Effect of Spraying Concentration of Silicon on some Physiological Characteristics of varieties of Maize by the effect of Water Stress

Hayder Hilal Abbas Alkhafagi1 Jassim Jawad Jader Alnuaimi2

1Department of Field Crop, College of Agriculture, Al-Qasim Green University, Babylon, Iraq.

2Department of Plant Production Techniques, Al-Musayyib Technical College, Al-Furat Al-Awsat Technical University, Babil, Iraq.

1E-mail: haider079@agre.uoqasim.edu.iq

2E-mail: alnuaimid92@atu.edu.iq

Abstract.

A field experiment was carried out in the Musayyib Technical College field for the autumn season 2021 to demonstrate the effect of silicon on some physiological characteristics of maize under the influence of water stress.. the split-split plot experiment was designed with (R.C.B.D)design with three Replication, including three water stress Treatments called it (I3, I2, I1) placed in the main plot, while the secondary panels They were include to the concentrations silicon (potassium silicate) (K2SiO3) called it (C1,C2,C3)(0,1,1.5m.L) respectively, As for the varieties(Tarkeby 5018, Sumer ,Baghdad 3) (V1, V2, V3), respectively, they were placed in the sub- sub secondary panels. The results show that there are significant differences for the leaf content of chlorophyll and the amino acid proline when depleting 50% of the available water (I1) and its interactions with the concentrations of silicon (C) and varieties (V), as the combination (V2*V3*I1) achieved The highest average of the traits was 46.327 mg.g-1wet.w. While the treatment (I3,V3,C1) was superior in giving the highest average of the proline content in the leaves reached 4.7367 Micromole. gm-1. The lowest average chlorophyll content was recorded with the treatment When the depletion treatment was 90% available water (I3) and its interactions, (v1*c1*I3) achieved the 22.583. mg.g-1wet.w, and the lowest average proline content was recorded with the treatment When the depletion treatment was 50% available water (I1) and its interactions, where the combination(v2*c3*I1) achieved the 3.6367 Micromole. gm-1 ,the highest rate of chlorophyll content and the lowest rate of proline content were recorded with the depletion treatments (I1) 50% achieved 39.746 mg.g-1wet.,3.8570 Micromole.gm-1respectively. The binary interaction between the water treatment and silicon concentrations (I*C) is significantly superior to the interaction (I1*C3) (50%, 1.5 ml/L-1 silicon) achieved 43.854 mg.g-1wet.w for the chlorophyll content. the lowest average chlorophyll content was recorded with the treatment (I3,C1) achieved 23.622 mg.g-1wet.w,and the lowest average proline content was recorded with the treatment (I1,C3) 3.6967 Micromole. gm-1 .all the binary interactions were significant between the depletion coefficients and varieties on the one hand, and the concentrations and varieties from the other side

Keywords. Water stress, Zea mays, Silicon, Chlorophyll content.

Introduction

Corn is one of the grain crops with high economic returns and comes in third place after wheat and rice in terms of importance in feeding low-income peoples, and it is characterized by its high ability to produce dry matter [1], and it is involved in many industrial fields such as the feed and oil industry. It is a very productive and fast-growing crop during a period of time approximately three months[2]. Iraq suffers from a scarcity of water resources because it is located within the semi-arid regions and because of the scarcity of water, which is one of the most important determinants that impede the cultivation of maize in addition to climatic fluctuations, drought and desertification due to increasing temperatures, and the consequent loss of large areas of arable land ,Therefore, this requires the application of different field technologies through irrigation scheduling and the use of anti-transpiration agents such as silicon. It is considered one of the effective methods in reducing the effects of water shortage, such as lack of crops and low growth rates in maize plants, and water stress from environmental stresses affecting crop production [3]. It may cause a clear reduction in growth, which reduces photosynthesis because the decrease in water content negatively affects the reproductive stages, which calls for maintaining the water stock during this period by increasing the efficiency of water use [4], Silicon is one of the necessary elements for yellow corn for its essential role in protecting the plant from high temperatures and transpiration and reducing the negative effects of water stress in field crops [5]. As well as the positive role it plays in regulating water relations within plant tissues and reducing transpiration through the formation of an insulating layer (silicon-cuticle) [6,7].The aim of the study To find out the importance of silicon in reducing the effect of drought

