Response of Sweet Pepper *Capsicum Annulus* L. (Qurtuba Cultivar) To Spraying With Two Types of Potassium Fertilizer Cultivated In Plastic House

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Abstract

Field experiment was conducted in the non-heated plastic house at Al-Mussaib Technical College in 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 in loamy sand soil. To study the effect of four levels of potassium fertilizer and micronutrients (0, 4, 6, 8 ml.L^{-1}), 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. The experiment was designed according to the Randomized Complete Block Design (RCBD) and the averages were compared with the least significant difference (LSD), with a significant level of 5%. The result indicated to the excelling of the spraying treatment with potassium and micronutrient (8 ml.L^{-1}) by giving it a significant level in increasing the averages of plant height, number of branches, leaf area, dry weight for total vegetative, number of flowers in plant, percentage of fruit set, the leaves content of (chlorophyll, nitrogen, Phosphorus and potassium), early and total yield, the content of vitamin C, and percentage of Total Soluble Solids, with an increasing percentage of (19.47, 29.54, 16.68, 30.01, 11.26, 24.09, 38.16, 24.36, 16.67, 34.00, 21.87, 20.27, 50.46, 45.96, 39.33, 70.85%), respectively, compared to control treatment. Which is the same behavior as spraying treatment with potassium fertilizer and sulfur, where treatment (4 ml.L^{-1}) was excelled in all the above traits, where the percentages of increasing were (31.72, 53.53, 49.88, 15.82, 14.84, 24.54, 19.79, 36.73, 21.05, 47.55, 24.53, 19.07, 49.43, 48.01, 30.29, 36.56%), respectively, compared to the control treatment. As for interaction treatments, it has showed excelling the spraying treatment with a mixture of (8 ml. L^{-1} + 4 ml. L^{-1}) by giving it the highest values for all the above traits amounted of (109.5 cm, 6.4 branches, 25.3 dm^2, 132.7 g, 62.7 flower, 43.9% 2.22%, 0.75%, 2.55%, 34.6 fruits, 108.3 g, 0.790 kg. $plant^{-1}$, 3.747 kg. $plant^{-1}$, 69.2 mg.100 ml^{-1}, 10.4%), respectively.

Keyword: Sweet pepper, Qurtuba, Potassium Fertilizer, Plastic House.

1. Introduction

Sweet pepper (Capsicum annulus L.) is belongs to the family Solonaceae, Its importance back to contain it on vitamins A and C as well as mineral elements such as calcium, iron and phosphorus, As well as fruits containing carbohydrates and proteins [1], It is cultivated in Iraq by the traditional exposed method at the beginning of spring and in the protected method at the beginning of autumn. The data of Central Bureau of Statistics, (2013) indicated that the total cultivated area, for the two methods of agriculture is estimated about (33840 dunums), with total productivity of (922925 tons) and a yield amounted of (27273 kg.dunums-1). The use of foliar nutrients is a complementary method of soil fertilization, which is one of the highways to address the shortage of one of the important nutrients for plant growth, It is a process that ensures a homogeneous distribution for nutrient elements on plant vegetative growth as well as the high efficiency of this method in providing plant in large quantities of the nutrient element [2].

