Effect of Addition different Levels of Potassium on The Yield of Maize under Water Stress Conditions.

Firas Abdul karim Makki Al-Gharawi* Hamza Nouri Al-Dulaimi Naim Shteiwi Matar

University of AL-Qasim Green / College of Agriculture/ Dept. of Field Crops

Firas1981221@gmail.com

naeem@agri.uoqasim.edu.iq

Abstract

In the fall of 2022, a study was conducted in an agricultural area in Raranjia (Hamzawiyah) province, situated 10 km south of Babylon Governorate and the center of Hilla. The study aimed to enhance the growth efficiency of Maize plants (Zea mays L.) Fajr 1 cultivar under water stress conditions through experimentation with different irrigation periods and amounts of potassium sulfate in soil with a sandy clay mixed texture. The experiment followed a randomized complete block design (R.C.B.D) with three replicates in a split-plot arrangement. The irrigation periods they consisted of four levels (6, 8, 10, and 12) days, while the levels of potassium sulfate included four levels (0, 150, 200, and 250) kg.h-1. The results indicated that the irrigation period of every eight days led to the highest yield, while 12 days significantly reduced output. Adding potassium sulfate also greatly enhanced maize yield, with the highest rates achieved at 250 kg.ha-1. Combining the two factors resulted in the highest average grain yield, with biological crops amounting to 8.7 tons.ha-1 and 19.06 tons.ha-1, respectively.

The study concluded that a balanced combination of irrigation periods and potassium sulfate levels can significantly improve maize yield.

Introduction

The maize crop (Zea mays L.) is one of the strategic crops for its economic and industrial importance. It represents one of the pillars of food security, and despite the appropriate environmental conditions for its cultivation in Iraq, its productivity is still low compared to the unit area due to the lack of basic factors, including water (17 ,31), as the cultivated area of maize for the year 2020 amounted to about 405,400 dunums, producing 419,300 tons, with an average productivity of 1.343 tons per dunum, a decrease of 21.3% from last season (16).

The term drought stress is used, which is a type of moisture stress as a result of the lack of water without increasing it, which affects plant growth, limits its productivity, and leads to many physiological and chemical effects of plants (6), as it causes a decrease of more than 50% of the global yield rate (36), especially maize (23,25).Several studies indicate that water stress causes many physiological and chemical changes in the plant and reduces yield significantly (35) which leads to reduced plant growth by reducing the absorption of water and nutrient (11). Reduced leaf size and stem elongation, root expansion and low water use efficiency (20) as well as inhibit cell elongation and division (19) and lead to stomata closure and reduced rates of transpiration in plant tissues as well as a decrease in metabolic activities such as photosynthesis, respiration, ion absorption, transport, carbohydrates, nutrient metabolism and growth stimulants, reduced

ISSN 2072-3857

leaf size and stem elongation, root expansion and low water use efficiency (16) as well as inhibit cell elongation and division (15) and lead to stomata closure and reduced rates of transpiration in plant tissues as well as a decrease in metabolic activities such as photosynthesis, respiration, ion absorption, transport, carbohydrates, nutrient metabolism and growth stimulants.

Potassium is one of the important positive ions in plant physiology due to its many physiological and biochemical functions (26) as potassium (K) can reduce the harmful effects of drought by causing various physiological changes such as modulation of osmotic pressure through its role in closing and opening stomata, protein synthesis and reducing the rate of transpiration. Potassium also plays an important role in the transport of sugars and protein in plants, as well as regulates the thickness of cellular roots, stimulates the activity of enzymes and enters into the formation of nucleic acids, especially ATP in plants suffering from water deficiency (19) and therefore the addition of potassium can mitigate the negative effects caused by drought on plant growth (38).

Therefore, the study aims to determine how the Zea mays plant responds to the addition of potassium under water stress conditions to determine the extent to which it is possible to compensate for the lack of water by adding a certain concentration of potassium in the form of potassium sulfate to the field planted with yellow corn as a water-consuming plant.

