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RESPONSE OF MAIZE (*ZEA MAYS L.*) TO TIME OF SPRINKLER IRRIGATION AND PLANTING DENSITY

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ABSTRACT
The relation between the time of sprinkler irrigation and planting density with the response of maize has been studied by many research due to its important. In the current study an experiment was conducted in the spring season (2022) to compare the Buhooth106 variety with four plant densities. Planting took place on 7/20/2022, using a Randomized Complete Block Design with a split plank arrangement (RCBD). The stress coefficients were placed in the main panels (2, 4 and 6 days) and four plant densities in the secondary panels are (53333, 66666, 88888 and 133333) (plant H-1, where the plant density was superior to 53333 and 66666 plants H-1 by leaf area, number of grains per ear, weight of 300 grains, and yield per plant) 4801.67 and 4361.33 (cm2), (450.3 and 433.0) grains, (134.20 and 113.30) grams, respectively. The two plant densities of 133333 and 88888 plants H-1 excelled in plant height and plant yield per unit area and reached (186.64 and 181.09) cm, (9.29 and 8.19) mega gm. h-1, respectively. The pivot irrigation interval of 2 days gave the highest leaf area, the highest weight of 300 grains, and the highest yield per unit area of 437 grains, 79.48 gm, and 9.21 mega gm. h-1, respectively. For the 6-day irrigation treatment gave a yield of 6.64 mega gm. h-1 and this amount is considered acceptable compared to the lack of irrigation. The irrigation interval exceeded 2 days with the plant density of 133333 h-1 plant had the highest yield per unit area, and reached 10.61 mega gm. h-1. While the irrigation interval of 6 days gave a plant density of 88888 h-1 plants with a yield of 6.84 mega gm. h-1. It was characterized by the homogeneity of its seeds on the ear and the large size of the grain, so it is possible to use little irrigation with the appropriate plant density to give an acceptable yield from an economic point of view.

Keywords: Drought, Grain Crops, Irrigation, Plant Density, Varieties.

INTRODUCTION
The pivot irrigation system is the ideal system in terms of meeting the future requirements in the field of food processing at the global level, due to its high efficiency, and the response of different plants to irrigation with this system in addition to its suitability for wide ranges of field conditions

with a high possibility of automatic control of the system as well as its ability to cover areas wide while maintaining relatively constant operating standards. Water is the significant factor for agricultural production of Iraq due to its location within arid and semi-arid regions, and attention to the optimal use of water is considered a priority for water management in these regions if it is to obtain a good return from a specific region. A good management method is to control the amount of water given in each irrigation and the time of its addition (irrigation period) according to the soil's absorption of water and the need of the plant in its various stages of growth to reach good productivity [1]. With new reclaimed regions such as sandy soils, irrigation represent a critical limiting factor because the scarcity of water resources, causing severe damage to crops [2]. Therefore, there is an urgent need to find the optimal water requirements to produce the highest crop yield while rationalizing water. In areas that have scarce water resources, increasing water production is essential [3].

Yellow maize *Zea mays L.* considered an important crop because it is representing a direct food for humans and as a fodder for animals. It constitutes a significant source of income for millions of people in different countries around the world because its grains containing starch, protein, oil, vitamins, and minerals. Also it is consider to its an important source of biofuel, for example in the production of ethanol gas [4].

Increasing grain yield is a major goal for plant breeders in general and maize in particular, and they are in constant search for genetic materials with superior field performance to alleviate the global food crisis In front of the global challenges of raising the standard of living, the development of the culture of societies, and the increase in population, it is necessary to increase crop productivity, increase the agricultural area, and convert some desert lands into productive land.

In Iraq, the total area cultivated with yellow maize in 2021 is about 115 thousand hectares. The total production of this planted area was 473.1 thousand tons for the spring and autumn seasons. Two-thirds of humanity will be subjected to the effects of water shortages by 2025, according to the Agricultural Statistics Directorate 2021 of 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. [5].

