Indian Journal of Ecology (2021) 48 Special Issue (15): 000-000

Manuscript Number: 000
NAAS Rating: 5.79

Response of Sweet Pepper *Capsicum Annulus* L. to Spraying With Potassium Fertilizer Cultivated in Plastic House

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Abstract: A field experiment was conducted in the non-heated plastic house at Al-Mussaib Technical College for the autumn season 2016 to study the response of sweet pepper *Capsicum annuum* L. to foliar spraying with two types of foliar commercial potassium fertilizers in loamy sand soil. The four levels of potassium fertilizer and micronutrients (0, 4, 6, 8 ml.L^{-1}) and four levels of potassium fertilizer and sulfur KTS (0, 2, 4, 6 ml.L^{-1}) and their interaction on some vegetative and flowering growth indicators, yield and its components was observed. .The spraying with potassium and micronutrient (8 ml.L^{-1}) significantly increased the plant height, number of branches, leaf area, dry weight for total vegetative, number of flowers in plant, percentage of fruit set, chlorophyll, nitrogen, phosphorus and potassium in leaves, early , total yield, vitamin C, and total soluble solids compared to control treatment. The spraying of potassium fertilizer and sulfur with micronutrient (4 ml.L^{-1}) excelled in all the above traits. The spraying of mixture of (8 ml. L^{-1} + 4 ml. L^{-1}) resulted in highest values for all the above traits.

Keywords: Sweet pepper, Qurtuba, Potassium Fertilizer, Plastic house

Sweet pepper (*Capsicum annulus* L.) belong to the Solonaceae family and source of vitamins A and C as well as mineral such as calcium, iron and phosphorus, carbohydrates and proteins (Khalil 2004). It is cultivated in Iraq by the traditional method at the beginning of spring and in the protected method at the beginning of autumn. The total cultivated area is estimated as 33840 dunums with total productivity of 922925 tons and a yield of 27273 kg. dunums^{-1} (Central Bureau of Statistics 2013). The use of foliar nutrients is a complementary method of soil fertilization to address the shortage of important nutrients for plant growth and ensures a homogeneous distribution for nutrient elements for vegetative growth with high efficiency. Al-Ghurairi (2003) observed that use of foliar fertilizers of micro and macronutrient elements increased the total vegetative growth of plants with high productivity. Al-Janabi (2005) indicated that the addition of fertilizers spraying on the leaves of plants is necessary in the Iraq, which is exposed to the washing, sedimentation and stabilization of nutrient elements, which requires spraying this fertilizer to meet the needs of plants for these nutrients. Al-Jubouri (2006) observed that the spraying of leaves of sweet pepper plants with foliar nutrients (Unigreen) led to a significant increase in plant height, number of branches, the chlorophyll content , fruit size and its weight, and this was reflected in the total yield. Al-Tihafi (2007) showed when spraying different levels of zinc element on the leaves of sweet pepper plant in plastic house at concentration of 25 mg.L^{-1} led to a significant increase in plant height, number of branches, number of flowers and the percentage of the set. Baloch (2008) indicated that the spraying of sweet pepper leaves with foliar fertilizer (Higrow) at a concentration of 8 ml.L^{-1} led to a significant increase in plant height, number of branches, weight of fruit and total yield. El- Bassiony (2010) showed that the spraying of potassium fertilizer on sweet pepper leaves led to a significant increase in plant height, weight of fruit and total yield. Abdul-Jabbar (2012) observed that the use of commercially imported liquid fertilizers (Aminoxin and Amino quilent minose) spraying on the leaves of the sweet pepper plant led to a significant increase in plant height, number of branches, weight of fruit, plant yield and total yield. Ali et al (2005) indicated that the spraying of the magnesium element at a concentration of 3000 ppm on the leaves of the sweet pepper plant led to a significant increase in plant height, weight of fruit chlorophyll and yield. The study aims to determine the response of the sweet pepper plant (Qurtuba cultivar) to foliar spraying with two types of potassium fertilizer.