Materials and methods

A field experiment was conducted in agricultural land in the province of Raranjia (Al-Hamzawiyah), 10 km south of Babylon Governorate, the center of Hilla, in the agricultural season 2022 (autumn seasons) in soil with sandy clay mixed texture, the results of which are shown in Table 1. The experiment was applied according to the design of the complete randomized sectors (RCBD) and the order of split-plots and three repeats, as the irrigation periods included four levels of irrigation every (6, 8, 10 and 12) days is a main factor and the difficulty of distributing irrigation randomly has been working to divide the field into four irrigation systems are I0 irrigation every 6 days and I1 irrigation every 8 days and I2 irrigation every 10 days and I3 irrigation every 12 days and each system contains 12 experimental units were given five irrigations to the plant before applying irrigation periods as needed based on checking soil moisture manually and then applied irrigation periods, while potassium sulfate included four levels (0, 150, 200 and 250) $kg.ha^{-1}$ as a secondary factor was added to the soil in three equal batches, the first batch in the vegetative growth stage (three weeks after emergence), the second batch when the male inflorescences appeared, and the last batch when the kitten appeared, by digging a slit adjacent to the planting line at a distance of 5 cm.

Seeds of Maize (Zea Mays. L.) of the synthetic variety Fajr 1 were sown in the autumn season on 1/8/2022 within experimental units of dimensions of each (3×2 m). The experimental unit included four planting lines, the distance between one line and another 75 cm and between one plant and another 25 cm on one line, i.e. a plant density of 32 plants. Urea fertilizer (46% N) in the amount of 176 $kg.H^{-1}$ (33) was added in two batches, the first before planting with DAB fertilizer and the second batch at the beginning of flowering, and phosphate fertilizer was added at a rate of 140 kg.H-1 in the form of DAB fertilizer (DAP) (46% P2O5 and N21%) before planting and during soil preparation (33) . The corn stem borer insect (SesamiacreticaL) was controlled using the pesticide diazinon granulated (10% active ingredient) twice by feeding method, the first batch after 18 days of planting and the second two weeks after the date of the first control (3).

Table 1 Some chemical and physical properties of field soil.

Property	**Value**	**Unit**
Soil interaction degree Ph	7.6	-
Electrical Conductivity EC	4.06	$dS.m^{-1}$
Total nitrogen	40.5	$Mgm.Kg^{1}$
Available phosphorus	4.3	
Available potassium	135.24	
Sand	675.25	$gm.Kg^{-1}$
Silt	56.50	
Clay	263.00	
Soil texture	Sandy clay	
Soil moisture weight content		
at saturation 0 kPa	45.82	%
at 33 kPa	19.05	%
at 1500 kPa	9.88	%
Bulk density	1.30	μgm^{-2}

The total yield of cereals after weight adjustment was calculated on the basis of 15.5% humidity by multiplying only one plant yield (g) × plant density per hectare (53333 $plants.ha^{-1}$)(10). The biological yield was calculated after harvesting the random sample plants from above the soil surface, then dried aerobically under sunlight, then dried by a dryer at a temperature of 65 ° C for 72 hours, then dried at a temperature of 105 ° C on the oven for three hours and then weighed at the stability of the weight and then adjusted on the basis of hectare (1). The percentage of protein in the leaves and grains for all experimental units was also estimated, after digesting the samples by using the Caldal method to estimate the percentage of nitrogen and then calculate the percentage of protein through the following equation:

Protein % = Nitrogen %× 6.25 (21).

The amount of total carbohydrates dissolved in the leaves was estimated according to the method adopted by (24), where 250 mg of the dried sample was crushed with 10 ml of water and then discarded in the centrifuge and took the filtrate and completed the volume to 10 ml with distilled water, took 1 ml of the filtrate and added to it 1 ml of phenolic reagent concentration of 5% and 5 ml of sulfuric acid concentration of 80% after which the sample was left for 25 minutes until It becomes room temperature and then the light absorption intensity is measured at the wavelength of 490nm and Blank was prepared in the same way without adding the sample. The amount of total carbohydrates dissolved in the leaves was estimated according to the method adopted by (24), where 250 mg of the dried sample was crushed with 10 ml of water and then discarded in the centrifuge and took the filtrate and completed the volume to 10 ml with distilled water, took 1 ml of the filtrate and added to it 1 ml of phenolic reagent concentration of 5% and 5 ml of sulfuric acid concentration of 80% after which the sample was left for 25 minutes until It becomes room temperature and then the light absorption intensity is measured at the wavelength of 490nm and Blank was prepared in the same way without adding the sample.

