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Determination of effective irrigation intervals in the center pivot sprinkler system for maize (*Zea mays* L.) varieties

Abstract

The increasing importance of the corn plant in animal nutrition as silage and grain feed has led to expand of corn cultivation in large areas. One of the best ways to meet the demand for irrigation of corn in large areas in Iraq is to establish a center pivot sprinkler system. This experimental study was carried out to determine the effective irrigation intervals in the center pivot sprinkler system in the cultivation of some corn varieties registered in Iraq in Kirkuk Governorate / Iraq in 2021. Another aim of this study is to identify the variety or varieties that have higher yields under different irrigation interval conditions. Another aim of this study was to determine the variety or varieties with higher yield under different irrigation interval conditions. The experiment was conducted in a randomized block design with three replications. Five registered maize varieties (AlFajer, AlMaha, AlSafa, Buhooth-106 and Sara) were used as experiment materials and three irrigation intervals (2, 4 and 6 day periods) were applied using the pivot sprinkler method. According to the result of this experiment, Buhooth-106 variety had the highest yield (7.23 kg ha^{-1}). Although the 6-day irrigation interval resulted in the lowest grain yield for all varieties, the difference in terms of corn grain yield between 4-day and 2-day irrigation interval was not found significant, statistically. In conclusion, the 4-day irrigation interval application using the center pivot irrigation system and Buhooth-106 variety can be recommended growing corn in conditions of Kirkuk Governorate of Iraq.

Keywords: maize (Zea mays L), sprinkler irrigation, center pivot irrigation, irrigation interval, variety

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Introduction

The sustainability of irrigated agriculture is threatened by adverse climate change and given future estimations that every one out of four people on earth may suffer from severe water scarcity by 2025. Two thirds of humanity will be subjected to the effects of water shortages by 2025, according to the UNESCO, and this will have a detrimental effect on the production of agricultural products. Also, around 1.8 billion people are going to suffer water shortages.[1] The wide and broad lands were being irrigated with sprinkler, gravity and drip or trickle systems in the broad agricultural fields in the world. The pressure irrigation systems and appropriate irrigation scheduling can increase water productivity. That is meaning the productivity of the crop per water consumed will be increase by the crop and reduce evaporation or system loss of water, unlike traditional surface irrigation methods. Adopting the modern irrigation systems and irrigation scheduling modernization resulting in increased the water use efficiency and changing from traditional surface irrigation methods to closed pressurized pipe network systems can lead to saving up to 90% of the total water saving.[2] Center pivot irrigation has been the most rapidly expanding form of irrigation in the Great Plains and broad fields with irrigation facility in the world. The movement of the continuous arm of the pivot system gives a specific volume of water from any point in the field with the same quantity, and this has many benefits, including reducing surface runoff, good maintenance of soil composition, good homogeneity of the water tip and the weather conditions.

Many studies have dealt with the large water needs of maize crop, which are greatly reflected in the increase in grain yield with the increase in the amount and timing of adding irrigation water.[3] However, water scarcity and drought are among the major factors limiting the yield of this crop, especially in arid and semi-arid regions of the world. Therefore, improvements must be made in global water management to conserve water and meet the growing demand for food crops. Inadequate irrigation is one way of rationalizing water use without being associated with a significant decrease in grain yield as it does not require the application of more than (50-70%) of the water used for complete irrigation.[4]

In Iraq, the total area planted with maize in 2021 is estimated at about 115 thousand hectares, with a total production for the spring and autumn seasons of 473.1 thousand tons according to declaration of Directorate of Agricultural Statistics - Central Bureau of Statistics 2021.[5] The maize crop is considered a sensitive crop to water stress, especially if it happens during the flowering period, as it will lead to a loss in yield in the range of 45- 60%.[3] To rationalize using of water, reduce its losses and improve the performance of field irrigation systems performance, the sprinkler irrigation method has been adopted.[6] The various sprinkler irrigation systems, including center pivot irrigation, have a high possibility of water management and achieving high homogeneity, which increases crop productivity.[7–9] The efficiency of the center pivot irrigation system is affected by several factors, including the operating pressure and the speed of movement of the arm of the system.[10]