MATERIAL AND METHODS

A field experiment was conducted in the non-heated plastic house at Al-Mussaib Technical College for the autumn season 2016 to study the response of sweet pepper *Capsicum annuum* L. (Qurtuba cultivar) to foliar spraying with two types of foliar commercial potassium fertilizers. The soil collected at a depth of 30 cm, which was cultivated in the previous season with vegetable crops and were used for experimental purpose. The loamy sand soil and peat moss

with ratio 1: 3 were then immersed in water to saturation limit and covered it with the used polyethylene, with thickness of (150 microns), for two months to the purpose of sterilization with solar energy. Random samples were taken from three areas with a depth of 0-30 cm. The samples were mixed well. Soil analysis for properties was done at the Soil Science Department, Technical Institute, Mussaib with standard method (Black 1965, Fawzy et al 2007) (Table 1). The area of the plastic house was divided after the sterilization to 5 plots with width of 150 cm (width of the channel plot and walkway were 50 and 100 cm), The plots were irrigated two days before transplanting with 40 days age seedlings and after the formation of 3-4 real leaves on both sides of the plot October 4, 2016, with distance of 40 cm between them, and 10 plant were taken to the experimental unit. The irrigation system was set up above the walkway of the plot and at a distance of 10 cm from the seedling site and left at a distance of 1 m at the beginning and end of the plastic house. The agronomic operations were performed as per recommendation. The 240 kg.dunam^{-1} of ammonium sulphate and 160 kg.dunam^{-1} of triple superphosphate were added in two batches during vegetative and flowering growth (Al-Mohammedi 1992). The experiment was in the randomized complete block in factorial layout design with three replicates. The first factor included four concentrates of potassium fertilizer with micronutrients (0, 4, 6, 8 ml.L^{-1}), while the second factor included four concentrations of potassium fertilizer with KTS (0, 2, 4, 6 ml.L^{-1}). The components and sources of fertilizers are given in Table 2. The spraying s was conducted five times at interval of 20 days. The first spraying was on October 25 before the flowering. The spraying was conducted in the early morning preceded by field irrigation the previous day to ensure the opening of the stoma.

Table 1. Soil specifications used in the experiment

Traits	Unit	Value
Electrical conductivity	ds.S^{-1}	3.2
pH	--	7.8
Organic matter	g.kg^{-1} soil	8.9
Interchangeable capacity	Cmol.kg^{-1} soil	14.23
Calcium carbonate	g.kg^{-1} soil	19.3
Nitrogen availability	Cmol.kg^{-1} soil	23.9
Phosphorus availability		5.8
Potassium availability		47.7
Apparent density	g.m^{-3}	1.46
Sand	g.kg^{-1} soil	647.5
Silt		235.2
Clay		117.3
Texture		Loamy sand soil

Observation: Six plants were selected randomly from each experimental unit and marked with the purpose of recording data for the following indicators:

Plant length (cm) was was measured at the end of the growing season from the contact area of the stem with the soil to the Apical meristem for the plant The number of branches bearing fruits for each experimental unit was calculated and then divided by number of plants of experimental unit. The leaf area of the plants for each experimental unit was measured by calculating the area of 3 completed growth leaves, which were taken from the top, middle and bottom of the plant, by using the planimeter. The plant leaves were scanned with the scanning machine, the average area of the leaf was multiplied by the number of leaves. The total vegetative of the plants was dried at 70-65 °C in an electric oven and until the weight stability; the dry weight was then measured. Chlorophyll content (SPAD Unit) was estimated by the chlorophyll meter (SPAD type) and on the plant directly by taking an average of three readings per leaf and from different locations for plant. For estimation of nutrient of elements (NPK) fourth leaf was taken from the Apical meristem for the plants from each experimental unit after flowering (Shaw 1961), then dried in the oven at 70 °C until the weight was stable, it was placed in sealed plastic bags and was digested with sulfuric acid and perchlorate, with ratio of 3: 5 (Black 1968) After completion of the digestion process, the following elements were estimated:

The percentage of nitrogen was estimated by distillation process using Micro-Kjeldahl and according to method (Jackson 1958) and percentage of phosphorus by the spectrophotometer at wavelength of 882 nm according to the method (Olsen and Sommers 1982). The percentage of potassium was determined by the Flame photometer (Black 1968). Number of fruits per plant estimated by counting the number of fruits for the experimental unit divided by the

