Response of corn to irrigation periods and spraying concentrations of the growth regulator brassinolide and its effect on some growth traits and yield

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Abstract

A field experiment was conducted in Babylon province - the Nile Test Station, located east of Hilla city, during the autumn season 2021. In a sandy clay soil mixture, in order to know the effect of irrigation periods and spraying concentrations of the growth regulator brassinolide in order to improve the growth efficiency and yield of yellow maize, Baghdad 3 cultivar .The Randomized Completely Block design(RCBD)was used in a split-plot arrangement with three replicates. The experiment included studying the effect of three periods of irrigation 6, 8 and 10 days and spraying the growth regulator brassinolide at a concentration of 0, 2, 4, 6 and 8 mg. L^{-1} and their interaction in growth and yield of corn. The results showed significantly excelled of the irrigation period every 6 days in the traits: the least number of days from planting to 50% female flowering, the highest plant height, leaf area, number of grains in cob, weight of 500 grains, and grain yield, which reached 52.20 days, 224.40 cm, 5958 cm 2 and 564 9 grain cob^{-1}, 157.73 g and 8.93 tons ha^{-1} respectively, while the 10-day irrigation period achieved a significantly excelled in the percentage of protein in the grains amounted to 12.05%. The spray concentration also 8 mg.L^{-1} of brassinolide significantly excelled in the number of days to 50% flowering, leaf area, number of grains per cob and ear, weight of 500 grains, and grain yield, which amounted to 52.00 days and 6378 cm2 and 573.3 grains.cob^{-1} and 158.78 g and 8.63 tons ha^{-1} The interactions showed a significant effect on the traits of vegetative growth, yield, its components, and quality. The interaction treatment between the irrigation period of 6 days and spraying at a concentration of 8 mg L^{-1} gave the highest averages of vegetative growth, yield, and quality.

Key words: yellow corn, irrigation periods, brassinolide growth regulator.

Introduction:

The yellow corn crop has a lot of importance to give it to the world, as it comes after the wheat and rice crops and is considered one of the pillars of food security.Its economic importance comes due to what the crop contains of protein, carbohydrates and oils, as well as vitamins, which are used as food for humans and animal feed.As for industrially, it is included in many industries, such as the biofuel industry (ethanol), which contributes to reducing environmental pollution (Capehart and Liefert, 2017). Irrigation scheduling within a period of time is one of the most effective means of optimal use of water, where it is considered one of the things related to the growth and productivity of the crop, so the crop is affected by insufficient irrigation, which is reflected in the field characteristics and thus on the yield and its components.Water plays an important role in increasing the absorption of nutrients and their readiness through its influence on the stages of emergence and formation of plant organs and their growth, and in the growth and division of cells and the regularity of the photosynthesis process, as it acts as a solvent and a medium for transporting nutrients to all parts of the plant.As well as the basic cycle in the photosynthesis process in which the dry

matter is produced and the temperature of the plant is cooled (Al-Sahoki et al., 2009).Many researches indicate the importance of plant growth regulators through their role in reducing the water stress of corn crop and improving growth and yield, such as the growth regulator brassinolide, which plays a major role in the growth, division, elongation and development of plant cells, as well as responding to many environmental pressures such as high temperatures and drought through Contribute to the regulation of stomata opening and closing and photosynthesis (Tanveer et al., 9201).Shah et al., (2018) found a significant difference in the number of days from planting to female flowering by giving 3 and 5 irrigations at the vegetative growth stage of corn, which was 56 and 57 days. The results of the Al-Akidi study (2015) when applying three irrigation periods of 5, 10 and 15 days showed a significant effect on the growth characteristics of yellow corn. The irrigation treatment every 15 days had a significant effect in reducing plant height and leaf area, with decrease rates of 11.8 and 31.0 respectively compared to the irrigation treatment. every 5 days. The results of the study conducted by Jader et al. (2017) showed that the corn yield was significantly superior during the 7-day irrigation period in the number of grains per ear, as it reached 285.5 grains per corn, the weight of 300 grains was 88.42 g, and the grain yield was 85.2 g, while the 14-day irrigation period gave the lowest average It reached 235.0 grain.cob $^{-1}$, 84.33 g, and 66.8 g, respectively. In a study conducted by Al-Mashhadani (2018) to find out the role of brassinolide in improving the vegetative growth traits and yield of corn crop at three concentrations of 0, 2, and 4 mg L^{-1}, it was concluded that the concentration 4 mg L^{-1} was significantly excelled in most of the studied traits, plant height, leaf area and number of grains In the corn, the weight of 500 grains and the grain yield compared with the treatment without spraying.The results of Hassan's study (2019) showed that when plants were treated with brassinolide regulator, a concentration of 5 mg. L^{-1} improved the components and yield of yellow corn kernels, with a relative increase of 9.22% for the weight of 500 kernels and 15.85% for the kernel yield.