The aim of this research is to determine the response of the cultivar Buhooth 106 to irrigation scheduling (water stress) and to determine the best plant density and the best bearing period for the cultivar and the most suitable period for sprinkler irrigation, which gives the highest yield of maize.

MATERIALS AND METHODS

An experiment was conducted to compare Buhooth106 cultivar with four plant densities (Table 1), sowing took place on 3/20/2022, by adopting a Randomized Complete Block Design in split plank arrangement (RCBD). Stress coefficients were set in the main plots (2, 4, 6 days) and densities vegetation in the secondary panels.

Table 1. The plant densities of yellow corn Buhooth 106

Distance between plants (cm)	The distance between the lines (cm)	Plant h^{-1}	Density number
10	75	13333	Density 1
15	75	8888	Density 2
20	75	6666	Density 3
25	75	5333	Density 4

Source: Prepared by the researcher based on the analysis of the results.

After the plants reached the stage of 5-6 leaves (growth stage 5-6 according to the Zadoks scale), the stress treatments were applied. All the agricultural operations to improve the soil and the crop such as plowing, smoothing, leveling and fertilizing, and data for each of the field characteristics were taken from ten plants guarded in Each experimental unit as follows:

Studied Traits

- Number of days from cultivation to 50% flowering and female.
- The average leafy area of plant (m^2) can be calculated by the following equation (El-Sahooki and Jiad):
  The leaf area of the plant = the square of the length of the leaf below the top leaf x 0.75
- An average number of grains per ear.
- Average total grain yield mega gm. h-1

Statistical analysis

- Analysis was done on Genstat Software and the L.S.D 5% test, as explain in Table 2.

Table 2. Field soil analysis before planting

Soil reaction pH 1:1		-------	7.7.
Electrical conductivity (EC) 1:1		Desi Siemens M^{-1}	2.4
soil organic matter (SOM)		%	0.69
Calcium carbonate		%	21
bulk density		M gm^{-3}	1.34
Cation exchange capacitance (CEC).		C mol kg^{-1} soil	20.1
positive dissolved ions	Ca^{2+}	Mille equivalents^{-1}	7.5
	Mg^{2+}		5.0
	Na^{+}		8.7
	K^{+}		2.1
Negative dissolved ions	SO^{2-}	Mille equivalents^{-1}	12.8
	HCO_3^{-}		2.0
	Cl^{-}		10.0

ready nitrogen		mg kg $^{-1}$ soil	15.2
ready phosphorous		mg kg $^{-1}$ soil	12.5
Ready Potassium		mg kg $^{-1}$ soil	86.0
ready iron		mg kg $^{-1}$ soil	2.73
Soil articulators PSD	sand	g kg^{-1} soil	42.4
	silt		44.0
	mud		13.6
Tissue type		Loamy soil	

Source: Prepared by the researcher based on the analysis of the results.

Female flowering (day)

There are significant differences between the irrigation interval by pivot sprinkler and the plant densities and the overlap between the irrigation interval and the plant densities for female flowering, as showed in Table 3. As Density 3 gave 66666 plants. H-1 the least number of days for female flowering and reached 65.65, and it did not differ significantly with the low density of 5333 plants.h^{-1}. The high-density Density 1 gave 13333 plants E-1 the longest duration of female flowering amounted to 73.04 days. The increase in plant density delays the female flowering and leads to the continuation of vegetative growth as a result of the increase in misleading that lowers the temperature of the soil near the plant (the plant environment). This is what happened to me [6] indicating that doubling the plant density from 35-70 thousand plants. H-1 extends the duration of female flowering by an average of 2-3 days for the strain and the hybrid, respectively, due to the lack of light capture by the plant and the decrease in photosynthesis products, from Table 3 the 6-day pivot irrigation treatment was better to giving it the shortest female flowering period of 67.57 days. It did not differ significantly with the 4-day irrigation treatment, which gave 68.99 days. While the female flowering was delayed in the 2-day irrigation treatment to 70.94 days. May be the cause for is the lack of water in plant environment increases the effectiveness of the raging hormones ethylene and abscisic and decrease the effectiveness of the growth hormones auxin, gibberellin, and cytokinin, and then the early entry of the plant into the phase [6-7].