Table 2. Components and sources of used foliar fertilizers in the experiment

Type of fertilizer	Potassium (%)	Sulfur (%)	Iron (%)	Copper (%)	Manganese (%)	Zinc (%)
Potassium and KTS sulfur*	36	25				
Potassium and micronutrients**	10		2.5	1.5	2.5	3.5

* Jordan, Import Al Wathba Land Company for Agricultural and Animal Production
** IBN Sina Public Company, Ministry of Industry

number of plants of experimental unit. Fruit weight (g) was measured by calculating the total fruit weight for the experimental unit divided by the number of fruits for the experimental unit. The early yield of the plant (kg) was calculated through the first three harvesting for the crop. The total amount yield per the plants was estimated. The vitamin C in fruits (mg. 100 g^{-1} dry weight) was determined by titration of fruit juice with 2-6-dichlorophenicol-Indophenol dye (Ranganna 1977). The percentage of total soluble solids was estimated with refractometer.

RESULTS AND DISCUSSION

Plant height and number of fruit branches: There was a significant difference between the different concentration of foliar spraying with the potassium on plant height and the number of fruit branches compared to the control treatment. The potassium and micronutrients (8 ml.L^{-1}) gave the highest value with percentage increase of 19.47 and 29.54%, respectively, compared to the control. The spraying with potassium and sulfur elements led to a significant increase in these two traits, where the spraying treatment 4 ml.L^{-1} was superior (31.7 and 53.53% respectively) compared to the control treatment and did not differ significantly with the spraying treatment 6 ml.L^{-1}. The spraying mixture of the two fertilizers (8 ml.L^{-1} + 6 ml.L^{-1}) gave the highest plant height and number of fruit branches (109.5 cm, 6.4 branches), as compared with control.

Leaf area and dry weight for the total vegetative of the plant: There was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the leaf area and the dry weight for the total vegetative compared to the control treatment. The potassium and micronutrients (8 ml.L^{-1}) gave the highest value with an increase percentage of 49.88 and 15.82, respectively, compared to the control. The spraying with potassium and sulfur elements led to a significant increase in these two traits, where the spraying treatment (4 ml.L^{-1}) excelled by giving it the highest increase of 49.88 and 15.82%, respectively, compared to the control treatment and did not differ significantly with the spraying treatment (6 ml.L^{-1}). The results of the data analysis showed that the interaction between the two factors had a significant effect. The spraying treatment by a mixture of the two fertilizers (8 ml.L^{-1} + 6 ml.L^{-1}) gave the highest leaf area and dry weight for the total

Table 3. Effect of the potassium fertilizer on plant height (cm) and number of fruit branches in black pepper

Potassium & sulphur (ml. L^{-1})	Plant length (cm)				Average	Number of fruit branches				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	64.4	74.1	82.9	103.5	81.23	3.2	3.4	3.8	4.3	3.68
2	89.1	88.4	95.6	105.3	94.60	3.6	3.9	4.4	4.9	4.20
4	104.6	103.8	106.1	109.5	106.00	4.9	5.5	5.8	6.4	5.65
6	97.8	98.4	101.6	106.9	101.18	4.8	5.3	5.6	5.8	5.38
Average	88.97	91.18	96.55	106.3		4.13	4.53	4.90	5.35	
LSD 0.05	Potassium and micronutrients = 6.52 Potassium and Sulfur = 13.04, Interaction = 6.52					Potassium and micronutrients = 0.32 Potassium and Sulfur = 0.64, Interaction = 0.32				

Table 4. Effect of potassium fertilizer on leaf area and dry weight for the total vegetative of plant

Potassium & sulphur (ml. L^{-1})	Leaf area (dm^2)				Average	Leaf area (dm^2)				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	19.6	20.9	22.1	22.8	21.35	87.4	95.1	102.3	109.4	98.6
2	20.2	21.4	22.7	23.6	21.98	88.9	101.6	115.8	122.3	107.2
4	21.7	22.5	24.2	25.3	23.43	97.6	110.4	118.7	132.7	114.9
6	21.2	22.4	23.6	24.8	23.00	98.1	108.7	119.5	130.4	114.2
Average	20.68	21.80	23.15	24.13		93.0	104.0	114.1	123.7	
LSD 0.05	Potassium and micronutrients = 0.84 Potassium and Sulfur = 1.68 Interaction = 0.84					Potassium and micronutrients = 6.75 Potassium and sulfur = 13.50				

vegetative of the plant (25.3 dm^2, 132.7 g), respectively).