[3] showed with increasing the demand for food, the use of foliar fertilizers increased by spraying it on the total vegetative for plant both for micro and macronutrient elements, which encouraged the production of large quantities from these fertilizers at the commercial level, scientific experiments has indicated to the response of most plants to them. [4] showed that the Plant leaf is considered an effective part in the photosynthesis proses and most of the phylogenetic processes occurring in the plant, for this the lack of nutrient elements shows first in the leaves, to treating this state it is preferable to add fertilizer by foliar spraying because it is more availability and therefore can play its role in the metabolism processes and the fixation of substances in the cells, which is reflected in the impact of plant growth and development during its various stages of growth. [5] indicated that the addition of fertilizers spraying on the leaves of plants is necessary in the soil of Iraq, which is exposed to the washing and sedimentation and stabilization of nutrient elements, which requires spraying this fertilizer to meet the needs of plants from these nutrients. [6] found 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 leaves content of chlorophyll, fruit size and its weight, and this was reflected in the total yield for fruits. [7] found that the spraying of eggplant plant with potassium fertilizer led to a significant increase in plant length, number of branches, weight of fruits, total yield for fruit and good quality for fruits. [8] 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 compared to the control treatment (without spraying). [9] found 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 the Indicators of the plant traits, especially the concentrations of (2 ml.L-1,1.5 ml.L-1), respectively. Plant height, number of branches, weight of fruit, plant yield and total yield were significantly increased. [10] indicated that the spraying of the magnesium element at a concentration of (3000 ppm) on the leaves of the sweet pepper plant (California and Wonderful cultivars) led to a significant increase in plant height, weight of fruit, plant yield, the leaves content of chlorophyll, the percentage of dry matter for fruits and percentage of Total Soluble Solids. The study aims to determine the response of the sweet pepper plant (Qurtuba cultivar) to foliar spraying with two types of potassium fertilizer; this is reflected in the indicators of vegetative growth, total yield and its quality.

2. Materials And Methods

A field experiment was conducted in the non-heated plastic house at Al-Mussaib Technical College in 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 of the field was removed at a depth of 30 cm, which was cultivated in the previous season with vegetable crops, which used Instead of it an agricultural media that represented by the loamy sand soil and peat moss with ratio 1: 3, the medias were then immersed in water to saturation limit and covered it with the used polyethylene, with thickness of (150 microns), for two months or 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. A sample for analysis was taken in the laboratory of the Soil Science Department, Technical Institute, Mussaib under the methods mentioned by [11, 12], the results of the analysis are shown in Table (1). The land of the plastic house was divided after the sterilization to 5 plots, the width of each them 150 cm (the width of the channel plot is 50 m while the width of the walkway was 100 cm), The plots were irrigated two days before cultivating, the produced seedlings were cultivated in one of the private farms (with 40 days age and after the formation of 3-4 real leaves) on both sides of the plot on 4/10/2016, awith distance of 40 cm between them, a 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 service operations were performed such as Replanting, grubbing and Pruning for all experimental units. The mineral fertilizer was added with an average of (240 kg. dunam-1) of ammonium sulphate and 160 kg.dunam-1 of triple superphosphate, on two batches during vegetative and flows growth, as following in the crop cultivation in greenhouses [13]. The study included 16 treatments, 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). Table (2) shows the components and sources of fertilizers. The spraying process was conducted with rate of five times, the period between them was 20 days. The first spraying was on 25/10/2016 before the appeared flowers, A plastic isolator was used between the experimental units when spraying to ensure that the spraying solution was not transferred between the two treatments. A plastic sprayers used with 2 L capacity

per treatment, the spraying process was conducted in the early morning preceded by field irrigation the previous day to ensure the opening of the stoma, The experiment was conducted according to the Randomized Complete Block Design (RCBD), with three replicates, The results were analyzed using the least significant difference (L.S.D) at the 5% probability level [14], while the SAS was used for data analysis [15].

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	$\mu g.m^{-3}$	1.46
Sand	$g.kg^{-1}$ soil	647.5
Silt		235.2
Clay		117.3
Texture		**Loamy sand soil**

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

Type of fertilizer	Potassium%	Sulfur%	Iron %	Copper%	Manganese%	Zinc%	Source
Potassium and KTS sulfur	36	25					Jordan, Import Al Wathba Land company for Agricultural and Animal Production
Potassium and micronutrients	10		2.5	1.5	2.5	3.5	Production of Ibn Sina Public Company, Ministry of Industry

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

1) **Plant length (cm):** It 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 by means of the metric tape.

2) **Number of branches per plant:** The number of branches bearing fruits for each experimental unit was calculated and then divided by number of plants of experimental unit.