Results and discussion

1- grain yield ton.ha^{-1}.

The results of the analysis of variance in Table (2) indicate a significant effect of irrigation periods ,levels of added potassium and the interaction between them on the total of grain yield of the maize plant. It had showed the presence of significant differences as a result of the effect of irrigation periods, As the periods of irrigation every 8 days, had achieved the highest average yield of 8.3 tons ha^{-1} compared to the periods of irrigation every 12 days had caused a significant decrease in the grain yield with an average of 6.0 tons.ha^{-1} The reason may be due to the exposure of plants to water stress has affected one or more of the components of the yield, as the lack of water, high temperature and low relative humidity during the period of growth and formation of ovaries may have affected the vegetative qualities and then decreased the products of photosynthesis and insufficient to form the largest number of rows and the low access of water and nutrients, specifically during the period of fullness of the grain leads to its small size and shrinkage and decline in the average weight of 500 grains While the availability of sufficient moisture caused an increase in the readiness of the elements then speed of their transfer to other parts and the wide activity in intercepting the falling solar rays, which contributes to the process of photosynthesis, which is the reason for the increase in the components of the yield and the weight of 500 grains reflected positively on the increase in grain yield. These results were consistent with the results of (2,33,13,4) who found that the spacing of irrigation periods significantly affected the decrease in grain yield per unit area of the maize crop.

As for the levels of added potassium, their effect was different from the irrigation periods, the values increased significantly with the increase in added potassium, as the potassium level of 250 kg.ha^{-1} achieved the highest average grain yield of 8.7 tons.ha^{-1} compared to the control treatment of 0 kg.ha^{-1}, which gave the lowest average grain yield of 5.1 tons.ha^{-1} .It is believed that the reason for this is that the addition of potassium has encouraged the absorption of other nutrients, especially nitrogen and phosphorus, and this was reflected in the yield of grains despite the spacing of irrigation periods, (14) in addition to the role of potassium in increasing vegetative growth indicators such as the number of leaves, their surface area, delaying aging, and then increasing the effective periods of grain filling and its reflection in increasing the yield (14).

The results of the table also showed a significant effect of the overlap between irrigation periods and potassium levels in increasing the average grain yield, as the interference treatment when watering every 8 days and the addition of potassium at the level of 250 kg.ha^{-1} gave the highest average of 4493.0 kg.ha^{-1}, while the lowest occurrence in the irrigation interference treatment was every 12 days with the addition of potassium at the level of 0 kg.ha^{-1} amounted to 2571.0 kg.ha^{-1} .

ISSN 2072-3857

Table (2) Effect of irrigation periods and potassium levels and their interaction on average grain yield for maize $ton.ha^{-1}$.

Treatment		Levels of Potassium $Kg.h^{-1}$				Average of Irrigation Duration
		0	150	200	250	
Duration of Irrigation Day	6	5.5	6.8	7.8	8.6	7.1
	8	5.6	8.4	9.3	10.0	8.3
	10	5.0	6.3	7.7	8.9	7.0
	12	4.5	5.6	6.7	7.3	6.0
Average of Potassium Levels		5.1	6.7	7.8	8.7	
L.S.D 0.05						
Duration of Irrigation		Levels of Potassium		Interaction		
0.2**		0.3**		0.4**		

2- Biological yield $ton.ha^{-1}$.