Number of flowers in plant and the percentage of fruits set: There was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on number of flowers in plant and the percentage of fruits set compared to the control treatment (Table 5). The potassium and micronutrients (8 $ml.L^{-1}$) gave the highest value and achieving an increase percentage amounted to 11.26 and 24.09%, respectively, compared to the control. The spraying with potassium and sulfur elements led to a significant increase in these two traits, where the spraying at 4 $ml.L^{-1}$ excelled by giving it the highest values with an average increase of 14.84 and 24.54%, respectively compared to the control treatment and did not differ significantly with the spraying at 6 $ml.L^{-1}$. The interaction between the two factors had a significant effect on the increase in the average number of flowers in plant and the percentage of fruits set. The spraying by a mixture of the two fertilizers (8 $ml.L^{-1}$ + 6 $ml.L^{-1}$) gave the highest increase of 62.7 and 43.9 percent in number of flowers per plant and fruits set, respectively, compared with control.

Chlorophyll content and the percentage of nitrogen in leaves: There was significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of chlorophyll content and the percentage of nitrogen in leaves compared to the control treatment (Table 6). The potassium and micronutrients (8 $ml.L^{-1}$) gave the highest value and achieving an increase percentage of 38.16 and 24.36%, respectively, compared to the control. The spraying with potassium and sulfur elements led to a significant increase in these two traits, where the spraying at4 $ml.L^{-1}$ excelled by giving the highest average increase of 19.7 and 36.73%) respectively, compared to the control treatment and did not differ significantly with the spraying treatment at6 $ml.L^{-1}$. The interaction between the two factors had a significant effect on the increase in the average of chlorophyll content and the percentage of nitrogen in leaves. The spraying t by a mixture of the two fertilizers (8 $ml.L^{-1}$ + 6 $ml.L^{-1}$) gave the highest values o (65.11 Spad, 2.22%, respectively) and the lowest average for these two traits was at the treatment without spraying with fertilizers.

Chlorophyll content and the percentage of nitrogen in leaves: There was significant difference between the levels

Table 5. Effect of potassium fertilizer on number of flowers in plant and the percentage of fruits set

Potassium & sulphur (ml. L^{-1})	Number of flower per plant				Average	Percent of fruit set				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	48.3	52.8	54.1	56.3	52.88	28.6	30.9	33.6	37.4	32.6
2	50.5	53.7	56.2	58.7	54.78	31.5	32.7	37.3	40.1	35.4
4	58.9	60.4	60.9	62.7	60.73	36.2	40.5	41.8	43.9	40.6
6	57.2	57.8	60.1	61.4	59.13	35.6	40.2	41.1	42.2	39.8
Average	53.73	56.18	57.83	59.78		32.96	36.08	38.5	40.9	
LSD 0.05	Potassium and micronutrients = 1.73 Potassium and Sulfur = 3.46, Interaction = 1.73					Potassium and micronutrients = 1.58 Potassium and Sulfur = 3.16, Interaction = 1.58				

Table 6. Effect of potassium fertilizer on chlorophyll content and the percentage of nitrogen in leaves