As the results of early study,[11] expressed based on the field experiment conducted in 1987 determined sprinkler-irrigated corn responses that the yield, water use, and water use efficiency of fully-irrigated corn were 11.7 Mg/ha, 838 mm, and 1.40 kg/m^3, respectively; and all decreased with irrigation deficits. Mohammed and Irmak[9] conducted an experiment on maize response to irrigation and nitrogen under center pivot (CP), subsurface drip and furrow irrigation. In the

CP method/field, plots were irrigated with a four-span hydraulic and continuous-move CP irrigation system and the irrigation intervals were usually weekly for CP. According to the study, combined treatments of Center pivot system and traditional nitrogen application (2.07 Mg ha^{-1}) proved to be the best combination to obtain highest grain yield production per 25.4 mm of irrigation application. Abd et al.[12] declared based on their experimental study in Khalidiya-east of Ramadi in two seasons-in Iraq that there were significant differences among the 5 different genotypes in individual plant yield. The plants grown under the 6-day irrigation intervals were superior to the individual plant yield, although, the yield dropped almost half with the 12-day irrigation treatment. They also reached the that the long irrigation interval of 12 days had a significant effect on the decrease in grain weight and the number of grains in the ear compared to 6-day interval application. Araya et al.[13] conducted field experiment to evaluate maize (Zea mays L.) yield and water productivities under various irrigation frequencies (2, 4, 7, and 9 days) in different plant available soil water (5%, 25%, 50% and 75%) on three soil types in Finney County, Western Kansas by setting a model to automatically apply 25 mm irrigation at selected day intervals. The result of the study showed that the highest yield was simulated at irrigation amount of 400–450 mm and the 4-day irrigation frequencies under 50% plant available soil water threshold provided the maximum maize yield and water productivities for all soil types. The efficiency of center pivot irrigation system depend on several properties of system capacity and components such as span widths, system discharge, Pressure available at each sprinkler, Required size of nozzle needed in each successive sprinkler to meet the discharge requirement. Besides the system capacity, sprinkler discharge, sprinkler pressure, end guns selection as technical properties, the uniformity of application, evaporative losses and runoff problems also have to be taken consideration.

In the practice, especially, system management, water use (consumptive use, beneficial use, and reasonable use), crop variety and farm scale are appearing as the needed to be answered challenges. In these aspects, the present study was conducted to determine of effective irrigation intervals in center pivot sprinkler system for obtaining optimum yield among three corn varieties registered in Iraq.

Material and method

The experimental study has been conducted in a private agricultural field in Kirkuk Governorate-Iraq in the autumn season in 2021. The varieties used in the experiment were AlFajer, AlMaha, AlSafa, Buhooth-106 and Sara, registered by Government in Iraq. Three irrigation intervals as 2-day, 4-day and 6-day were determined to perform with center pivot irrigation system as the topics of experiment treatments.

The 2021 climate data and soil properties of the experimental field are given in Table 1 and Table 2, respectively.

Table 1 The average temperature and the precipitation data during maize growing season in the experiment field in Kirkuk Governorate-Iraq in 2021

Climatic properties	Months (2021)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Des
Average Temperature (°C)	10.62	12.63	15.96	23.07	30.26	32.82	37.24	36.48	30.6	24.52	17.92	11.05
Precipitation (mm)	12	13.8	6.3	0.1	0.5	0	0	0	0	0	0.4	10.2

Iraqi Agrometeorological Center, Ministry Of Agriculture Baghdad- Iraq. https://www.agromet.gov.iq/eng/index.php

Table 2 The results of soil analysis of experimental field, a private agricultural field in Kirkuk Governorate/Iraq in 2021

Soil properties	Value	Unit
Soil Tissue Type	Loamy soil	
Soil Reaction (pH)	7.7	
Electrical Conductivity (EC)	2.4	dS/m
Soil Organic Matter (SOM)	0.7	%
Cation Exchange Capacity (CEC)	20.1	mol kg^{-1} soil
Avilable N	15.2	mg kg^{-1} soil
Avilable P	12.5	mg kg^{-1} soil
Available K	86	mg kg^{-1} soil
Avilable Fe	2.3	mg kg^{-1} soil

The field experiment was conducted in a split-plot design arranged in a Randomized Block Design (RBD) using three replications. The main plots dedicated irrigation intervals (2-day, 4-day and 6-day) and varieties lined in sub plots. When the plants reached the stage of 5-6 leaves irrigation intervals treatments were applied.