The results of the analysis of variance in Table (3) showed that there are significant differences in the biological yield by the effect of irrigation periods and levels of added potassium and the overlap between them in the average of this characteristic.The results of the table indicate that there are significant differences for irrigation periods in the average biological yield, as the biological yield decreased with increasing the periods between irrigation and another, and gave the lowest average for this trait of 12.4 tons.e-1 in the irrigation treatment every 12 days compared to the irrigation treatment every 8 days, which gave the highest average biological yield of 17.5 $tons.ha^{-1}$. It is believed that the reason for this is due to the decrease in the components of the yield as, which was reflected in the increase in biological yield and to the lack of vital activities in the vegetative total, represented by the height of the plant, its leaf area and the content of the leaves of chlorophyll and then its dry weight as a result of lack of water, and this leads to a defect in physiological processes such as photosynthesis, respiration, transpiration, water absorption and nutrients, Also, the moisture tension when the irrigation periods diverge negatively affects the processes of cell division, as it leads to a decrease in the number of dividing cells and prolonging the time required for division, and this is what (28) said, and this is consistent with what was obtained by (27,12,4) who indicated that water tension affects the reduction of the biological yield of maize crop.

While the added potassium levels led to a significant increase in the biological yield, the potassium level of 250 $kg.ha^{-1}$ gave the

ISSN 2072-3857

highest average biological yield of 19.0 tons.ha^{-1} compared to the control treatment of 0 kg.ha^{-1}, which gave the lowest average biological yield of 10.8. tons.ha^{-1}. This indicates the great role played by potassium in increasing yield and increasing the vegetative and root total, as potassium works to transport water and nutrients, which is an important factor in photosynthesis, as (8) stated that the addition of potassium led to an increase in the biological yield of maize crop.

Table (3) Effect of irrigation periods and potassium levels and their interactions on average plant biological yield of maize tons.ha^{-1}

Treatment		Levels of Potassium Kg.h^{-1}				Average of Irrigation Duration
		0	150	200	250	
Duration of Irrigation Day	6	11.4	14.8	17.6	19.0	15.7
	8	11.3	17.8	18.4	22.6	17.5
	10	10.9	13.1	16.4	17.9	14.6
	12	9.8	10.3	13.0	16.6	12.4
Average of Potassium Levels		10.8	14.0	16.3	19.0	

L.S.D 0.05		
Duration of Irrigation	Levels of Potassium	Interaction
1.9**	1.7**	N.S

3-Leaf protein content (%) .

The results showed in Table (4) that there is a significant effect of irrigation periods and levels of added potassium in the percentage of protein in the leaves, the effect of spacing between irrigation periods was significant in reducing the percentage of protein in the leaves, as the irrigation treatment every 12 days gave the lowest average for this trait amounted to 8.4% compared to the periods of irrigation every 5 days, which gave a concentration of protein of 10.5 %at the same time, the irrigation treatment every 8 days gave the highest concentration of 15.3% protein in the leaves,

The reason for the decrease in protein concentration may be attributed to the decrease in the absorbed amounts of nitrogen by increasing the irrigation period to 12 days, because in close periods, soil moisture is suitable for dissolving the nutrients in it, as the presence of ready-made images of nutrients is either dissolved in soil solution or reciprocated on its surfaces, That is, they are more ready for absorption by the plant compared to the periods of irrigation every 12 days, and this is consistent with the findings of (2,18) It was found that the concentrations absorbed of nitrogen in the maize grains increased with the

ISSN 2072-3857

convergence of irrigation periods and decreased with their spacing.

As for the effect of added potassium levels, it had a significant effect in increasing the concentration of protein in the leaves, as the potassium level of 250 $kg.ha^{-1}$ gave the highest average for this trait of 14.7% compared to the control treatment of 0 $kg.ha^{-1}$ The lack of potassium addition, which gave the lowest average protein concentration in the leaves amounted to 6.9%. It is believed that the increase in the concentration of protein in the leaves when increasing the levels of potassium added to the importance of potassium in the process of reducing nitrates and transporting and metabolizing amino acids and proteins in the plant in addition to building carbohydrates and increasing the effectiveness of photosynthesis and its products, and as a result increasing the protein content in the leaves.

Table (4) Effect of irrigation periodss and potassium levels and their interaction on leaf protein content (%) for maize.