Potassium & sulphur (ml. L^{-1})	Chlorophyll content (SPAD)				Average	Nitrogen (%)				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	40.16	43.28	46.92	51.17	45.38	1.28	1.44	1.58	1.59	1.47
2	42.59	47.09	52.88	59.29	50.46	1.31	1.67	1.75	1.81	1.64
4	44.00	51.35	57.03	65.11	54.37	1.72	1.98	2.03	2.22	2.01
6	44.09	52.12	59.44	60.47	54.03	1.75	1.92	2.06	2.14	1.99
Average	42.71	48.46	54.07	59.01		1.56	1.75	1.86	1.94	
LSD 0.05	Potassium and micronutrients = 3.07 Potassium and Sulfur = 6.14, Interaction = 3.07					Potassium and micronutrients = 1.58 Potassium and Sulfur = 3.16, Interaction = 1.58				

of foliar spraying for the pepper plants with the potassium element on the traits of chlorophyll content and the percentage of nitrogen in leaves compared to the control treatment (Table 6). The potassium and micronutrients (8 ml.L^{-1}) gave the highest value and achieving an increase percentage of 38.16 and 24.36%, respectively, compared to the control. The spraying with potassium and sulfur elements led to a significant increase in these two traits, where the spraying at4 ml.L^{-1} excelled by giving the highest average increase of 19.7 and 36.73%) respectively, compared to the control treatment and did not differ significantly with the spraying treatment at6 ml.L^{-1}. The interaction between the two factors had a significant effect on the increase in the average of chlorophyll content and the percentage of nitrogen in leaves. The spraying t by a mixture of the two fertilizers (8 ml.L^{-1}+ 6 ml.L^{-1}) gave the highest values o (65.11 Spad, 2.22%, respectively) and the lowest average for these two traits was at the treatment without spraying with fertilizers.

Number and weight of fruit: There was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of the number of fruits and weight of fruit compared to the control treatment. The treatment of potassium and micronutrients (8 ml.L^{-1}) gave the highest increase percentage of 21.87 and 20.27%, respectively compared to the control (Table 8) the spraying with potassium and sulfur resulted in significant increase in these two traits. The spraying at 4 ml.L^{-1} excelled by giving it the highest values of 24.53 and 19.07%, respectively, compared to the control and did not differ significantly with the spraying of 6 ml.L^{-1}. The interaction between the two factors had a significant effect on the increase in the average number of fruits and weight of fruit. The spraying treatment of the two fertilizers (8 ml.L^{-1} + 6 ml.L^{-1}) gave the highest values of 34.6 and 108.3 g, respectively.

Early and total yield per plant: There was a significant difference between the levels of foliar spraying for the pepper plants with the potassium on the early and total yield for the plant compared to the control treatment. The potassium and micronutrients (8 ml.L^{-1}) gave the highest value and achieving an increase percentage of 50.46 and 45.96%, respectively, compared to the control (Table 9). The spraying with potassium and sulfur led to a significant increase in these two traits, where the spraying treatment 4 ml.L^{-1} excelled by giving it the highest values of 49.43 and 48.01%, respectively, compared to the control and did not differ

Table 7. Effect of potassium fertilizer on phosphorus and potassium content in leaves

Potassium & sulphur (ml. L^{-1})	Phosphorus (%)				Average	Potassium (%)				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	0.51	0.56	0.59	0.63	0.57	1.29	1.39	1.46	1.59	1.43
2	0.57	0.61	0.67	0.72	0.64	1.30	1.46	1.57	1.68	1.50
4	0.62	0.68	0.69	0.75	0.69	1.82	1.92	2.13	2.55	2.11
6	0.68	0.61	0.67	0.68	0.64	1.58	1.69	1.92	2.23	1.86
Average	0.60	0.62	0.66	0.70		1.50	1.62	1.77	2.01	
LSD 0.05	Potassium and micronutrients = 0.02 Potassium and Sulfur = 0.04, Interaction = 0.02					Potassium and micronutrients = 0.21 Potassium and Sulfur = 0.42, interaction = 0.21				

Table 8. Effect potassium fertilizer on number and weight of fruit

Potassium & sulphur (ml. L^{-1})	Number of fruits				Average	Weight of fruit (g)				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	21.2	25.3	26.7	28.4	25.40	75.4	78.6	85.3	90.4	82.43
2	24.5	27.7	29.8	30.5	28.13	79.6	81.9	89.6	97.1	87.05
4	28.9	30.4	32.6	34.6	31.63	89.4	93.2	101.7	108.3	98.15
6	29.1	29.1	32.1	32.9	30.80	90.1	92.1	98.8	106.5	96.88
Average	25.93	28.13	30.30	31.60		83.63	86.45	93.85	100.58	
LSD 0.05	Potassium and micronutrients = 1.23 Potassium and sulfur = 2.46, Interaction = 1.23					Potassium and micronutrients = 6.44 Potassium and sulfur = 12.88, Interaction = 6.44				

significantly with 6 ml.L^{-1}. The interaction between the two factors had a significant effect on the increase in the average of the early and total yield for the plant. The spraying of two fertilizers (8 ml.L^{-1} + 6 ml.L^{-1}) gave the highest values of 0.790 and 3.747 kg.plant^{-1}, respectively.