Materials and methods:

A field experiment was carried out during the fall season 2021 in the fields of Al- Nile Test Station located 10 km east of Hilla city in Babylon province. In order to study the effect of spraying concentrations of brassinolide growth regulator and irrigation periods to improve growth efficiency and yield of corn. The experiment was carried out using the randomized complete block design (RCBD) and in the arrangement of split-plots and with three replications. The area of the experimental unit was 6 m2 with dimensions of 2×3 m. The experimental unit included five planting lines, the distance between one line and another was 75 cm and between one plant and another 25 cm, and a plant density amounted to 53333 plants. ha^{-1} The irrigation periods (6, 8 and 10 days between one irrigation and another) occupied the main plot,While the sub plot were occupied by spraying concentrations of the growth regulator brassinolide (0, 2, 4, 6 and 8 mg. L^{-1}. The replicates were divided into a secondary experimental unit amounting to 15 experimental units for one replicate, the distance between one replicate and the last 2 m for the work of waterways and crop service corridors, Intervals were left between the experimental units within 1 m to ensure that there was no interference between the experiment transactions. The panels were randomly distributed within the sector, thus the total experimental units became (5 x 3 x 3 = 45 experimental units).Random samples were taken from field soil at a depth of 0-30 cm for different locations and analyzed in the Laboratory of the Water and Soil Management Division in El-Moradia, the results of which are shown in Table 1.

Table (1) represents some chemical and physical properties of field soil

The planting was conducted on 15/7/2021 by placing 2-3 seeds in the pit after testing the germination percentage of synthetic cultivar Baghdad 3, which reached 98%. At the

completion of male flowering, growth traits were calculated.

1- Number of days from planting to 50% female flowering: The period from planting (the date of the first irrigation) until the emergence of the 50% female flowering of plants in the experimental unit (Odongo and Bockholt 1995) was calculated.

2- Plant height cm: The average height of ten plants was measured randomly, taken from each experimental unit, according to their average, starting from the surface of the soil to the end of the node bearing the male inflorescence.

3- Leaf area of the plant cm^2: The square of the leaf length was measured under the main cob and multiplied by the constant 0.75 (Elsahookie, 1985)

4- The number of grains in cob ($grin.cob^{-1}$): It is calculated from the product of multiplying the number of rows by the number of grains per row for an average of ten cobs.

5- the weight of 500 grams: It was calculated after neglecting 500 grains of the ten plant aegis, which were randomly taken after drying the seeds and the stability of moisture by 15.5%, then weighed with a sensitive scale.

6- Grain yield, ton ha^{-1}: It was extracted after adjusting the weight on the basis of 15.5% moisture by multiplying the yield of one plant (gm) by the plant density per hectare (53333 plants. ha-1) (Al-Sahoki, 1990).

7- The percentage of protein in grains (%): The percentage of protein in grain samples was estimated using the (Microkeldhal) device in the laboratory of the Department of Field Crops / College of Agriculture / Al-Qasim Green University, the (Kjeldahl) method was used to estimate the percentage of nitrogen and the percentage of protein: protein was calculated. = % for nitrogen x 6.25 (Hart and Fisher 1971)The results of the experiment were statistically analyzed according to the method of analysis of variance using a randomized complete block design (R.C.B.D).By arranging the split plates, the significant differences between the treatments were calculated at the 0.05 level of significance for the least significant difference LSD. The Genstat program was used in the statistical analysis.