The seeds were planted on 20 July 2021 in the form of lines with distance 75 cm and distance between plants 20 cm. The DAP fertilizer was added to the field by 200 ton ha through land preparation and 100 ton ha of urea added in splitting two parts, a half at the start of blooming and the other half when the plant height averaged 25 cm. Granular diazinon (10% effective substance) was applied in two batches, the first when the plant reached 20 cm and the second two weeks after the first addition, to suppress the maize stem borer.

The corn crop was irrigated by a center pivot sprinkler system, and the watering time period ranged from half an hour to a full hour, depending on the weather condition with the application rate of 25 mm/day per irrigation event (Araya et al., 2021a and 2021b). The first irrigation treatments were performed when the number of yellow corn leaves reached 4-5 leaves. In the present experiment, the criterion related to application time was the irrigation intervals as 2-day, 4-day and 6-day.

The studied plant characteristics were plant height (cm), leaf area (cm^2), corncob length (cm), the number of corncob per plant, the number of rows per corncob, the number of grains per corncob, 1000-grain weight (g), grain yield (t ha^{-1}) in the present experiment.

Variance analysis (ANOVA) was performed for significance testing and the difference among the means of treatments were compared based on the Least Significant Difference (LSD) at the 5% probability level by using the Genstat Statistical Software program.[14]

Results and discussion

Plant height (cm)

It is clear from Table 3 that there is considerable variation in the plant height characteristic between the irrigation interval averages, the cultivars and the joint overlap of the two study factors for the plant height characteristic. The lowest mean for the trait was given at 166.00. From the same table, it appears that the plants grow with irrigation period of 2 days had the highest average of the trait, which reached 187.30 cm, while the plants grow with irrigation period of

6 days gave the lowest average of 157.50 cm. Stem cells and leaves and their small size as a result of the low water potential in them due to the lack of readiness of soil water, that result in a reduction in the efficiency of interception and solar energy conversion into chemical energy and the production of dry matter necessary to complete the elongation process of the stem and that the low degree of swelling of the cell results in the limit that finds the elongation of the stem and the widening of the leaves. This in turn leads to the closure of stomata, a decrease in carbon metabolism, a decrease in auxin levels, and the accumulation of abscess, which leads to inhibition of plant growth. Table 3 indicates that there is a significant overlap between the two study factors, which indicates a difference in the behavior of the genotypes towards the moisture stress treatments. day, as it was less by 29.9% decrease in plant height for the cultivar AlMaha under the sprinkler irrigation interval of 6-day than for the Sara variety under the sprinkler irrigation interval of 2-day. These results are consistent with what was mentioned by Al-Hakim.[15] This leads to a decrease in the water content of the soil, which reflects negatively on reducing its readiness for the plant, and thus a decrease in its absorption, which causes a decrease in the average plant height.

Table 3 Plant height (cm) and Leaf area (cm^2) values of corn varieties subjected to 2-day, 4-day and 6-day sprinkler irrigation intervals with the Center pivot irrigation system in 2021

Varieties	Irrigation intervals (days)				Irrigation intervals (days)			
	2-day	4-day	6-day	Means	2-day	4-day	6-day	Means
	Plant height (cm)				Leaf area (cm^2)			
AlFajer	182.8	173.1	162.7	172.8 b	5549	5075	4822	5149 a
AlMaha	185.2	170.6	142.2	166.0 b	4978	4278	3976	4411 b
AlSafa	185.9	170.9	161.4	172.7 b	4645	4233	3669	4206 b
Buhooth-106	181.7	177.3	157.8	172.3 b	4762	4258	3759	4226 b
Sara	202.9	186.9	163.1	184.3 a	5127	4465	3987	4526 b
Means	187.7 a	175.7 b	157.5 c		5012 a	4462 b	4043 c	
	Irrigation			10.06				253
LSD 5%	Varieties			9.94				345
	Varieties x Irrigation			17.21				597.6

The means with the same letter are not significantly different (P≤0.05) according to LSD.