1. .2 Materials and Methods

A field experiment was carried out in the fields of Al-Musaiyb Technical College in the autumn season of 2021, To show the effect of silicon on some qualitative characteristics of maize under the influence of water stress in a mixed clay soil. Split-split plots experiment, according to the RCBD design .The relationship between the structural tension and the moisture content of the field soil sample sieved with a sieve with holes diameter of(2 mm) was estimated to estimate the soil water holding capacity as different stresses (33, 100, 300, 500, 1000 and 1500) k.Pa were applied to it. The relationship between relative moisture content (%) and moisture tension was plotted and represented graphically in the soil moisture description curve. The soil available water content was calculated from the difference in volumetric moisture content at field capacity and wilting point, The experiment included three replications and three treatments for adding irrigation water placed in the main panels, which are irrigation when draining 50%, 70%, 90% of the amount of available water (I_1, I_2, I_3)respectively , while the secondary panels were allocated to spraying concentrations of silicon (10% K_2O, SiO_2 25%) (K_2SiO_3) at a concentration of (0, 1, 1.5) ml/L^{-1} (C_1,C_2,C_3) respectively, As for the varieties (Tarkeby 5018 , sumer , Baghdad 3) (V1,V2,V3) respectively, they were placed in the sub- sub secondary panels.

the seeds were planted and irrigated on 30/07/2021, Soil moisture was measured after calibrated by the weight method to measure the humidity of the soil of the field, by taking soil samples from the experimental units (treatments) for different depths from (0-0.4 m) and according to the depth of the rootstock, drying them at a temperature of 105°C for 24 hours and extracting the moisture percentage Relative humidity was measured with a device relative humidity meter (Soil Moisture Meter model:PMS-714-Lutron Electronic Enterprise CO;LTD) according to the following equation [8]:

$$(Pw\%) = \frac{Mw - Dw}{Dw} \times 100 \quad (1)$$

Pw% = moisture content based on dry weight.
Mw = moisture weight (gm).

Dw = dry weight (g).

After following up on the depletion of (50%, 70% and 90%) of the available water in the experimental units, the experimental units are re-irrigated by adding water for each experimental unit. according to the following equation [9]:

$$w = a \times \ell b \left[\frac{\%Pw^{f.c} - \%Pw^{w}}{100} \right] \times \frac{D}{100} \quad (2)$$

W = the volume of water to be added during irrigation (m^3).

a = irrigated area (m^2).

ℓb = Bulk density (mg. m^{-3}).

$Pw^{f.c}$ = Percentage of soil moisture based on weight at field capacity(after irrigation).

Pw^{w} = Percentage of soil moisture before watering.

D = Depth of soil to be irrigated (m).

The following characteristics were studied:

- Chlorophyll content of the leaves $mg.g^{-1}$ wet.w [10].
- Leaf content of proline (µg g^{-1}) [11].

The data were statistically analyzed according to the RCBD design in the arrangement of the split split panels in the Genstat program, and the arithmetic means of the coefficients were compared using the least significant difference test at the 5% probability level [12].

.3Results and Discussion

.3.1Chlorophyll Content of the Leaves mg. g-1 wet .w

The results showed in Table (1) that there was a significant superiority in the chlorophyll content in the leaves in relation to the triple interaction between water depletion Varieties and silicon concentrations. (I*C*V) As the highest rate of the trait was at the treatment (v2,c3, I1,) which gave 46.327 mg. g-1 wet .w, While the lowest rate was the treatment(I3,C1,V1) which gave22.583 mg. g-1 wet .w and the reason may be attributed to the effect of water stress, lack of water absorption and the transfer of photosynthetic products, this result is in agreement with the result [13]. that the water tension significantly affected the chlorophyll content of maize ,As for the interaction between (I*C) the depletion of the available water and silicon was significantly , the treatment (I1*C3), which gave43.854 mg. g-1 wet.w, while the lowest average for the trait was when treatment (I3*C1), where it reached 23.622 mg. g-1 wet.w the reason may be attributed to the role of silicon in inhibiting the synthesis of ethylene responsible for the destruction of chlorophyll, as well as its ability to reduce heat stress and maintain the water content of the leaf [14].As for the attrition coefficients, the treatment was superior(I1) which gave39.746 mg. g-1 wet.w, While the lowest rate was(I3) where it reached 26.480 mg. g-1 wet.w,. Also, the interaction between the depletion treatments and cultivars (I*V) was a significant. the treatment (I1*V2) giving the highest average of, 41.241 mg. g-1 wet, the lowest rate recorded when treatment was (I3*V1), which amounted to 25.254 mg. g-1 wet, the cultiver, Sumer (v2) outperformed with an average of 35.407 mg. g-1 wet on the two cultivars Baghdad and Bohouth 5018 (V1, V3), the interaction between cultivars and silicon concentrations (C*V) was a significant, as the highest rate of the trait when overlapping was (C3*V2) with a rate of 39.747 mg. g-1wet.w, while the lowest average of the trait when overlapping was (C1*V1) With rate of 29.492 mg.g-1wet.w, the concentrations (C3) was a highest average of 37.473 mg.g-1wet.w. the lowest rate of the concentration (C1), which gave 30.694 mg

Table 1. Effect of water stress, silicon and cultivars and the interaction between them on The chlorophyll content of the leaves mg. g-1 wet .w.