Vitamin C and total soluble solids: There was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on vitamin C and the percentage of total soluble solids compared to the control treatment. The potassium and micronutrients 8 ml.L^{-1} gave the highest value and with percentage increase 39.33 and 70.85% respectively compared to the control (Table 10). The spraying with potassium and sulfur elements led to a significant increase in these two traits, where the spraying at 4 ml.L^{-1} excelled by giving the highest with average increase of 30.29 and 36.56%, respectively, compared to the control and did not differ significantly with 6 ml.L^{-1}. The interaction between the two factors had a significant effect on the increase in the average of the fruits content from vitamin C and the percentage of total soluble solids. The spraying treatment by a mixture of the two fertilizers (8 ml.L^{-1} + 6 ml.L^{-1}) gave the highest Vitamin C and total soluble solids (69.2 mg.100 ml^{-1} and 10.4%, respectively).

The spraying with the two types of fertilizer (potassium with micronutrients and potassium with sulfur) differed significantly in all indicators of vegetative and flowering growth. The (8 and 4 ml.L^{-1} for two fertilizers respectively significantly excelled in plant height, number of branches per plant, leaf area, dry weight of total vegetative, the leaves content of chlorophyll, percentage of nitrogen, phosphorus and potassium in leaves, number of flowers in plant and percentage of fruit set. The may be sue to the potassium element which is a necessary element for plant growth and development, although it does not enter into any of the cellular components and plays the role of a catalyst in many of the bio-processes, including the formation process of proteins, nucleic acids and photosynthesis as well as the importance of potassium in the division of cells as a result of activating the enzymatic systems for this. This led to the increase of plant height and the dry weight of the total vegetative in the plant, which eventually increases the height of the plant and the dry weight for the total vegetative in the plant. This result agrees with Ali et al., (2005) in their study on the tomato and Abbas (2007) on the eggplant where the potassium fertilization significantly increased the height of the plant and its dry weight. The spraying process with the

Table 9. Effect of potassium fertilizer on early and total yield per the plant

Potassium & sulphur (ml. L^{-1})	Early yield per plant (kg)				Average	Yield per plant (kg)				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	0.320	0.432	0.476	0.510	0.435	1.598	1.989	2.278	2.567	2.108
2	0.390	0.493	0.533	0.603	0.505	1.950	2.269	2.670	2.962	2.463
4	0.517	0.576	0.716	0.790	0.650	2.584	2.833	3.315	3.747	3.120
6	0.524	0.583	0.692	0.732	0.633	2.622	2.680	3.171	3.504	2.994
Average	0.438	0.521	0.604	0.659		2.189	2.443	2.859	3.195	
LSD 0.05	Potassium and micronutrients = 0.47 potassium and sulfur = 0.94, Interaction = 0.47					Potassium and micronutrients = 0.205 Potassium and sulfur = 0.410, Interaction = 0.205				

Table 10. Effect of potassium fertilizer on vitamin C and the percentage of total soluble solids

Potassium & sulphur (ml. L^{-1})	Vitamin C (mg. 100 g^{-1} dry weight)				Average	Total soluble solids (%)				Average
	Potassium and micronutrients (ml. L^{-1})					Potassium and micronutrients (ml. L^{-1})				
	0	4	6	8		0	4	6	8	
0	38.4	44.8	47.9	50.5	45.40	4.3	5.3	6.8	7.1	5.88
2	42.8	45.3	57.1	62.7	51.98	4.9	5.9	7.3	8.2	6.58
4	49.6	53.4	64.4	69.2	59.15	5.8	6.7	9.2	10.4	8.03
6	49.2	52.2	63.8	68.4	58.40	5.7	7.1	8.8	9.7	7.83
Average	45.00	48.93	58.30	62.70		5.18	6.25	8.03	8.85	
LSD 0.05	Potassium and micronutrients = 4.06, potassium and Sulfur = 8.12, interaction = 4.06					Potassium and micronutrients = 0.67, potassium and Sulfur = 1.34, interaction = 0.67				