Leaf area (cm^2)

The leaf area is an important field characteristic with high heterogeneity, as the yellow maize breeders seek to improve it towards increasing the efficiency of the source. Increasing the effectiveness of absorbing sunlight that is falling on the ground will improve photosynthesis, which will raise the amount of dry matter in the leaves that serve as the source of the light, which will increase the light's reflection on the result and each of its components.

The listed results in Table 3 showed that a large differences between the averages of the center pivot irrigation treatment and the cultivars, and the joint overlap of the two study factors in the average leaf area, which means that there are genetic differences between them. For the paper area, it reached 4206 cm^2. The cause of this may be result from the genetic differences between the cultivars in their efficiency to give high leaf space in response to growth factors. This result coincided with the findings of Ahmed.[16] The same table indicates that the cultivated plants excelled in the 2-day center pivot irrigation treatment, recording the maximum mean of the trait 5012 cm^2, with an increase of 12.32% and 23.96% over the 4 and 2 day center pivot irrigation treatments, respectively.

The reduction of the leaf area under the irrigation interval of 4 and 6 days is probably caused by the water stress which is leading to a significant decrease in the size of the cells of the leaf tissue, which led to a decrease in its ability to elongate and stretch the leaf and in the growth processes of division, cell widening and cellular differentiation. The moisture stress during the growth stage of Al-Khudari variety has reduced the elongation and expansion of leaves as a result of the loss of bulging pressure imposed on the cell walls from the inside and outside, so the growth of leaf cells is affected and their elongation stops, which negatively affects the increase in leaf area,[17] this result agrees with the results.[18] The AlFajer cultivar achieved the maximum average of the two-overlap of the leaf area amounted to 5549 cm^2 when the irrigation treatment was 2 days, which did not differ significantly with 3 cultivars according to the irrigation intervals, while the cultivar AlSafa achieved the minimum average of the trait amounted to 3669 cm^2 when the 6-day pivot irrigation treatment.

Corncob length (cm)

The results of Table 4 showed that there were large differences between the averages of the axial spraying treatments and the cultivars, and the joint overlap of the two study factors for the corncob length characteristic. AlSafa cultivar plants gave the lowest average head length of 16.13 cm. The irrigation treatment by pivot sprinkler 2 days recorded the maximum average head length of 17.86 cm, and it did not differ so much from the 4-day irrigation treatment. While the plants of the 6-day irrigation interval treatment recorded minimum average of 16.88, and this reduction in the head length may be attributed to the reduction Duration until female flowering and vegetative growth characteristics such as plant height and leafy area Table 3 which led to a decrease in the capacity of the source and then a reduction of the amount of dry matter processed in the plant and an increase in competition between the different parts of the plant over the products of photosynthesis with a reduce in the rate of their transfer from the source to the estuary. This is negatively affected the shortening of the head length. These findings are agreed with the findings those of the other researches[19–22] when they prove that the stress is the reason for the decrease of the spike length of maize plants.

Table 4 Corncob length (cm) and Number of corncob per plant (pcs plant^{-1}) values of corn varieties subjected 2-day, 4-day and 6-day of sprinkler irrigation intervals by center pivot irrigation system in 2021

Varieties	Irrigation intervals (days)			Means	Irrigation intervals (days)			Means
	2-day	4-day	6-day		2-day	4-day	6-day	
	Corncob length (cm)				Number of corncob (pcs plant-1)			
AlFajer	17.9	18	17.2	17.7	1.1	1.14	1	1.04
AlMaha	17.7	17.6	17.1	17.46	1.13	1.11	1.09	1.11
AlSafa	16	15.6	14.8	15.47	1.09	1.08	1.07	1.08
Buhooth-106	19.8	19.6	18.3	19.23	1.2	1.15	1.02	1.12
Sara	17.9	17.8	17	17.56	1.15	1.17	1.01	1.11
Means	17.86	17.72	16.88		1.15	1.13	1.04	
LSD 5%	Irrigation			1.01				NS
	Varieties			2.75				NS
	Varieties x Irrigation			4.76				0.11

The means with the same letter are not significantly different (P≤0.05) according to LSD.

The genotypes responded significantly to the change in the number of days of irrigation by spraying, as the Buhooth-106 cultivar get maximum value of binary overlap for the trait, which reached 19.8 cm at the irrigation interval of 2 days, and did not differ significantly with 11 cultivars with different irrigation intervals. While the cultivar AlSafa with center pivots irrigation produce the minimum average spike length of 14.8 cm.

