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EFFECT OF SPRAYING POTASSIUM PHOSPHATE ON SOME CHARACTERISTICS OF THE EGGPLANT UNDER DROUGHT STRESS

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ABSTRACT

A factorial experiment has been implemented by using the randomized complete block design (R.C.B.D) in plastic house Biology Department/College of Science/University of Diyala during the autumn season 2016 to study the effect of potassium phosphate on some growth characteristics of eggplant under drought stress. Three levels of potassium phosphate P_1, P_2 and P_3 (0, 1, and 2) gm l^{-1} were used, which have been sprayed in two batches, the first after 40 days of planting, and the second after 10 days of the addition of the first batch. Two drought stress were used: S_1 level (irrigation by 21.6 l day^{-1}) and S_2 level (irrigation by 10.8 l day^{-1}). Leaf area, chlorophyll index, total solid substances (TSS) and total phenol concentration(TPC) were studied. Results showed that mean leaf area was 141.4 cm^2 at S_1 treatment, while it was decreased to 89.7 cm^2 at S_2 treatment with a significant decrease of 36.6%. Treatment S_2 had a significant increase in the total soluble solid substances (TSS), and the total phenol concentration (TPC) were 13.9% and 128.8% respectively. Spraying with potassium phosphate resulted in a significant increase in the mean leaf area and chlorophyll index. The highest value of the mean leaf area was recorded at the treatment P_3 (136.6) cm^2 when compared with treatment P_1 (103.2) cm^2. while chlorophyll index recorded (14.8) units at the treatment P_3 when compared with treatment P_1 (12.3) units.

KEY WORDS: Potassium phosphate, Drought stress, Eggplant.

INTRODUCTION

Solanum melongena is the most common plant in the solanaceae family, which is an economically important family because it contains food source genera such as tomatoes, potatoes and pepper (Al-Katib, 2000). Eggplant is a herbaceous plant with a height of up to 70 cm. It has purple leaves, violet flowers and relatively large fruits. It is successfully grown in the protected environment and comes third after tomato and cucumber as a crop grown in a protected environment. Eggplant fruits are one of the richest vegetable crops with an iron content of 7 mg/100g^{-1} fresh, and their seeds contain 21-28% oil. The quality of its oil is as good as the quality of sun flower, groundnuts and soybeans oil (Mahmood and Maryam, 2014). Eggplant contains many active compounds such as phenolic acid as well as large amounts of vitamin C and vitamin B group (Helmja *et al*., 2007). Iraq is generally suffering from drought and lack of fresh water resources due to climate change, such as global warming, desertification and the decline of agricultural land (Bakoor *et al*., 2009). The water deficit in Iraq is expected to reach 150 billion m^3. year^{-1} in the year 2030 (Arab Organization for Agricultural Development,1999). Potassium is one of the main nutrients needed by the plant in large amounts. The importance of this element is particularly prominent under drought stress and high temperature conditions. This element plays an important role in maintaining the osmotic potential within the plant cells and in regulating the transpiration process through its involvement with the abscisic acid in the control of opening and closing of the stomata, as the pumping of potassium outside the guard cells leads to the exit of water to the neighboring cells and then close the stomata. This mechanism allows to maintain the appropriate content of water in plant cells (Saidi, 2007), as well as its role in stimulating plant roots to grow and creating a balance of fertility with other nutrients (Loch and Vago, 2007). Phosphorus element is one of the major nutrients that the plant need in large amounts for its role in many metabolic and physiological processes as it is involved in the synthesis of nucleic acids, energy compounds and phosphorated oils (Follett and Donahue, 1995). It also helps to increase cell division and stimulate growth and development of roots, which is associated with water absorption, and enhances the ability of the plant to tolerate higher water stress levels (Al-Naqeeb, 2008). Due to the lack of studies on the effect of drought stress and the role of some nutrients in increasing the tolerance of drought stress and improve plant growth, therefore, this study was carried out to identify some effects of drought stress on eggplant growth (vegetative growth stages) and the role of potassium phosphate in reducing the negative effects of drought stress.

MATERIALS AND METHODS

A factorial experiment was carried out in plastic house of Biology Department / College of Science / University of Diyala for the autumn season 2016 in a Clay loam soil to study the effect of spraying with three concentrations of potassium phosphate (0, 1 and 2 g L^{-1}) and symbolized as P_1, P_2 and P_3 respectively with two irrigation levels: S_1 level for 10 minutes at (21.6 L day^{-1}) and S_2 level for 5 minutes (10.8 L day^{-1}).

The experiment was designed according to the Randomized Complete Block Design (RCBD) with three replicates.