This leads directly to early female flowering. The results indicated that the plants subjected to water stress reduced the number of days to reach the female flowering. The effect of the irrigation interval by pivot sprinkler overlapped significantly, as the irrigation interval took 6 days. The last time to reach the female flowering reached 64.07 days with Density 3b. While the watering interval took 2 days with Density 1 the longest duration for female flowering reached 62.71 days (i.e. a decrease in the number of days by 67.13%). The increase in plant density leads to a delay in female flowering and the important role of the genetic factor in the synchronization of female flowering.

Table 3. Effect irrigation intervals of 2, 4 and 6 days on plant density of Buhooth 106 maize silking (days until 50%) for spring season 2022.

Density	**Irrigation interval (days)**			**Mean**
	2	4	6	

Source:

Thousand plants. h				
Density 1	74.21	73.07	71.84	73.04
Density 2	73.34	71.41	69.26	71.34
Density 3	67.73	65.15	64.07	65.65
Density 4	68.46	66.33	65.11	66.63
Mean	70.94	68.99	67.57	
L.S.D 5%	Irrigation			2.08
	Density			2.49
	Density x Irrigation			4.31

Prepared by the researcher based on the analysis of the results.

Leaf area (cm²)

The factory of nutrients in the plant is the leaf, and therefore the measurement of the leaf area is of great importance in highlighting the productive capacity of the genetic makeup, and since the competition between plants for light, water, and other growth requirements is an important factor in the average leaf area (Aziz,). The results of Table 4 show that the low plant density is significantly higher than Density 4 in leaf area, with an increased rate of 10.09%, 25.57%, and 46.88% over the densities Density 3, Density 2, and Density 1, respectively, where the increase in plant density leads to a reduction in the leaf area of the plant due to competition. On light water and nutrients from Table 4, we notice the superiority of the 2-day pivot irrigation interval by giving it the highest average heritable area of 4517 cm², and it did not differ significantly with the 4-day irrigation interval, which gave an average leaf area of 4092 cm², while the leaf area was reduced in the 6-day irrigation interval by giving it the lowest average leaf area of 4092 cm². 3583 cm², the cause of the reduction of the leaf area under the irrigation interval of 6 days is probably because the water stress led 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 represented by division, cell widening and cellular differentiation, and that moisture stress during the stage Vegetative growth 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 [8]. This result agrees with the results of that there is a large reduction in the average leaf area due to spacing irrigation periods [7, 9].

As for the overlap between irrigation treatments and cultivars, the 2-day pivot irrigation interval was superior by giving it the highest mean for the trait with Density 4, which reached 5162 cm2, reaching 88.88% for the 6-day irrigation interval with Density 1, as explain in Table 4.

Table 4. Effect irrigation intervals of 2, 4 and 6 days on plant density of Buhooth 106 maize Leaf area ($cm^{2)}$ for spring season 2022

Density Thousand plants. H	Irrigation interval (days)			Mean
	2	4	6	
Density 1	3752	3321	2733	3269.00
Density 2	4385	3822	3264	3823.67
Density 3	4769	4397	3918	4361.33
Density 4	5162	4827	4416	4801.67
Mean	4517	4092	3583	
L.S.D 5%	Irrigation			588
	Density			496
	Density x Irrigation			859

Source: Prepared by the researcher based on the analysis of the results.