Treatment		Levels of Potassium $Kg.h^{-1}$				Average of Irrigation Duration
		0	150	200	250	
Duration of Irrigation Day	6	7.1	10.5	11.3	13.2	10.5
	8	8.9	15.1	15.2	22.1	15.3
	10	6.7	9.2	11.1	12.4	9.8
	12	4.9	8.5	9.3	11.0	8.4
Average of Potassium Levels		6.9	10.8	11.7	14.7	

L.S.D 0.05		
Duration of Irrigation	Levels of Potassium	Interaction
1.0**	1.1**	N.S

4-Protein content of grains (%) .

The results showed in Table (5) that there is a significant effect of irrigation periodss and potassium levels and the overlap between them in the percentage of protein in grains, the effect of spacing between irrigation periods was significant in reducing the percentage of protein in grains if the irrigation treatment every 12 days gave the lowest average for this trait amounted to 8.5% compared to the periods of irrigation every 5 days, which gave a concentration of protein of 14.2% at the same time gave the irrigation treatment every 8 days the highest concentration of 18.4% in the concentration of protein in the grains. The reason for the decrease in protein concentration may be due to the decrease in the absorbed amounts of nitrogen by increasing the periods of irrigation to 12 days, because in close periods the soil

ISSN 2072-3857

moisture is suitable for dissolving the nutrients in it, as the presence of ready-made images of nutrients is either dissolved in the soil solution or reciprocated on its surfaces, meaning that it is more ready for absorption by the plant compared to the periods of irrigation every 12 days.

As for the effect of added potassium levels, it had a significant effect in increasing the concentration of protein in the grains, as the potassium level of 250 $kg.ha^{-1}$ gave the highest average for this trait of 17.7% compared to the control treatment of 0 $kg.ha^{-1}$ No potassium was added, which gave the lowest average protein concentration in cereals of 8.8%. It is believed that the increase in the concentration of protein in grains when increasing the levels of potassium added to the importance of potassium in the process of reducing nitrates and transporting and metabolizing amino acids and proteins in the plant in addition to building carbohydrates and increasing the effectiveness of photosynthesis and their products, and as a result the activity of the ongoing transport processes of nitrogen compounds from source to downstream and then increasing the concentration of nitrogen in grains (7 ,28) and this is consistent with what (2,18) found.

As for the interactions between irrigation periods and potassium levels, it had a significant effect in increasing the protein content in cereals of the yellow corn plant, as the highest value was 23.8% in the interference treatment when irrigating every 8 days with the addition of potassium at the level of 250 $kg.ha^{-1}$, while the lowest value of the irrigation interference treatment was every 12 days with no potassium added 0 $kg.ha^{-1}$, which amounted to 5%, due to the importance of potassium. As for the overlap between irrigation periods and potassium levels, it had a significant effect in increasing the protein content in cereals of the maize plant, as the highest value was 23.8% in the interference treatment when irrigating every 8 days with the addition of potassium at the level of 250 $kg.ha^{-1}$, while the lowest value of the irrigation interference treatment was every 12 days with no potassium added 0 $kg.ha^{-1}$, which amounted to 5%, due to the importance of potassium.

Table (5) Effect of Irrigation and potassium levels and interaction between them on grain protein content (%) of maize

Treatment		Levels of Potassium Kg.h^{-1}				Average of Irrigation Duration
		0	150	200	250	
Duration of Irrigation Day	6	8.5	12.5	14.4	21.2	14.2
	8	14.9	15.7	19.2	23.8	18.4
	10	6.9	11.4	12.1	14.8	11.3
	12	5.0	7.8	10.0	11.1	8.5
Average of Potassium Levels		8.8	11.8	13.9	17.7	
L.S.D 0.05						
Duration of Irrigation		Levels of Potassium		Interaction		
2.8**		1.7**		3.4**		

5-Carbohydrate content of leaves (%).