Results and discussion:

Number of days from planting to 50% female flowering: - It is noticed from Table 2 that there is a significant difference in the number of days from planting to 50% female flowering in different irrigation periods, as the irrigation period took 6 days, the least number of days for female flowering was 52.20 days, with an insignificant difference With an 8-day irrigation period of 52.73 days,Whereas, the 10-day irrigation period gave an average of 53.27 days. The reason is that the water tension before female flowering caused a decrease in cell growth and elongation, as well as the reduction in the average carbon metabolism associated with stomata closure and a decrease in leaf area, which reduces the accumulation of dry matter as a result of obstructing physiological processes (Kramer, 1995)This is reflected in the delay in plant growth, disruption of vital activities and a decrease in the efficiency of the photosynthesis process, thus delaying the emergence of cob. Spraying the concentrations of the growth regulator brassinolide had a significant effect on this trait, and increasing the concentrations of the growth regulator brassinolide reduced the number of days from planting to 50% female flowering.The concentration of 8 mg L^{-1} recorded the lowest average number of days from planting to 50% of female flowering amounting to 52.00 days, which did not differ significantly from the concentration 6 mg L^{-1} where it reached 52.33 days compared to the concentration of 0 mg L^{-1} which gave the highest average number of days reached 54.00 days,This is due to the stimulation of flowering by the growth regulator brassinolide, which reduces the levels of potent floral repression (Domagalska et al., 2010).It is noticed from Table 1 that there is a significant interaction between the irrigation periods and the concentrations of the

brassinolide regulator. The highest average number of days was 56.00 days.

Table 1. Role of irrigation periods and concentrations of brasserolide growth Regulator and Interaction between them in the average the days to 50% flowering .

irrigation periods	brassinolide concentrations(mg L^{-1})					Average
	0	2	4	6	8	
6	52.33	52.67	52.67	52.33	51.00	52.20
8	54.00	52.67	52.33	52.33	52.33	52.73
10	56.00	52.67	52.67	52.33	52.67	53.27
Average	54.11	52.67	52.56	52.33	52.00	
LSD (p=0.05)	irrigation periods		brassinolide concentrations		Interaction	
	0.69		0.68		1.16	

Plant height cm :- The results in Table 2 showed a decrease in the average plant height due to the effect of irrigation periods, where the 10-day irrigation period recorded the lowest average plant height of 204.81 cm, with a decrease average of 8.73% Compared to the 6-day irrigation period, which achieved the highest average plant height of 224.40 cm,This may be due to the fact that the lack of water supply during the vegetative stages affects the reduction of stem elongation through its effect on the processes of cell expansion and division, and this in turn reduces the height of the plant.This is in agreement with the results of Hameedi et al (2015). The results of Table 2 showed that the plant height traits differed significantly when increasing the concentrations of spraying with the growth regulator brassinolide. The concentration of 6 mg L^{-1} excelled by giving the highest mean of 218.89 cm, which did not differ significantly from the concentration of 8 mg L^{-1}, while the control treatment sprayed 0 mg L^{-1} gave the lowest average of 208.53 cm.The reason may be due to the role of the growth regulator Brassinolide in controlling the division, elongation and differentiation of cells and increasing the size of cells and thus an increase in plant height. As for the interaction between irrigation periods and spraying concentrations of the regulator brassinolide, The interaction treatment between the 6-day irrigation period and spraying with a concentration of 6 mg L^{-1} was superior and gave the highest average height of 234.47 cm.Compared with the lowest mean of 201.37 cm for the treatment of the interaction between the irrigation period 10 days and the concentration 0 mg L^{-1}.

.Table 2. Role of irrigation periods and concentrations of brasserolide growth Regulator and Interaction between them in the average plant height cm.

irrigation periods	brassinolide concentrations(mg L^{-1})					Average
	0	2	4	6	8	
6	213.60	217.65	224.73	234.57	231.47	224.40
8	210.63	211.53	213.77	215.20	215.63	213.35
10	202.07	204.48	201.37	206.92	209.21	204.81
Average	208.77	211.22	213.29	218.89	218.77	
LSD (p=0.05)	irrigation periods		brassinolide concentrations		Interaction	
	0.99		1.07		1.80	