Cultivar					
Mean	**V3**	**V2**	**V1**	**silicon .conce**	**Water stress**
	36.250	36.907	34.837	C_1 (0) ml. L	
	40.007	40.490	37.660	C_2 (1) ml. L	I1 50%
	44.330	46.327	40.907	C_3(1.5) ml. L	
	32.743	33.583	31.057	C_1 (0) ml. L	
	34.433	36.917	34.030	C_2 (1) ml. L	I2 70%
	39.857	42.097	34.843	C_3(1.5) ml. L	
	24.173	24.110	22.583	C_1 (0) ml. L	
	26.183	27.417	24.953	C_2 (1) ml. L	I3 90%
	29.857	30.817	28.227	C_3(1.5) ml. L	
		I*C*V= 0.8862			LSD 0.05
Mean	C3	C2	C1		
39.746	43.854	39.386	35.998	I1	I*C
35.507	38.932	35.127	32.461	I2	
26.480	29.633	26.184	23.622	I3	
I= 0.4408		I*C= 0.5511			LSD 0.05
Mean	I3	I2	I1		
32.122	25.254	33.310	37.801	V1	I*V
35.407	27.448	37.532	41.241	V2	
34.204	26.738	35.678	40.196	V3	
V= 0.2963		I*V= 0.5403			LSD 0.05
Mean	V3	V2	V1		
30.694	31.056	31.533	29.492	C1	C*V
33.566	33.541	34.941	32.214	C2	
37.473	38.014	39.747	34.659	C3	
C=0.3136		C*V=0.5066			LSD 0.05

Prolen Content of the Leaves Micromol.gm-1

The results shown in Table (2) regarding the triple interaction between the tensile tretment, silicon and varieties (I*C*V) indicate that there is a significant effect of the interaction on the average of the trait, as the combination (v3*c1*I3) achieved the highest mean for the trait reached 4.7367 Micromole. gm-1

,and the lowest rate of the trait was with the combination (v2*c3*I1), which gave 3.6367 Micromole. gm-1, and the reason for the lack of water content of the plant has inhibited the process of building protein, leading to an increase in the level of amino acids, including the amino acid proline [15.[

As for the binary interaction between the depletion of available water and silicon concentration, the treatment (I3*C1) significantly outperformed the rate of this trait, reaching 4.7133 Micromole. gm-1.as for the lowest average for the trait, it was at the treatment (I1*C3) with the lowest average of 3.6967 Micromole. gm-1 the reason may be due to the effect of silicon in reducing the osmotic effort and improving the water relations of the plant [17,18] which does not require the synthesis of proline and its synthesis in large quantities to raise the osmotic effort.

As for the stress coefficients(I), the results indicate that there is a significant difference for the trait when treating the depletion of 90% (I3) at a rate of 4.5411 Micromole. gm-1, and the lowest average was when treating(I1) 50% where it reached 3.8570 Micromole. gm-1,

As for the interaction between the depletion of available water and the varieties, the results indicated that there were significant differences for the trait. The treatment (I3*V1) had the best luck with a rate of 4.5633 Micromole. gm-1, while the lowest rate for the trait when the treatment was (I1*V2) at a rate of 3.8011 Micromole. gm-1. As for the cultivars, the cultivar Buhouth 5018(V1) gave the highest average for the trait with a rate of 4.1659 Micromole. gm-1, in contrast to the cultivar Sumer, which gave the lowest rate of 4.0859 Micromole. gm-1for the trait.

Also, the results of the interaction between the concentrations of silicon and cultivars(C*V) indicated that the trait was significant, as the highest rate of the trait reached (C1*V3) at the rate of 4.3700 Micromole. gm-1, While the lowest average of the trait when overlapped was (C3*V2) at a rate of 3.8856 Micromole. gm-1.As for the concentrations, the concentration (C1) was superior to an average of 4.3448 Micromole. gm-1,unlike the concentration (C3), which gave the lowest rate for the trait, which reached 3.9459 Micromole. gm-1 .

Table 2. Effect of water stress, silicon and cultivars and the interaction between them on The proline content of the leaves Micromole. gm-1.