The results of Table (6) showed a significant effect of irrigation periods and levels of potassium added in the concentration of carbohydrates in the leaves of the maize plant, the effect of irrigation periods was significant in reducing the concentration of carbohydrates in the leaves of the yellow corn plant, if the periods of irrigation every 12 days gave the lowest value of carbohydrate concentration in the plant amounted to 3.5% compared to the treatment of watering every 8 days, which gave the highest concentration of carbohydrates amounted to 5.5%. This may be attributed to the plant's exposure to spacing in irrigation periods reduces its ability to absorb essential nutrients, which leads to reduced cell growth and division and a decrease in photosynthesis and lack of outputs, and this is consistent with what was mentioned by (37,28) , either the effect of potassium levels was significant in increasing the concentration of carbohydrates in the leaves, as the potassium addition treatment gave 250 kg.ha^{-1} The highest rate for this trait amounted to 5.7% compared to the control treatment of 0 kg.ha^{-1} No potassium addition, which gave the lowest concentration carbohydrates were 2.7%. The reason for this may be attributed to the role of potassium in the transfer and movement of carbohydrates from the places of formation to the places of storage and its great role in the metabolism of carbohydrates in plants.

ISSN 2072-3857

Table (6) Effect of Irrigation periods and potassium levels and the Interaction between them on the carbohydrate content of leaves (%) for maize

Treatment		Levels of Potassium Kg.h^{-1}				Average of Irrigation Duration
		0	150	200	250	
Duration of Irrigation Day	6	2.6	3.1	4.4	5.0	3.8
	8	3.2	5.7	6.4	6.8	5.5
	10	2.9	4.0	5.5	6.6	4.7
	12	2.3	2.9	4.3	4.6	3.5
Average of Potassium Levels		2.7	3.9	5.2	5.7	

L.S.D 0.05		
Duration of Irrigation	Levels of Potassium	Interaction
1.1**	1.1**	N.S

6-Carbohydrate content of grains (%) .

It is noted from Table (7) the significant effect of irrigation periods and potassium levels and the interaction between them in the concentration of carbohydrates in the grains of the yellow corn plant, which decreased significantly in the irrigation treatment every 12 days and gave the lowest value of 68.9% when compared with the control treatment of irrigation every 5 days, which gave 73.0% to the concentration of carbohydrates, while the treatment of irrigation every 8 days gave the highest rate for this trait of 74.2%.The reason for this may be attributed to the increase in the percentage of protein in irrigation coefficients due to the rapid increase in the movement of nitrogen from leaves to grains during the period of filling the grain with a decrease in the accumulation of carbohydrates, which led to an increase in the percentage of protein in the grains, and this is from the principle of compensation between the components of the grain (5) . These findings are consistent with the findings of (33,15) who pointed out that water tension led to an increase in the percentage of protein in grains and thus a decrease in the percentage of carbohydrates in grains exposed to high stress.

As for the levels of potassium added, their effect was significant in increasing the content of the grains of carbohydrates, the potassium level of 250 kg.ha^{-1} gave the highest value of carbohydrate concentration of 75.7% compared to the control treatment 0 Kg.ha^{-1}, which gave the lowest carbohydrate content of 68.3%, may be attributed to the significant role that potassium plays within the plant in activating energy transfer enzymes, the formation of sugar, starch and protein, as well as carbohydrates and increasing the conversion of photosynthetic products into dry matter in grains (7,22).

There was no significant effect of the interaction between irrigation periods and

ISSN 2072-3857

potassium levels on the concentration of carbohydrates in maize grains.

Table (7) Effect of irrigation periods and potassium levels and their interaction on grain content of carbohydrates (%) of maize.

Treatment		Levels of Potassium Kg.h^{-1}				Average of Irrigation Duration
		0	150	200	250	
Duration of Irrigation Day	6	68.9	71.4	74.7	77.1	73.0
	8	70.1	73.2	75.5	78.2	74.2
	10	67.7	70.0	73.9	75.8	71.8
	12	66.3	68.3	69.7	71.6	68.9
Average of Potassium Levels		68.3	70.6	73.4	75.7	
L.S.D 0.05						
Duration of Irrigation		Levels of Potassium			Interaction	
1.2**		1.2**			N.S	

References

1- **A.O.A.C. 1975.** Association of Official Analytical Chemists . Official method of analysis . A.O.A.C. 10th (Ed.) republished by A.O.A.C. Washington , D. C., U. S. A. , V. 58 (4) . pp : 115.