Leaf area cm^2: The results in Table 3 showed that there were significant differences between irrigation periods for this trait, as the 10 day irrigation period gave the lowest average leaf area amounted to 5537 cm^2. While the irrigation period of 6 days gave the highest average of 5958 cm^2, which did not differ significantly from the irrigation period of 8 days, and the reason may be due to the effect of water tension in the stage of growth and expansion of leaves, which led to the lack of elongation of cells, which negatively affected the leaf area. Also, the reduction of the leaf area is one of the mechanisms that the plant resorts to counteract the water stress and thus reduces the water loss from the plant through transpiration, and that the reduction of the leaf area comes by reducing the emergence and expansion of new leaves or accelerating aging (Prasad et al., 2008).It is noted from the same table that there is a significant effect on the leaf area with an increase in the concentration of brassinolide spray.Where the concentration of 8 mg L^{-1} gave the highest mean of the protective area amounted to 6378 cm2, while the control treatment (spraying distilled water) gave the lowest average of the traits amounted to 5379 cm^2.The reason for the increase in the leaf area when spraying brassinolide is due to the synchronization of the spraying stages with the growth and expansion of the leaves, as well as its positive role in the vital processes inside the plant, affecting the increase in cell division, which is reflected in the growth and stimulation of the roots to increase the absorption of nutrients more (Ross and Quittenden, 2016).As for the interaction between the two factors of the study, it differed significantly for these traits. The interaction treatment between the 6-day irrigation period and the concentration of 8 mg L^{-1} gave the highest average of the leaf area traits which amounted to 6638 cm^2, while the irrigation period of 10 spraying concentration of 0 mg L^{-1} gave the lowest average of 5016 cm^2.

Table 3. Role of irrigation periods and concentrations of brasserolide growth Regulator and Interaction between them in the average leaf area (cm^2)

irrigation periods	brassinolide concentrations(mg L^{-1})					Average
	0	2	4	6	8	
6	5512	5660	5733	6245	6638	5958
8	5610	5665	5835	5994	6324.	5886
10	5016	5148	5514	5835	6171	5537
Average	5379	5491	5694	6025	6378	
LSD (p=0.05)	irrigation periods		brassinolide concentrations		Interaction	
	107.7		79.6		147.2	

The number of grains in cob: - It is noted from Table 4 that there are significant differences between irrigation periods in this trait,The 10-day irrigation period caused a reduction in the number of grains in cob to the lowest average of 430.1 grain .cob^{-1}, with a decrease of 23.86% compared to the 6-day irrigation period, which gave the highest average of 564.9 grain .cob^{-1}.The exposure of the plant in the flowering stage to water stress leads to irregular emergence of silk, which leads to a delay or acceleration of its appearance and thus takes it away from the appropriate time for the dispersal of pollen grains, and this is accompanied by a lack of fertilization and thus a decrease in the number of grains per ear (Zinselmeier et al. 1999).As for the concentrations of brassinolide, it significantly increased the number of grains in the ear, as the concentration of 8 mgL^{-1} gave the highest average for the trait amounted to 573.3 grain .cob^{-1}, while the concentration of 0 mgL^{-1} gave the lowest average of 416.8 grain.cob^{-1}. The reason for the increase may be due to the role of brassinolide in increasing the fertility and vitality of pollen grains and stimulating the flowering contract as a result of improving and increasing the indicators of vegetative growth.As for the interaction between irrigation periods and spray concentrations of the regulator brassinolide, the interaction treatment between irrigation period 6 days and spraying concentration 8 mg L^{-1} gave the highest average number of grains in the ear reached 632.7 grain.cob^{-1}, which did not differ significantly from the concentration 6 mg L^{-1} and the period the irrigation itself, While the irrigation period of 10 days and the concentration of 0 mg L^{-1} of the control treatment gave the lowest average of 359.8 grain.cob^{-1}.

Table 4 . Role of irrigation periods and concentrations of brasserolide growth regulator and Interaction between them in the average Kernel number/grain.

irrigation periods	brassinolide concentrations(mg L^{-1})					Average
	0	2	4	6	8	
6	469.6	537.8	564.1	620.4	632.7	564.9
8	421.1	426.2	521.3	532.2	591.6	498.5
10	359.6	399.2	455.1	441.0	495.5	430.1
				531.2		
Average	416.8	454.4	513.5	531.2	573.3	
LSD (p=0.05)	irrigation periods		brassinolide concentrations		Interaction	
	29.54		23.01		41.82	