Number of corncob per plant

Table 4 indicates that there are no high differences in the coefficients of the sprinkler irrigation interval as well as the cultivars, while there were large differences in the overlap between the sprinkler irrigation interval and the cultivars. The Buhooth cultivar with the sprinkler irrigation interval of 2 days gave the highest average number of cobs per plant, which reached 1.20 cobs per plant, with a ratio of an increase of 20% compared to the cultivar AlFajer, with an interval of 6 days of spray irrigation, for the characteristic of the number of hairs per plant.

Number of rows per corncob

Table 5 explain that there are considerable differences between the averages of sprinkler irrigation treatments and between maize cultivars, and the joint interaction of the study factors for the number of corncob rows. There is a significant difference between the cultivars among them, as the AlFajer cultivar produce the highest average number of rows per corncob, which amounted to 16.53 rows per corncob, and it did not differ significantly with the two cultivars Buhooth and AlSafa, which gave 16.23 and 16.03 rows per corncob, while the AlMaha cultivar gave the lowest average number of the trait amounted to 14.97 rows per corncob, respectively. This result is consistent with the other researcher's expressions.[23,24] It is noted from the results that the 2-day pivot irrigation treatment was better to giving it the maximum average number of rows per corncob, that reached 16.26 rows. It did not differ highly from the 4-day pivot irrigation treatment. While the 6-day irrigation treatment produce the minimum average number of rows per corncob (15.40 rows per corncob). Being the initial part of the corncob to be determined by the corncob after defining the corncob size, this may be caused by an insufficient amount of photosynthetic products to produce the highest number of rows. The environment, stresses, particularly water stress, genetic structure, and this characteristic all have an impact.[25] The less water available to the plant with high degrees of temperature and relative humidity during the vegetative and reproductive growth phases result in reduce the duration of female flowering, plant height, leaf area, and pin length. Therefore, the lack of dry matter production is necessary for the downstream, which caused a reduction in the number of rows per corncob. This result agrees with the other researcher's[22,26,27] who indicated that water who indicated that water stress caused the reduction in the number of rows per corncob of maize.

Table 5 Number of rows per corncob (pcs corncob^{-1}) and Number of grains per corncob (pcs corncob^{-1}) of corn varieties subjected 2-day, 4-day and 6-day of sprinkler irrigation intervals by center pivot irrigation system in 2021

Varieties	Irrigation intervals (days)			Means	Irrigation intervals (days)			Means
	2-day	4-day	6-day		2-day	4-day	6-day	
	Number of rows (pcs corncob-1)				Number of grains (pcs corncob-1)			
AlFajer	17.3	16.5	15.8	16.53 a	669	592	525	595.33 a
AlMaha	15	15.1	14.8	14.97 b	520	452	407	459.67 b
AlSafa	15.9	15.6	15.2	15.57 b	405	357	268	343.33 c
Buhooth-106	16.5	16.1	15.5	16.03 ab	596	537	471	534.67 ab
Sara	16.6	16.4	15.7	16.23 ab	546	452	393	463.67 b
Means	16.26 a	15.94 b	15.40 c		547.2 a	478.0ab	412.8 b	
LSD 5%	Irrigation			0.32				75.32
	Varieties			0.94				107.58
	Varieties x Irrigation			1.63				186.33

The means with the same letter are not significantly different (P≤0.05) according to LSD.

The smaller number of rows in the corncob is result from the water stress that occurs during the vegetative growth stage, leading to the formation of small female flowers and fewer grains in the corncob. Significant overlap between the cultivars and the irrigation interval treatments by pivot sprinkler has been noticed as shown in Table 3. The irrigation interval is 6 days compared to the pivot irrigation intervals of 2 and 4 days. The reduction in the number of rows per corncob was 16.9% with the 6-day irrigation interval for AlMaha cultivar, compared to the 2-day irrigation interval with the AlFajer type.