Table 1. Some physical and chemical properties of plastic house soil.

Property	**Unit**	**Value**
Clay	gm kg^{-1}	161.6
Silt	gm kg^{-1}	98.6
Sand	gm kg^{-1}	739.8
Clay loam		**Texture class**
$CaCO_3$	gm kg^{-1}	260.36
Organic substance	gm kg^{-1}	14.49
Ready made elements		
Nitrogen	mg kg^{-1}	24.51
phosphorus	mg kg^{-1}	30.618
potassium	mg kg^{-1}	192.6
$EC_{1:1}$	dsm^{-1}	2.82
pH	-	7.61

The area of the experimental plastic house was divided into 60 cm width terraces, with a width of 50 cm left between each terrace and the other. Soil Samples were taken before planting from depth of 30.0 cm. Some of their physical and chemical properties were measured as shown in table(1). Barcelona var. eggplant seedlings were planted on 9/10/2016, and irrigation, fertilizing, bush, insect and fungi control were conducted. The plants were fertilized with neutral compound fertilizer (20-20-20) containing the major elements N-P-K as well as minor elements. The plants were sprayed with potassium phosphate twice after 40 days of plantation of seedling, and after 10 days of the first spraying. The following analyzes were carried out for the plants one week after the second spraying:

1- Leaf area (cm^2)

The leaf area was measured according to Carleton and foote (1965), and the following equation was applied to calculate the leaf area: Leaf area cm^2 = Length (cm) x Width (cm) x 0.75.

2- Measurement of total chlorophyll index in leaves

The total chlorophyll index was estimated by the Chlorophyll meter (Spad).

3- Total soluble solids (T.S.S)

The percentage of total solids (T.S.S) was measured by the handheld digital refractometer by extracting the leaf juice and recording to the reading as % pursuant to Ranganna method (1977).

4- Total phenol concentration (T.P.C)

The total phenolic concentration of eggplant extract was estimated by Molan *et al*. (2009), by mixing 10 µl of the extract with 200 µl of 2% of the aqueous solution of sodium carbonate in the microplate-96well, and then left for 5 minutes at room temperature. After that, 10 µl of folin-reagent solution were added and the microplate was left for half an hour at room temperature. After the incubation period, absorbance of the reaction mixture was read at 490 nm wavelength. The mixture was titrated with an aqueous solution prepared of the standard (Gallic Acid), with concentrations ranging from 100 to 1000 µg ml^{-1}. The phenolic concentration in aqueous extracts was represented in milligrams of Gallic acid by using the following calculation equation:

Y = 0.0596 – X/0.0008.

Y = Phenolic concentration (mg Eq. Gallic acid gm^{-1} of dry weight).

X = Absorbance.

The Statistical Analysis System (SAS 2010) was used for the statistical analysis, and variance of means were tested according to Duncan multiple range test at a significance level of 0.05 for data analysis.

RESULTS AND DISCUSSION

1-Leaf area

Results in table (2) showed that drought stress caused a significant decrease (36.6%) in the leaf area from 141.4 cm^2 at S_1 to 89.7 cm2 at S_2. This can be attributed to the direct water involvement in light reactions, and therefore sufficient abundance of water that leads to increased photosynthesis rates, which in turn improves the growth of plant cells and increases their size**.** The abundance of water keeps the cells swelling, and helps to increase their size and elasticity, thus, increasing and expanding the growth of the new leaves of the plant. On the contrary, drought conditions cause the leaf area to shrink (Hassan, 2012).

Table 2. Effect of drought stress and potassium phosphate on the leaf area of eggplant cm^2.

Potassium phosphate gm L^{-1} p		Levels of drought stress		Mean effect of potassium phosphate
		Irrigation for 10 minutes S_1	**Irrigation for 5 minutes S_2**	
P_1	0	126.7bc	83.6d	103.2b
P_2	1	131.2b	76.3d	103.8b
P_3	2	163.9a	109.2c	136.6a
Mean effect of drought stress		141.4a	89.7b	

In addition, spraying by potassium phosphate at the third level P_3 had a significant effect on the increase of the leaf area, reaching 136.6 cm^2, while the treatment P_1 recorded an area of 103.2 cm^2. This can be attributed to the role of phosphorus mainly in building energy compounds, nucleic acids and cellular membranes, and contributing to the transfer of sugars from their formation sites in the leaf to all parts of the plant (Abu-Dhahi and Ali, 2010), In addition, the element of potassium found in potassium phosphate is a necessary element for plant growth and development, especially in drought conditions, for its important role in controlling the opening and closing of stomata, in addition to its importance in stimulating cell division due to the activation of relevant enzymatic systems (Bidwell, 1979), which results in the increase of the total leaf area of the plant (Al-Sahaf, 1989). The S_1P_3 interference treatment achieved a significant increase over the rest of treatments, when it recorded the highest surface area value of 163.9 cm^2, while The S_2P_2 interference treatment recorded the lowest value of 76.3 cm^2, which did not differ statistically from the S_2P_1 treatment.