The weight of 500 grains:- The results in the table showed 5 significant differences as a result of the effect of the irrigation periods for this trait, where the 10 day irrigation period caused a significant decrease in the weight of 500 grains for the lowest average of 148.07 g compared to the 6-day irrigation period, which achieved the highest average of 157.73 g.The reason may be due to the decrease in the accumulation of dry matter, which reduces the division of endosperm cells and thus leads to a decrease in the number of cells and their small size, and then a decrease in the weight of grains (Al-Aboudi and Shati, 2014). The spraying of the growth regulator brassinolide concentrations had a significant effect on this trait.The concentration of 8 mg L^{-1} gave the highest average for the trait, which was 158.78 g, which did not differ significantly from the concentration 6 mg L^{-1}, which amounted to 158.11 g.While the spraying treatment with a concentration of 0 mg L^{-1} gave the lowest average of trait which was 148.56 gm, and the control treatment did not differ significantly from the concentration of 2 mg L^{-1} .The reason for the increase is due to the mechanism of action of Brassinolide, which stimulates the genes of gibberellins and auxins that affect the increase in cell division and elongation, including the endosperm cells, which constitute 80% of the weight of the seed and thus increase the weight of the grain (Gao et al., 2017).The interaction between the two factors of the study differed significantly in this traits, where the interaction treatment between the 6-day irrigation period and spraying with a concentration of 6 mg L^{-1} achieved the highest average weight of 500 grains amounted to 164.33 g, while the interaction treatment gave 10 days and spraying with a concentration of 2 mg L^{-1} the lowest Average reached 140.33 g.

.Table 5. Role of irrigation periods and concentrations of brasserolide growth Regulator and Interaction between them in the average 500 grain weight g.

irrigation periods	brassinolide concentrations(mg L^{-1})					Average
	0	2	4	6	8	
6	154.33	154.33	154.67	164.33	161.00	157.73
8	150.33	151.00	152.00	157.67	159.33	154.07
10	141.00	140.33	150.67	152.33	156.00	148.07
Average	148.56	148.56	152.44	158.11	158.78	
LSD (p=0.05)	irrigation periods		brassinolide concentrations		Interaction	
	1.02		0.97		1.67	

Grain yield: The results in (Table 6) showed a significant effect of irrigation periods on grain yield, where the 10-day irrigation period caused a significant decrease in the total grain yield, with an average of 6.67 tons ha-1, with a relative decrease of 25.30%.In comparison with the 6-day irrigation period, which achieved the highest average of 8.93 tons ha^{-1}, the reason for the decrease in the yield may be due to the decrease in the access to water and nutrients, specifically during the period of filling the grain, which leads to its small size and shrinkage, so the average weight of 500 grains decreased. This result agreed with the results of Al Shubr (2021).As for the concentrations of brassinolide spray, the concentration of 8 mg L^{-1} achieved the highest average grain yield of 8.63 tons ha^{-1}, with a relative increase of 15.99% compared to the spray treatment at a concentration of 0 mg L^{-1}, which gave the lowest average of 7.25 tons ha^{-1}. This may be due to the role of brassinolide, which was evident in improving water relations and reducing the transpiration process, which was reflected in growth, cell elongation, leaf expansion, an increase in the rate of plant growth, and the accumulation of dry matter and that this increase in growth was positively reflected in the increase in the yield components, the number of eaves, the number of rows, the number of grains in the cob, and the weight of grains, affecting the grain yield.This finding is agreed with Hu et al. (2017). The interaction between the two study factors had a significant difference in the average grain yield.The interaction treatment between the irrigation period of 6 days and spraying at a concentration of 8 mg L^{-1} achieved the highest average grain yield of 10.07 tons ha^{-1}.While the interaction treatment between the irrigation period of 10 days and the concentration of 0 mg L^{-1} gave the lowest average of 6.01 tons $ha^{-1.}$

Table 6 . Role of irrigation periods and concentrations of brasserolide growth regulator and Interaction between them in the average Grain yield (t ha^{-1}).

irrigation periods	brassinolide concentrations(mg L^{-1})					Average
	0	2	4	6	8	
6	8.17	8.25	8.41	9.75	10.07	8.93
8	7.56	8.14	8.10	8.33	8.55	8.13
10	6.01	6.44	6.69	6.96	7.26	6.67
Average	7.25	7.61	7.73	8.34	8.63	
LSD (p=0.05)	irrigation periods		brassinolide concentrations		Interaction	
	0.11		0.10		0.19	

