllo. after 20 days	Chllo. after 30 days	Chllo. after 40 days	Chllo after 50 days	Chllo. after 60 days	Chllo. after 70 days	Chllo. after 80 days	Chllo. after 90 days	Chllo. after 100 days
<b>treatments</b>	<b>Means</b>								
<b>H1</b>	66.60b	68.39b	70.86b	70.06b	69.20b	68.87b	64.15b	54.44a	41.17a
<b>H2</b>	68.20a	70.30a	72.74a	73.14a	71.94a	70.25a	66.25a	55.36a	42.34a
<b>I1</b>	67.12a	69.13a	71.20a	71.12a	68.20b	69.43a	67.65a	59.24b	50.40a
<b>I2</b>	68.15a	70.07a	72.20a	71.70a	70.41a	69.38a	56.18c	36.04d	27.80d
<b>I3</b>	67.15a	68.67a	71.49a	70.69a	71.17a	69.86a	65.37b	56.12c	39.56c
<b>I4</b>	67.41a	69.53a	72.15a	72.09a	71.42a	69.68a	67.39ab	57.99bc	41.97b
<b>I5</b>	67.17a	69.35a	71.96a	72.42a	71.64a	69.46a	69.41a	65.10a	49.04a
<b>H1x I1</b>	67.25a	69.19abc	70.15b	69.92bc	65.61d	68.60a	66.86bc	59.01b	50.67a
<b>H1x I2</b>	67.69a	69.45abc	71.98ab	70.40bc	69.65bc	68.55a	55.91d	35.61c	26.53d
<b>H1x I3</b>	65.98a	67.24c	70.63ab	68.52c	71.93ab	69.08a	63.84c	56.29b	38.75c
<b>H1x I4</b>	65.91a	68.41abc	71.04ab	71.00abc	68.51c	69.30a	65.80bc	56.83b	40.67bc
<b>H1x I5</b>	66.17a	67.69bc	70.50ab	70.47bc	70.32abc	68.83a	68.34ab	64.44a	49.24a
<b>H2x I1</b>	66.99a	69.06abc	72.25ab	72.32ab	70.79abc	69.43a	68.44ab	59.48b	50.14a
<b>H2x I2</b>	68.61a	70.69a	72.41ab	72.92ab	72.69ab	69.38a	56.45d	36.47c	29.08d
<b>H2x I3</b>	68.32a	70.11ab	72.35ab	72.87ab	70.92abc	69.86a	66.91bc	55.95b	40.37bc
<b>H2x I4</b>	68.90a	70.65a	73.26ab	73.17ab	72.32ab	69.68a	68.97ab	59.16b	43.27b
<b>H2x I5</b>	68.18a	71.01a	73.43a	74.37a	72.97a	69.46a	70.49a	65.77a	48.84a

Within the individual factor or their interaction, the value that share the alphabet do not differ significantly according to DMRT,1955at 5%.

Table 7. Total number of irrigation, reference crop evapotranspiration (ET<sub>o</sub>), seasonal crop evapotranspiration (ET<sub>c</sub>), seasonal irrigation water applied, grain yield and water use efficiency (WUE), from July to October for corn crop under different irrigation treatments for both sites.

sites	Treatments	Total Number irrigation	Seasonal ET <sub>o</sub> (mm)	Seasonal ET <sub>c</sub> (mm/plant)	Seasonal irrigation water applied (m <sup>3</sup> . ha <sup>-1</sup> )	Grain yield (Kg.ha <sup>-1</sup> )	WUE (Kg.m <sup>3</sup> )
Guar	T1	35	247.25	184.53	3334	13989	4.19
	T2	27	222.89	157.49	2620	11937	4.55
	T3	29	230.24	166.31	2907	13222	4.54
	T4	31	236.36	173.37	3072	13818	4.49
	T5	33	241.65	178.93	3202	14075	4.39
Qushtapa	T1	35	253.3	188.26	3390	11786	3.47
	T2	27	228.12	158.42	2735	9733	3.55
	T3	29	235.81	167.64	2950	10360	3.51
	T4	31	241.41	174.08	3035	10640	3.50
	T5	33	247.18	180.14	3315	11568	3.48

#### 4. Conclusion

In this experiment, two hybrid corn were evaluated under five treatments of irrigation at two sites, the results of the experiment showed the water stress 20 days after flowering (T2) have the greatest effect on the grain yield, 300-grain yield, moisture percentage at harvest time and chlorophyll content. The highest grain yield was recorded from (T5, and T4). deficit irrigation during the vegetative phase of corn development without significant yield reduction. the best interaction on the grain yield was the interaction between (H2 x I1, I5) in both sites. Also, deficit irrigation during 20 days after flowering (silking) had the greatest effect on the corn yield. In this study, the highest WUE was recorded for I2 in both sites.

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