2- **Al-Akidi, Hadeel Abdul Razzaq Wahib. 2015.** Effect of duration between irrigations and potassium levels on some growth characteristics and maize yield Zea mays L. Master Thesis. College of Agriculture – University of Baghdad.

3- **Al-Ali,Aziz. 1980 ..** Agricultural Pest Control Guide - Public Authority for Plant Protection - Prevention Research Section, Ministry of Agriculture and Agrarian Reform.

4- **Al-Bakri, Aad Abdullah Obaid.2022.**Effect of parasinolide growth regulator and irrigation durations on the growth and yield Zea mays L. Master's thesis. Faculty of Agriculture - Al-Qasim Green University.

5- **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 . JStreet Physio. Bioche, 8:150-170.

6-**Abedelgawad , Z.A,A.A. Khalafaallah and M.M. Abdallah.2014.**Impact of methyl jasmonate on antioxidant activity and some biochemical aspects of maize plant grown under water stress condition. Agric. Sci., 5(12): 1077-1088.

7-**Ahanger,.M .A , R . M . Agarwal , N.S . Tomar .and M. Shrivastav. 2015.** Potassiun minduces positive changes nitrogen metabolism and antioxidant system of oat (Avena sativa L cultivar

ISSN 2072-3857

kent) .J. plant Interactions , 10 (1) : 211-223 .

8-Akram , A. , M. Fatima , S. Ali , G. Jilani and R. Asghar.2007. Growth , Yield and Nutrients uptake of Sorghum in response to integrated phosphorus and potassium management. Pak. J. Bot. , 39(4):1083-1087.

9-Aparna, B. 2001. Potassium status and enzymatic activities un different agroecosystems of Kerala. Proceeding international symposium on importance of potassium nutrient management for sustainable crop production in 1 PRII-IPI, New Delhi, India.

10-Al-Sahuki, Medhat Majeed. 1990. Zea mays: Its Production and Improvement, University of Baghdad, Ministry of Higher Education and Scientific Research, p. 400.

11-Aslam, M. , M.S. Zamir , I. Afzal , M. Yasseen , M. Mubeen , A. Shoaib.2013. Drought stress, its effect on maize production and development of drought tolerance through potassium application. Cercetări Agronomice în Moldova Vol. XLVI , No. 2 (154) / 2013.pp:99-114.

12-Al-Obaidi, Haider Mohsen Rashid. 2014. Effect of spraying with salicylic acid and phosphorus on the growth and yield of yellow corn Zea mays L under under-irrigation conditions. Al-Qasim Green University. Master's thesis. Faculty of Agriculture.

13- Baque, A., A. Karim, A. Hamid , and H. Tetsushi.2006. Effects of Potassium Fertilizer on Growth , Yield and Nutrient Uptake of Wheat (Triticum aestivum) under Water Stress Conditions. South Pacific Studies.27(1): 25-35.

14- Ebrahimi, S. T. , M. Yarnia , M. B. K. Benam and E. F. M. Tabrizi. 2011. Effect of potassium Fertilizer on corn yield (Jeta cv.) under Drought Stress condition. Am-Euras . J. Agric & Environ. Sci. , 10(2): 257-263.

15-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.

16- Directorate of Agricultural Statistics - Central Bureau of Statistics / Iraq (2020).

17- Faraj, Ali Hussein and Abdul Wahab Abdul Razzaq. 2007. Effect of ground and foliar fertilization with NPK elements on the properties and quality of wheat grains. Iraqi Journal of Agricultural Sciences. 37(5) : 11-25 .

18-Farhan, Louay Dawood.2017. Effect of irrigation dates and potassium and antitranspiration levels on maize growth and yield. PhD thesis. College of Agriculture, University of Baghdad.

19- Farooq . M , A. Wahid, N. Kobayashi, D. Fujita and S.M.A. Basra .2009. Plant drought stress effects , mechanisms and mangement . Agron. Sustain. Dev., 29: 186 – 212.