The percentage of protein in grain: - The results in Table 7 showed a significant effect of the irrigation periods in the percentage of protein, where the 10-day irrigation period achieved the highest average of 12.05% compared to the 6-day irrigation period, which gave the lowest average of 10.59%.The reason for the increase in the proportion of protein when the irrigation periods are spaced is due to the rapid increase in the movement of nitrogen from the leaves to the grains during the period of filling the bean with a decrease in the accumulation of carbohydrates, which led to an increase in the proportion of protein in the grains and this is from the principle of control between the components of bean (Aldesuquy et al. 2012). . The results in Table 7 indicate that spraying the maize plant with brassinolide concentrations led to an increase in the protein content in the grains, where the concentration of 6 mg L^{-1} gave the highest average for trait reaching 11.56%, while the spraying treatment with a concentration of 0 mg L^{-1} gave the lowest average of 10.88 % , This may be due to the role of brassinolide in increasing the cell content of nucleic acids and protein and raising the efficiency of the photosynthesis process of the vegetative system by affecting some enzymes through stimulating the enzyme Carboxylase responsible for increasing protein and increasing the effectiveness of DNA and RNA Kumar (2012). The same table shows that there are significant differences for the interaction between irrigation periods and spraying concentrations of the brassinolide.The interaction treatment between the 10-day irrigation period and spraying with a concentration of 6 mg L^{-1} was superior, which gave the highest average of the harvest index of 13.12, compared to the lowest average of 10.27 for the interaction treatment between the 6-day irrigation period and concentration 0 mg L^{-1}.

Table 7. Role of irrigation periods and concentrations of brasserolide growth Regulator and Interaction between them in the average protein content in grain%.

irrigation periods	brassinolide concentrations(mg L^{-1})					Average
	0	2	4	6	8	
6	10.27	11.51	11.66	11.29	11.22	11.19
8	10.28	10.56	11.15	10.27	10.71	10.59
10	12.10	11.73	11.73	13.12	11.58	12.05
Average	10.88	11.27	11.51	11.56	11.17	
LSD (p=0.05)	irrigation periods		brassinolide concentrations		Interaction	
	0.52		0.45		0.80	

Conclusions:

The irrigation period of 6 days had a significant effect in increasing most indicators of vegetative growth and yield of corn. The treatment of spraying with the growth regulator brassinolide at a concentration of 8 mg L-1 was significantly superior in improving most of the studied traits under drought conditions, which was positively reflected in the increase in yield and its components.

References

1- **Al Shibr**, Blessed be the Merciful Hamdallah.2021. Effect of bio-vaccine and irrigation duration on growth and yield of maize Yellow and its readiness for some elements. Master's thesis. College of Agriculture, University of Al-Qadisiyah.

2- **Al-Akedi**, Hadeel Abdul-Razzaq Waheeb. 2015. Effect of duration between irrigations and potassium levels in Some characteristics of the growth and yield of yellow corn. Master Thesis. College of Agriculture - University of Baghdad.

3- **Aldesuquy** ,H. S .A .Abo-Hamed , A .M .Abbas and A.H.Elhakem.2012. Role of glycine betaine and salicylic acid in improving growth vigour and physiological aspects of drought wheat cultivars . JStress physio .Bioch ,8:150-170.

4- **Al-Mashhadani**, Ahmed Jamil Mahmoud. 2018. Response of growth parameters and yield of maize to regulator Brassinolide growth. Master Thesis. Baghdad University.

5- **Al-Sahoki**, Medhat Majeed (1990). Maize, its production and improvement, University of Baghdad, Ministry of Higher Education and Scientific Research, pg. 400

6- **Al-Sahoki**, Medhat Majid, Ayoub Obaid Al-Falahi and Ali Fadam Al-Mohammadi, 2009. Crop Management The soil is breeding for drought tolerance. Iraqi. J. Agri. Sci.40 (2): 1-28.

7- **Antony.**E**.,** K. Sridhar and V. Kumar.2017. Effect of chemical sprays and management practices on *Brachiaria ruziziensis* seed production Field Crops Research 211:19-26.

8- **Capehart,** T and O. Liefert. 2017. First Forecast for 2017/18 Lowers

Corn Supply and Use Feed outlook. Economic Research service. United States Department. . https://www.ers.usda.gov/publication.

9- Desoky, E. S. M., Mansour, E., Ali, M., Yasin, M. A., Abdul-Hamid, M. I., Rady, M. M., & Ali, E. F. (2021). Exogenously used 24-epibrassinolide promotes drought tolerance in maize hybrids by improving plant and water productivity in an arid environment. Plants, 10(2), 354.