The number of grains per ear

After determining the number of rows, the number of ovules in each row is determined, which turn into mature grains after pollination and fertilization. Which is the characteristic of great importance in determining the number of ear pods with an increasing rate of 3.99%, 19.13%, and 37.16% for the plant densities of Density 3, Density 2, and Density 1, respectively. Increasing the plant density results in a decrease in the leafy area, which is leading to a reduction in the transfer of nutrients from the source to the estuary, also decrease in the length of the ear, which is reflected in the number of grains per ear, and this is similar to what was found by [10]. The 2-day pivot irrigation interval's superiority gave it the highest average quantity of grains per ear, totaling 437.0 grains, as shown in Table 5. The 6-day irrigation interval produced the lowest average number of grains per ear 348.3 grains, whereas the 4-day spray irrigation interval produced the highest average number of grains per ear, reaching 407 grains. The reduction in the number of grains per ear in the 6-day irrigation treatment may be due to the decrease the length of the ear, which result in a reduction in the number of grains, moreover the water stress, which negatively affected the supply of nutrients and the activity of enzymes and hormones inside the plant. This behavior was reflected in the process of pollination, fertilization and the number of grains per ear. The agreement between the current results and the results of reference [11] is good.

Table 5. Effect irrigation intervals of 2, 4 and 6 days on plant density of Buhooth 106 maize Number of grains Ear (grain) for spring season 2022

Density Thousand plants. h	Irrigation interval (days)			Mean
	2	4	6	
Density 1	381	346	258	328.3
Density 2	401	379	354	378.0

Density 3	476	442	381	433.0
Density 4	490	461	400	450.3
Mean	437.0	407.0	348.3	
L.S.D 5%	Irrigation			72.84
	Density			58.96
	Density x Irrigation			102.12

Source: Prepared by the researcher based on the analysis of the results.

Weight of 300 tablets (gm)

The final grain weight is determined by the size of the downstream (number of progenitors) and its ability to withdraw the largest amount of metabolic materials from the source, which is related to the effectiveness of the leaves to carry out photosynthesis [12]. The grain also begins to form and fill quickly after fertilization. The weight of the grain is an important components of the yield, which directly affects the yield of one plant of grain. The results are shown in Table 6. The lower plant density is higher than Density 4 and did not differ significantly from Density 3, while the plant density Density 1 gave the lowest average weight of 300 seeds amounting to 66.47 gm. Accordingly, the number of endosperm cells and their starchy granules decreases, and the number of cells increases with the increase in photosynthesis and the increase in manufactured materials, and this is reflected in the weight of the grain [13]. It is noted from Table 6 that the irrigation interval is 2 days, giving it the highest average grain weight of 79.48 g, with an increased rate of 4.33% and 13.22% over the irrigation intervals of 4 and 6 days, respectively. Increasing the water tension, which affected the reduction of the duration of female flowering and the leaf area, it decreased the amount of generated and temporarily stored materials in the stem which in turn decreased the amount of light that was reflected by it, which determined the efficiency of the source capacity in delivering water and nutrients to the grain specifically during the fullness of the grain, which led to its shrinkage, small size, and low weight. This result agrees with the collected results by Jin et al, 2018, Abdul Amir, 2018 and Hassan, 2019 which show that water stress caused the reduction of grain weight in the ear of maize plants. Also, these results agree with [7, 11, 12] who indicated that there was a significant difference in grain weight between different irrigation treatments. Table 6 indicates the difference in the response of the trait according to the irrigation interval and the plant densities, as the best response was achieved for the irrigation interval of 2 days with the plant density Density 4 by giving the highest seed weight 88.2 and the lowest average weight of 300 grains was in the 6-day irrigation interval with Density 1 plant density reaching 61.7 g (With a decrease of 30% compared to the treatment of Al-Rai 2 days and Density 4.

Table 6. Effect irrigation intervals of 2, 4 and 6 days on plant density of Buhooth 106 maize Weight 300 grain (gm) for spring season 2022

Density	**Irrigation interval (days)**	**Mean**

Thousand plants. h	2	4	6	
Density 1	70.4	67.3	61.7	66.47
Density 2	74.9	71.4	65.8	70.70
Density 3	84.4	80.3	72.9	79.20
Density 4	88.2	85.7	80.4	84.77
Mean	79.48	76.18	70.20	
L.S.D 5%	Irrigation			7.14
	Density			6.17
	Density x Irrigation			10.69

Source: Prepared by the researcher based on the analysis of the results.