Number of grains per corncob

One of the secondary components of the yield is the characteristic of the number of grains in each row, which is also one of the quantitative characteristics. By increasing it, the number of grains in the corncob also increases, and thus the yield increases in the yield. This characteristic is greatly affected by environmental conditions.[28] It appears from the results of Table 5 that a considerable differences between the rate of the irrigation treatments by pivot sprinkler and the cultivars used in this trait, and number of grains per corncob is the joint interaction between the two factors of the study. The results show that the irrigation treatment of 2 and 4 days was better producing the maximum average number of grains per corncob of 547.20 and 478.00 grains per corncob for the two intervals of spray irrigation, respectively. While, the 6-day irrigation treatment gave 412.80 grains per corncob an average number.

A bean with a corncob may be the cause for the reduction in the number of grains per corncob in the 6-day irrigation treatment, as well as the water stress, which negatively affected the processing of nutrients and the activity of enzymes and hormones inside the plant. This was evident in the pollination and fertilization process and, consequently the amount of grains per corncob. This result is in line with some researchers[21,22,27] were concluded that water stress result in the reduction in the number of grains per corncob in maize.

With regard to the interaction between pivot irrigation treatments and cultivars, it was found that AlFajer for the 2-day sprinkler irrigation treatment achieved the highest average of the bilateral overlap of 669 grains per corncob, and it did not differ significantly with 6 varieties according to the sprinkler irrigation treatments. While the 6-day irrigation treatment recorded the highest mean for the trait amounted to 525 and 471 seeds per corncob for the two cultivars AlFajer and Buhooth, while the treatment of spraying every 6 days produce the minimum average number of seeds per corncob, which was 268 seeds per corncob for the cultivar AlSafa.

Weight of 300 grain (g)

Table 6 showed that there was high variation between the irrigation interval averages and cultivars, and the common interaction between the two study factors for the weight of 300 grains. The Buhooth variety gave the maximum average weight of 300 grains of 85.63 g, and did not differ so much with the Sara variety. While the AlSafa cultivar gave the minimum mean of 77.47 g for the trait. The current results agreed with the other researchers[24,29,30] findings for the high differences between the genotypes. The results of the same table indicate the superiority of the 2-day irrigation treatment by giving it a larger weight of 300 grains, which amounted to 86.94 g. It did not differ significantly with the 4-day spray irrigation treatment, while the 6-day pivot irrigation treatment gave the least weight of 300 grains, amounting to 75.16 g. The decrease in the irrigation interval is 6 days in The characteristic of 300 grains is due to the low weight of the grains due to the increase in water tension, which affected the reduction of the female flowering period and the leaf area, which reduced its interception to light, and thus reduced the amount of produced materials temporarily stored in the stem, which determined the efficiency of the source capacity in delivering water and nutrients to the grains, specifically during the grain fullness, which this led to its shrinkage, small size, and low weight. This result agrees with those of some researcher's findings[22,27,31] that water stress is the reason of the reduction of grain weight in the corncob of maize plants. These results are consistent with.[32] As for the interaction between irrigation treatments and cultivars, Table 3 showed that Buhooth-106 plants for the 2-day irrigation treatment gave the highest rate of bilateral overlap of 91.2 g and it did not differ highly with 4 cultivars with different irrigation treatments, while the AlSafa cultivar for the 6-day irrigation treatment gave the lowest average of 71.2 g.

Table 6 The weight of 300 grain (g) and the grain yield (t ha^{-1}) of varieties of maize subjected 2-day, 4-day and 6-day of sprinkle irrigation intervals by center pivot irrigation system in 2021

Varieties	Irrigation intervals (days)			Means	Irrigation intervals (days)			Means
	2-day	4-day	6-day		2-day	4-day	6-day	
	Weight of 300 grain (g)				Grain yield (t ha-1)			
AlFajer	86	81.6	73.8	80.47 b	8.14	7.11	4.58	6.61 ab
AlMaha	87.2	82.6	75.5	81.77 ab	6.73	5.49	4.07	5.43 b
AlSafa	82.9	78.3	71.2	77.46 bc	5.88	4.66	3.51	4.68 bc
Buhooth-106	91.2	86.7	79	85.63 a	8.86	7.75	5.08	7.23 a
Sara	87.4	83.5	76.3	82.40 ab	7.71	6.43	4.44	6.19 ab
Means	86.94 a	82.54 b	75.16 c		7.46 a	6.29 b	4.34 c	
LSD 5%	Irrigation			5.06				1.34
	Varieties			3.76				1.38
	Varieties x Irrigation			6.51				2.39

The means with the same letter are not significantly different (P≤0.05) according to LSD.