2- Chlorophyll index

Drought stress had no significant effect on the chlorophyll index shown in table(3), since S_1 treatment value of 13.7 units was statistically similar to the S_2 treatment value of 14.4 units.

Table 3. Effect of drought stress and potassium phosphate on the chlorophyll index.

Potassium phosphate gm L-1 p		Levels of drought stress		Mean effect of potassium phosphate
		Spraying for 10 minutes S_1	Spraying for 5 minutes S_2	
P_1	0	11.2b	13.4ab	12.3b
P_2	1	14.7a	15.2a	15.0a
P_3	2	15.1a	14.5a	14.8a
Mean effect of drought stress		13.7a	14.4a	

While its value was significantly increased by spraying with potassium phosphate, with the highest value in the P_2 treatment, which reached 15.0 units, and the lowest value in the P_1 treatment, which reached 12.3 units. This may be due to the important role of potassium in the activation of a large number of enzymes, which is responsible for the synthesis of chlorophyll and Phosphorus that is important in building energy compounds and nucleic acids (Abu Dhahi and Muayad, 1988).

The interference between drought stress and spraying by potassium had a significant effect on the values of the chlorophyll index. The interference treatment S_2P_2 achieved the highest chlorophyll value of 15.2 units, while the interference treatment of S_1P_1 recorded 11.2 units.

3- Percentage of total soluble solid substances (TSS)

The drought stress had a significant effect on the percentage of soluble solids in the leaves, which reached 8.7% in the S_2 treatment and 6.6% in the S_1treatment with an increase of 31.9% as seen in table (4) while Potassium phosphate spraying had little effect in that capacity.

Table 4. Effect of drought stress and potassium phosphate on the percentage of total soluble solid substances%.

Potassium phosphate gm L^{-1} p		Levels of drought stress		Mean effect of potassium phosphate
		Spraying for 10 minutes S_1	Spraying for 5 minutes S_2	
P_1	0	6.4b	8.6a	7.5a
P_2	1	6.7b	8.6a	7.7a
P_3	2	6.6b	8.8a	7.7a
Mean effect of drought stress		6.6b	8.7a	

The interference treatment S_2P_3 achieved the highest value at 8.8%, while the S_1P_1treatment recorded the lowest value at 6.4% with a significant difference. In drought conditions, many plants can increase the accumulation of soluble solids as a result of the transformation of starch into soluble sugars and low sugar consumption because of decreased growth rates (Turner *et al.*, 1978). The higher content of soluble sugars acts on lowering the water stress of plant cells, especially leaves, thus reducing the negative effects of drought stress (Venkateswarlu et al., 1980).

4- Total phenol concentration(TPC)

The concentration of total phenols was significantly affected by drought stress, and the values shown in table (5) reveal that the mean total phenolic concentration in the S_2 treatment was 20.6 mg gm^{-1}, while it was 9.0 mg gm^{-1} in the S_1 treatment.

Table 5. Effect of drought stress and potassium phosphate on total phenolic concentration mg gm^{-1}.

Potassium phosphate gm L^{-1} p		Levels of drought stress		Mean effect of potassium phosphate
		Spraying for 10 minutes S_1	Spraying for 5 minutes S_2	
P_1	0	9.3b	21.2a	15.2a
P_2	1	8.7b	20.6a	14.7a
P_3	2	8.9b	20. 1a	14.5a
Mean effect of drought stress		9.0b	20.6a	

Spraying by Potassium phosphate had little effect on the concentration of total phenols. Although there was a decrease in the total phenols value, the results of the statistical analysis showed no significant differences, while the interference between drought stress and potassium phosphate spraying showed that the S_1P_2 treatment recorded the lowest concentration of total phenols 8.7 mg gm^{-1} with a significant difference from S_2P_1treatment results, which recorded a concentration of 21.2 mg gm^{-1}. Increasing the production of phenolic compounds is one of the mechanisms used by the plant when exposed to environmental stresses, especially drought stress, by activating the genes responsible for the production of both enzymetic and non-enzymetic antioxidants, and those genes responsible for the production of phenols (Winkel-Shirley, 2001).

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