potassium element increased its concentration in the leaves and tissues of pepper plants for easy absorption, the presence of potassium in sufficient quantities also promotes the growth of the root mass and increased nutrient absorption, including phosphorus and nitrogen, which is reflected positively on growth. Potassium contributes to increasing the ability of the leaves to carry out photosynthesis through its role as a catalyst for the process of opening and closing the stoma as well as its role in increasing the leaf area for the leaves and the availability of CO_2 gas necessary for the photosynthesis process and the formation of carbohydrates and proteins, then contribute to the transfer to fruits. It also contributes to the stimulation and formation of the adenosine triphosphate (ATP) needed by the plant to fill the sieve tubes with photosynthetic materials, in the formation of compounds with large partial weights (carbohydrate and proteins), thus increase the dry weight of the plant. The addition of potassium led to increase the efficiency of photosynthesis, increase the total vegetative, this is reflected in the increasing the number of leaves in the plant, increase the leaf area, increase the dry matter of plant and plant metabolism as well as increase the number of flowers in the plant. There was significant increase in the number of fruits, their weight and the early and total yield due to spraying with two types of potassium fertilizers. This can be attributed to increase potassium availability and increase its concentration within the plant, which plays a large role in increasing the amount of manufactured carbohydrates in the places of manufacture and transfer to storage locations, thus increase the number of fruits and weight increase, which reflected in the increase in the early and total growth for plants (Faze et al 2005). Increasing the percentage of Total Soluble Solids by increasing potassium levels can be attributed to the role of the element in increasing the efficiency of building processes of carbohydrates, sugars, amino and organic acids (Abdul Amir et al 2015).

CONCLUSION

The use of potassium fertilizer with micronutrients at a rate of (8 $ml.L^{-1}$) and potassium fertilizer with sulfur at a rate of 4 $ml.L^{-1}$ significantly increase in all vegetative growth, yield and quality parameters.

REFERENCES

Abu Dahl Yousef Mohammed, Umayyad Ahmed Al Yuns 1988. *Guide to plant nutrition*. University of Mosul, Ministry of Higher Education and Scientific Research, Republic of Iraq.

Al-thief Sami Ali Abdul Masjid and Raid Kazak Cadim 2007. Effect of incubation and spraying with zinc in the growth and yield of the sweet peppers (Qurtuba cultivar) cultivated inside the plastic house under drip irrigation system. *Journal of Babylon University of Science* **14** (4): 447-453.

Al-Jubouri Abdul-Jassim Moheisen, Fadel Hussain Al-Sahaf, Abdulrahman Khamas Al-Jowari 2006. Effect of spraying with foliar nutrients on vegetative and flowering growth of pepper plant. *Journal of Agricultural Sciences Iraq* **36** (5): 43-50.

Al-Janabi Ainas Abdul-Dime Mohammed 2005. *Effect of adding potassium to soil and spraying in the quality and quality of cultivated tomatoes in heated plastic houses*. Master Thesis, College of Agriculture, University of Baghdad, Iraq.

Al-Jawari Abdul Rahman Khamas Suhail 2002. *Effect of Spraying with Different Nutrients on the Growth and Extract of Capsicum annuum L*. Master Thesis, College of Agriculture, University of Baghdad, Iraq.

Al-Rawi Khasha Mahmood, Abdel-Aziz Khalaf El-Elah 1980. *Design and analysis of agricultural experiments. College of Agriculture and Forestry.* University of Al Mosul. Iraq.

Al-Ghurairi Fadel Eawda Kareidi 2003. *The behavior and efficiency of iron fertilizers in calcareous soils under protected agriculture conditions*. Master Thesis, College of Agriculture, University of Baghdad, Iraq.