10- **Domagalska**, M. A., Sarnowska, E., Nagy, F., and Davis, S. J. (2010). Genetic analyses of interactions among gibberellin, abscisic acid, and brassinosteroids in the control of flowering time in Arabidopsis thaliana. *PloS one*, *5*(11), e14012.

11- **El-Sahookie**, M. M.1985. A short cut method for estimating plant leaf area in maize . J. Agron. Crop Sci. 15(4):157-160.

12- **Gao,** Z., X. G.Liang, L. Zhang,S. Lin, X. Zhao, L.Li –zhou ,S. Shen and S.Li-Zhou.2017. Spraying exogenous 6- benzyladenine and Brassinolide at tasseling increases maize yield by enhancing source and sink capacity.Field Crops Research, 211,1-9.

13- **Hameedi**,I.H., A. S. Ati and .H. M.Karim. 2015 . Effect of Irrigation Period and Organic Fertilization (TOP10) on Growth, Production and Water Use by Maize Crop. Journal of Agriculture and Veterinary Science .,8(5): 2319-2380.

14- **Hart**, F. L., and Fisher, H. J. (1971). Introduction—General methods for proximate and mineral analysis. In *Modern food analysis* (pp. 1-27). Springer, Berlin, Heidelberg.

15- **Hassan**, Ali Abdel Hadi. 2019 .Studying the physiological and biochemical effects of stimulants Growth and biofertilizers in the growth and yield of maize under different irrigation levels PhD thesis. faculty of Agriculture . Baghdad University.

16- **Hu,** S., D.L. Sanchez, C. Wang, A.E. Lipka. Y. Yin,C. A. C. Gardner and T. Lubbersted. 2017. Brassinosteroid and gibbrerllin control of seedling traits in maize(*zea mays* L.). Plant Science. 263: 132-141.

Kenya . E. Afr. agric. Forg. 62 , (2) : 171 – 178 .

Kenyan and cimmyt maize germplasm -Mid-altitude Zone of

17- **Kramer,** P.J and J.S Boyer. 1995. "Water relations of plants and soils," Academic pres.

18- **Kumar**,H.2012.Isolation and characterization of brassinosteroid from (Camellia sinensis L.) Kntze and evaluation of their antioxidative potential. Ph.D.Thesis faculty of life ,Guru Nanak Dev University Amritsar.

19- **Odongo** , O.M. and A.J. Bockholt (1995) . Combining ability among

20- **Prasad**, P.V.V. , S.A. staggenborg and Z. Ristic .2008. Impaets of Drought and Or Heat stress on physiological , Developmental , Growth , and Yield processes of Crop plants . ASA , CSSA , SSSA , 677 S.segoe Rd , Modison , Wl 53711 , USA .

21- **Rasheed**, M., Hussain, A., & Mahmood, T. (2003). Growth analysis of hybrid maize as influenced by planting techniques and nutrient management. International Journal of Agriculture and Biology, 5(2), 169-171.

22- **Ross**,J.J. and L.J.Quittenden.2016.Interaction between Brassinolide and gibberellins: Synthesis or signaling .The Plant Cell.28:829-832.

23- **Shah**, T., H., Khan, M. A., A., Noor, Ghoneim, X., Wang, A. Sher, M. A. and Basahi. 2018. effects of potassium on phenological, physiological and agronomic traits of maize (zea mays l.) under high nitrogen nutrition with optimum and reduced irrigation. applied ecology and environmental research, 16(5): 7079-7097.

24- **Tanveer**, M., Shahzad, B., Sharma, A., & Khan, E. A .2019. 24-Epibrassinolide application in plants: An implication for improving drought stress tolerance in plants. Plant Physiology and Biochemistry, 135, 295-303.

25- **Zinselmeier**, C., B.R. Jeong, and J. S. Boyer.1999. Starch and the Control of Kernel Number in Maize at Low Water Potentials. Plant physiol.121:25-36.

26- Jader, Jassim Jawad, Abdullah Fadel Sarheed, and Rasha Adel Abdel Nabi. 2017. Response of four genotypes of maize (Zea mays L.) under the influence of water stress. Karbala University Scientific Journal, Volume 15 - Issue 1.