Grain yield (t ha^{-1})

The results of Table 6 showed that there were large differences between the averages of the irrigation interval by pivot sprinkler and the cultivars, and the joint overlap of the two study factors for the properties of the total plant yield, as the cultivars varied significantly between them, as the Buhooth cultivar produce the range of 7.23 t ha^{-1}, with an increase of 9.38% and 33.15%. %, 54.48%, and 16.80% for the cultivars AlFajer, AlMaha, AlSafa, and Sara, respectively. The reason for the superiority of the Buhooth-106 cultivar and high yield is the superiority of the crop components. Ferdoush et al.[33] and

Ramadan[34] found near results by high differences between genotypes in plant yield. From the findings of the same table, it can be seen that the plants with a 2-day irrigation interval produced more plants overall, with an average yield of 7.46 t ha^{-1}. While, it did not vary highly from the yield of the irrigation interval of 4 days so that the yield decreased by approximately 40% due to the effect of decreasing the number of irrigation days when the irrigation treatment was achieved 6 The lowest average day of yield was 4.34 t ha^{-1}. When there is limited soil moisture, the crop's growth and development may have an impact on the grain production, which may explain the drop in yield. Six days of irrigation time had a substantial impact on the quantity of grains per corncob, low grain weight, corncob length, and leaf area. Additionally, because the duration of the grain-filling stage is shortened and ripening is accelerated during abortion, tiny, wrinkled, and undersized seeds are produced. Also, water stress result in a lack of supply of photosynthetic materials to fertilized grains, due to the abortion of pollinated grains, so their number decreases, and some of them atrophy. Water stress also leads to early male flowering, which leads to it led to shortening of the growth stages, and forces plants to complete their life cycle and form grains within a shorter period of time. These findings reinforce what was many other researchers' foundlings.[21,22,27,31,32,35,36]

Those who reported that yellow maize plants exposed to water stress had considerably lower grain yields and who ascribed this to the smaller corncob size, the reduction in the number of grains per corncob, and the weight of the grains in it. The analysis of results shows that there is a significant overlap between the two study factors, which indicates a difference in the behavior of the genotypes towards the irrigation interval treatments of 6 days (moisture stress). The genotypes responded significantly to the change in the number of irrigation days, with the type of overlap being a difference in the amount of response rather than in the direction of the response, such that all cultivars had a decrease in grain yield of the 6-day irrigation treatment compared to the 2- and 4-day irrigation treatments. It did not differ significantly with cultivars, while the response of Buhooth-106, AlFajer, and Sara cultivars upon irrigation treatment was 6-day achieving the highest mean yield of 5.80, 4.58, and 4.44 t ha^{-1}, respectively, While the response of other compositions AlSafa was different when irrigated by pivot sprinkler 6 days by achieving the lowest average of the trait amounted to 3.51 t ha^{-1}. These findings are consistent with those of previous studies carried out by Kanjou et al.[32] and Aidan.[37]

Conclusion

The current study was conducted to study the response of maize (Zea mays L.) varieties under the different sprinkler irrigation intervals in Kirkuk Governorate/Iraq in 2021. Five approved yellow maize cultivars (AlFajer, AlMaha, AlSafa, Buhooth-106-106 and Sara) were used with three irrigated intervals (2-day, 4-day and 6-day), using the center pivot sprinkler irrigation system. From the analysis of provided data and the evaluated results, it can be deriving the following conclusions. Buhooth-106 variety was superior in terms of yield and some of its components and irrigation intervals of 2, 4, and 6 days. The highest grain yield obtained from 2-day irrigation intervals and it followed by 4-day irrigation intervals treatments. However, the difference of the grain yield means between them was not found significant, statistically. The 6-day irrigation treatment resulted in the lowest grain yield. The result of the both of 2-day and 4-day treatments in terms of grain yield were differing significantly compared to those of 6-day irrigation interval, statistically. According to the result of the present study, Buhooth-106 variety and 4-day irrigation intervals using the center pivot irrigation system can be recommended to growing maize in Kirkuk Governorate-Iraq to provide optimum grain yield considering being environmentally friendly.

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Conflicts of interest

Authors declare that they have no conflicts of interest.

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