Al-Mohammedi Fadel Musleh Hammadi 1992. *Protected agriculture*. University of Baghdad, Ministry of Higher Education and Scientific Research. Baghdad. Iraq.

Hassan Nouri Abdel Qader, Hassan Al-Dulaimi, Latif Al-Ithawi 1990. Fertility and soil fertility. University of Baghdad, Ministry of Higher Education and Scientific Research, Iraq.

Khalil Mahmood Abdel Aziz Ibrahim 2004. *Vegetable plants, propagation and cultivation of plant tissues*. Zagazig University, Manshaet El Maaref General Printing Press, Alexandria, Egypt.

Abbas Gamal Ahmed 2007. Effect of potassium fertilization and irrigation periods on growth and yield of eggplant plant. *Jordanian Journal of Agricultural Sciences* (**3**): 361-350.

Abdul Amir Hamid Kadhim, Zoya Glub Murad and Mostafa Hamid Kadhim 2015. Effect of Potassium and Iron on some vegetative and flowering parameters of tomato plant *Lycopersicon esculentum* Mill grown in plastic house. *University of Karbala Scientific Journal* **13**(2): 206-213.

Abdul-Jabbar Ghalib 2012. Effect of foliar nutrition on the Growth and yield of sweet pepper Capsicum annuum L. (carisma cultivar). *Al-Furat Journal of Agricultural Sciences* **3**(2): 57-62.

Ali Mohammed Hassan Salman 2012. Effect of different levels of humic fertilizer and spraying magnesium on characteristics of growth in pepper plants cultivated in plastic houses. *Kufa Journal of Agricultural Sciences* **4**(1): 296- 304.

Ali Nour Al-Din Shawqi, Hasan Yusuf Al-Dulaimi and Mashreq Naeem Amara 2005. Effect of the level of potassium fertilizer and its adding methods in the growth and production of tomato *Lucopersicon esculentum* Mill under the conditions of plastic house, *Iraqi Journal of Soil Sciences* (**1**) 162-153.

Mohammed Abdul Azim Kadhim 1977. *Principles of plant nutrition*. Beit Hikma Press, Baghdad University, Ministry of Higher Education and Scientific Research, Iraq.

Baloch QB, Chachar QI and Tareen MN 2008. Effect of foliar application of macro and micro nutrients on production of green chilies (*Capsicum annuum* L.). *Journal of Agricultural Technology* **4**(2): 177-184.

Black CA 1965. *Methods of soil analysis. Part 2.* Amer. Soc. Agro. Madison, Wisconson. USA. 34-41.Black CA 1968. *Soil Plant relationships* 2ed Ed New York. Wiley

El-Bassiony AM, Fawzy ZF, Abd El-Samad EH and Riad GS 2010. Growth, yield and fruit quality of sweet pepper plants (*Capsicum annuum* L.) as affected by potassium fertilization. *Journal of American Science* **6**(12): 123-128.

Fawzay ZF, Behairy AG and Shehata SA 2005. Effect of potassium fertilizer on growth and yield of sweet pepper plants (*Capsicum annuum* L.) *Agricultural Research* **2**: 599-610.

Fawzy ZF, El-Nemr MA and Saleh SA 2007. Influence of levels and methods of potassium fertilizer application on growth and yield of eggplant. *Journal of Applied Sciences Research* **3**(1): 42-49.

Jackson ML 1958. *Chemical analysis prentice*. Hall Inc Englewood cliffs. N.J.

Olsen SR and Sommers LE 1982. *Methods of soil analysis, Agron. No9, Part2: chemical and microbiological properties*. Am. Soc. Agron., Madison, WI, USA. Phosphorus, p: 403-43.

Mengele K, Kirkby EA 1987. *Principles of plant Nutrition*. 4th International potash institute, IPI, Berr, Switzerland, and 685p.

anganna S 1977. *Manual of analysis of fruit and vegetable products*. Tata Mc-Garw Hill Publishing Company Limited, New Delhi, pp.634.

Shaw EJ 1961. *Western Fertilizer Handbook*, Soil Improvement Committee. Calif. Fertilizer Association.

Received 29 March, 2019; Accepted 10 May, 2019