Cultivar					
Mean	**V3**	**V2**	**V1**	**Silicon Concon**	**Water stress**
	4.0367	3.9867	4.0467	C_1 (0) ml. L	
	3.8600	3.7800	3.9133	C_2 (1) ml. L	I1 50%
	3.6833	3.6367	3.7700	C_3(1.5) ml. L	
	4.3367	4.2467	4.3100	C_1 (0) ml. L	
	3.9900	3.9067	3.9600	C_2 (1) ml. L	I2 70%
	3.7933	3.7267	3.8033	C_3 (1.5) ml. L	
	4.7367	4.6833	4.7200	C_1 (0) ml. L	
	4.5500	4.5133	4.5667	C_2 (1) ml. L	I3 90%
	4.4033	4.2933	4.4033	C_3 (1.5) ml. L	
		I*C*V= 0.05971			$LSD_{0.05}$
Mean	C3	C2	C1		
3.8570	3.6967	3.8511	4.0233	I1	I*C
4.0081	3.7744	3.9522	4.2978	I2	
4.5411	4.3667	4.5433	4.7133	I3	
I=0.03243		I*C= 0.03320			$LSD_{0.05}$
Mean	I3	I2	I1		
4.1659	4.5633	4.0244	3.9100	V1	I*V
4.0859	4.4967	3.9600	3.8011	V2	
4.1544	4.5633	4.0400	3.8600	V3	
V=0.02132		I*V=0.03929			$LSD_{0.05}$
Mean	V3	V2	V1		
4.3448	4.3700	4.3056	4.3589	C1	C*V
4.1156	4.1333	4.0667	4.1467	C2	
3.9459	3.9600	3.8856	3.9922	C3	
C=0.01366		C*V=0.03248			$LSD_{0.05}$

Reference

[1] Al-Sahoki M M 1990. Yellow corn production and improvement Ministry of Higher Education and Scientific Research University of Baghdad p 400

[2] Al-Douri S A M 2002. Response of growth and yield of yellow maize as green fodder to nitrogen fertilization under different plant densities and weed stages. Master's thesis. College of Agriculture and Forestry - University of Mosul.

[3] Abdul Amir, Osama Q 2018. The Effect Of Anti-Transpiration And Humic Acid On The Growth Yield And Quality Of Maize Under Water Stress Conditions. PhD Thesis University Of Baghdad / College Of Agriculture

[4] Ronaghi, A S A A M and R Ghasemi 2017. The effect of vermicompost on reducing the adverse effects of water stress on growth and chemical composition of corn in soil Majallah-i ab va Khak 30(5) 1607-1619.

[5] Araujo A, G C S N, Luz P 2019. Potassium silicate as a resistance elicitor in sweet corn yield traits under water stress revista colombiana de science horticoles Vol 13 No 1 p 99-107 January-April 2019.

[6] Ma,JF 2005.Role Of Silicon In Enhancing The Resistance Of Plant To Biotic And A Biotic Stresses Soil Sci Plant Nature50(1) 11-18.

[7] Ma J F, Miyake Y and Takahashi E 2001. Silicon as a beneficial element for crop plants In Silicon in Agriculture Ed LE Datnoff G D Snyder and G H Korndofer p 17-39 Elsevier Science Amesterdam.

[8] Hassan, H M 1990. Soil Physics Ministry Of Higher Education And Scientific Research University Of Al Mosul.

[9] Yang, L J C ,Fountain, P Ji X Ni S Chen R D Lee and B Guo 2018. Deciphering drought- induced metabolic responses and regulation in developing maize kernels Plant bio j 1-13.

[10] Zhang, J and M B kirkham 1996. Antioxidant responses to drought in sunflower and sorghum seedling New phytol 132 361-373.

[11] Bates, L S, R P Waldes, and T D Teare 1973. Rapid determination of free proline for water stress studies Plant Soil 39 205-207.

[12] Steel,Rand J Torrie 1980. Principles And Procedures Of Statics.2nd Edition Mcgrew Hillbook Newyork USA Pp194.

[13] 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.

[14] Jill, E 2017. Potential benefits of drought and heat tolerance for adapting maize to climate change in tropical environments Climate Risk Management 19 106-119 .

[15] Van Gioi H, M G Mallikarjuna, M Shikha, B Pooja, S K Jha, P K Dash and T Nepolean 2017.Variable level of dominance of candidate genes controlling drought functional traits in maize hybrids. Front. Plant Sci 8 940 doi 10 3389 /fpls 2017 00940 .

[16] Khalil, S E, M M Hussein and JAT dasilva 2012. Roles of antitranspirants in improving growth and water relations of Jatropha Curcas L grown under water stress conditions Plant Stress 6(1) 49-54

[17] Murtadha, MA, OJ Ariyo, SS Alghamdi 2018. Analysis Of Combining Ability Over Environments In Diallel Crosses Of Maize Zea Mays L J Of Saudi Soci Of Agri Sci 17: 69–78

[18] Shaymaa IS,Assessing 2018. Effect Of Potassium Silicate Consecutive Application On Forage Maize Plants (Zea Mays L.) Journal Of Innovations In Pharmaceutical And Biological Sciences (JIPBS) ISSN 2349-2759 Vol 5 (2) 119-127 ,