20-Jaleel , C. A., Manivannan , P. A., Wahid, A., Farooq, M., Al-Juburi, H. J., Somasundaram, R. A., & Panneerselvam, R. 2009. Drought stress in plants: a review on morphological characteristics and pigments composition. *Int. J. Agric. Biol*, *11*(1), 100-105.

21- Hart , F. L., and Fisher, H. J. (1971). Introduction—General methods for

ISSN 2072-3857

proximate and mineral analysis. In *Modern food analysis* (pp. 1-27). Springer, Berlin, Heidelberg.

22- Havlin , J. L. ;J. D. Beaton , S. L. Tisdal ,and W. L. Nelson .2005. Soil fertility and fertilizers . 7 th Ed. An introduction to nutrient management.Upper Saddle River, New Jersey .

23- Hirich, A., Fatnassi, H., Ragab, R., & Choukr-Allah, R. 2016. Prediction of climate change impact on corn grown in the south of Morocco using the saltmed model. Irrigation and Drainage, 65(1), 9–18. https://doi. org/10.1002/ird.2002 .

24- Kerepesi, I and Galiba, G. 2000. Osmotic and Salt Stress-Induced Alteration in Soluble Carbohydrate Content in Wheat Seedlings. CropScience, 40(2): 482-

25-Khongdee, N., Hilger, T., Pansak, W., & Cadisch, G. 2021. Early planting and relay cropping: Pathways to cope with heat and drought? Journal of Agriculture and Rural Development in the Tropics and Subtropics, 122(1), 61–71. https://doi.org/10.17170/kobra-20210 4133652

26- Mengel, K., and E. A. Kirkby. 2001. Principles of plant nutrition.5thed.press,Londn.

27- Nabizadeh , E., **M. Banifazel and E. Taherifard .2012.** The effects of plant growth promoting on some of traits in maize (cv. S.C.704) under drought stress condition . Euro. J.Exp. Biol., 2(4):875-881

28- Najy , Aram Sameer. 2009. Response of corn (*Zea mays* L.) to deficit irrigation at different growth stages. A thesis of master.College of Agriculture. Al-Sulaimani university.

29-Netondo, G. W. , G. C. Onyango and E. Beck.2004. Sorghum and Salinity : I. Response of growth , water relations and Ion Accummulation to NaCl Salinity. Crop Sci. 44(3): 797-805.

30- Rezaeian ,M .,E .R .Petroudi ,M .Mohseni and M.H.Haddad . 2014 . Effect of row spacing , nitrogen and potassium fertilizer on yield of silage corn after wheat harvesting . Int . J.plant.Anim . Envi. Sci ., 4 (3) : 358-361 .

31- Sallah , P.Y.K.; Antwi, K.O. and Ewool, M.B. 2002. Potential of elite maize composites for drought tolerance in stress and non drought stress environments . Afr. Crop Sci. J., 10: 1-9.

32-Simsek ,M., A.Can,N.Denek and T.Tonkaz. 2011. The effect of different irrigation regimes on yield and silage quality of corn under semi-arid condition . African Journal of Biotechnology 10(31) : 5869-5877.

33-Shukla ,R.S.; P . S . Chandel .2010. A Text Book of Ramager, . Plant Ecology . S. Chard and Company Ltd New Delhi :544p.

34- Soni , N. V., H. L. Dhaduk , C. K. Desai and J. R. Patel. 2018. Comparative response of *Zea mays* L. genotypes to moisture stress regimes. J. of Pharmacognosy and Phytochemistry., 7(1):1393-1397.

35- 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.

36- Wang, Z. L.; B. R. Huang and Q. Z. Xu. 2003. Effect of abscisic acid on

ISSN 2072-3857

drought responses of Kentucky bluegrass. Am. Soc. Hort. Sci., 128(1): 36-41.

37-Weedsoft .2006. Corn Growth Stage development URL: http://weedsoft.unl.edu/documents/GrowthStageModule/Corn/

38-Zhang, K., B. Pang, I. Kisekka, M. Zhang, D. Rogers and D.Wang. 2018. Effect of irrigation on physicochemical properties and bioethanol yield of drought tolerant and conventional corn. Irrig. Sci., 1-11.

ISSN 2072-3857