Total grain yield (Mega gm. h^{-1})

The yield increase with the increase in the plant density, as the amount of increase in the yield as a result of the increase in the number of plants is more than the amount of reduction resulting from the decrease in the yield of one plant due to competition for the main growth requirements, and this increase rises up to the optimum plant density. The two amounts are equal (Increase and decrease) is considered the most important goal that plant breeders always seek to increase the grain yield per unit area, and this is by adopting the best standards in order to diagnose genotypes that are characterized by high yield as well as following scientific agricultural processes. Table 7 indicates the differences between the factors of the study, where the high density surpassed 133333 plants H-1 by giving it the highest grain yield of 9.29 mega grams H-1, although it did not differ significantly from the density 88888 Density2. Where the percentage of increase was 23.05% and 29.75% for the density 66666 Density3 and 53333 Density 4 plant H-1, respectively, but the quality of the grains was in terms of their shape and size, as well as their arrangement on the ear in an irregular way for the first density 133333 Density1.

Plant density is one of the most important agricultural processes that affect the grain yield, and its increase, along with the availability of other conditions suitable for growth, leads to an increase in the grain yield until reaching the optimum density that gives the highest grain yield rate. The results are consistent with what [5, 13], found that increasing plant density leads to an increase in grain yield per unit area. From Table 7, we see that the pivot irrigation interval is 2 days, giving it the highest average grain yield per unit area of 9.21. Mg H-1 with an increased rate of 10.96% and 30.70% for the plants of the 4 and 6-day irrigation intervals, respectively. The 300 grains and these results were reinforced by what was found by [14–18]. They conclude that grain yield yellow maize plants subjected to water stress decreased significantly, and they attributed this to a decrease in the number of grains per ear and the weight of grains in it. The stress result in formation of small, atrophied, and wrinkled seeds due to the acceleration of ripening and the shortening of the length of the grain filling period, and the water stress leads to a lack of supply of photosynthetic

materials to fertilized grain because pollinated grains are aborted, their number decreases and part of them atrophies. Also, water stress leads to early flowering, which leads to shortening of growth stages and forces plants to complete their life cycle and form grains within a shorter period of time. We note from the combinations between the irrigation interval plants and the plant densities were significant, as the 2-day irrigation treatment plants excelled by giving them the highest average yield per unit area of 10.61 mega grams H-1 with a high plant density of 133333 plants. H-1 (Density1) did not differ significantly with the same interval irrigation and Density 3 density also did not differ significantly with the 4-day irrigation interval for the same density (Density 1), but it was superior with an increased rate of 85.49% in the low density of 53333 plants. E-1 (Density4). Source: Prepared by the researcher based on the analysis of the results.

Table 7. Effect irrigation intervals of 2, 4 and 6 days on plant density of Buhooth 106 maize Grain Yield (Mg gm.h^{-1}) for spring season 2022

Density Thousand plants. h	**Irrigation interval (days)**			**Mean**
	2	4	6	
Density 1	10.61	9.47	7.79	9.29
Density 2	9.48	8.26	6.84	8.19
Density 3	8.58	7.89	6.19	7.55
Density 4	8.17	7.58	5.72	7.16
Mean	9.21	8.30	6.64	
L.S.D 5%	Irrigation			1.24
	Density			1.12
	Density x Irrigation			1.87

CONCLUSIONS

Because there are genetic differences between varieties and for most traits

The Buhooth 106 cultivar was performed better in terms of yield, some of its components, and irrigation interval of 2, 4, and 6 days. Likewise, Density 4 (53333.3) plants per hectare excelled in the yield of one plant. The other densities excelled in total yield per unit area and the highest was Density 1 (133333.3) plants per hectare, and since water stress negatively affected most of the field traits, including grain yield. Also, irrigation treatment 2 and followed by 4 days results in the highest mean for grain yield for the two seasons. An increase in plant density and an average yield that was satisfactory were produced by the 6-day irrigation treatment..

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