3) **The leaf area of the plant (dm^2):** 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 by the scanning machine, the average area of the leaf was multiplied by the number of leaves.

4) **Dry weight of the total vegetative (g):** 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 by a sensitive balance.

5) **Chlorophyll content (SPAD Unit):** It was estimated by the chlorophyll meter (SPAD type) locally and on the plant directly by taking an average of three readings per leaf and from different locations for plant.

6) **The leaves content of nutrient elements (NPK):** The fourth leaf was taken from the Apical meristem for the plants from each experimental unit after flowering [16], then dried in the oven at 70 °C until the weight was stable, it was placed in sealed plastic bags, it was digested with sulfuric acid and perchlorate, with ratio amounted of 3: 5 [17] After completion of the digestion process, the following elements were estimated:

A) **The percentage of nitrogen:** It was estimated by distillation process using Micro-Kjeldahl and according to method [12].

B) **The percentage of Phosphorus:** It was estimated by the spectrophotometer at wavelength of 882 nm according to the method [18].

C) **The percentage of Potassium:** It was estimated by the Flame photometer according to the method described in [17].

7) **Number of fruits per plant:** It was estimated by counting the number of fruits for the experimental unit divided by the number of plants of experimental unit.

8) **Fruit weight (g):** It was measured by calculating the total fruit weight for the experimental unit divided by the number of fruits for the experimental unit.

9) **The early yield of the plant (kg):** It was calculated through the first three harvesting for the crop.

10) **The total amount for the plant (kg):** It was calculated through the sum of the total harvesting for the experimental units (15) harvesting divided by the number of their plants.

11) **The content of the fruits of vitamin C (mg. 100 g^{-1} dry weight):** it was estimated according to the method [19] by Titration a certain volume of fruit juice with 2-6-dichlorophenicol-Indophenol dye.

12) **The percentage of Total soluble solids T.S.S%:** It was estimated using a certain volume of fruit juice in the Refractometer.

3. Results And Discussion

1- Average plant length and number of fruit branches

Table (3) shows that there was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of plant height and the number of fruit branches compared to the control treatment. The treatment of potassium and micronutrients (8 $ml.L^{-1}$) gave the highest value and achieving an increasing percentage (19.47%, 29.54%), respectively, compared to the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (31.72%, 53.53%), 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 on the increase in the length of the plant and the number of fruit branches. The spraying treatment by a mixture of the two fertilizers (8 $ml.L^{-1}$ + 6 $ml.L^{-1}$) gave the highest values amounted to (109.5 cm, 6.4 branches), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 3: Effect of the Type of Potassium Fertilizer and the interaction between them in Average of Plant Length (cm) and Number of Fruit Branches for Plant.

Potassium& Sulphur ml.L^{-1}	Plant Length (cm) potassium and micronutrients (ml.L^{-1})				Average	Number of Fruit Branches potassium and micronutrients (ml.L^{-1})				Average
	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 = **6.52** , interaction= **13.04**					potassium and micronutrients = **0.32** potassium and Sulfur = **0.32** interaction = **0.64**				

2- Average of leaf area and dry weight for the total vegetative of the plant

Table (4) shows that there was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of leaf area and the dry weight for the total vegetative compared to the control treatment. The treatment of potassium and micronutrients (8 ml.L-1) gave the highest value and achieving an increasing percentage (16.68%, 30.01%), respectively, compared to the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (49.88%, 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 on the increase in the average of leaf area and the dry weight for the total vegetative. The spraying treatment by a mixture of the two fertilizers (8 ml.L-1 + 4 ml.L-1) gave the highest values amounted to (25.3 dm2, 132.7 g), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 4: Effect of the Type of Potassium Fertilizer and the interaction between them in Average of leaf area and dry weight for the total vegetative for Plant.

Potassium& Sulphur ml.L^{-1}	Leaf area dcm^2 potassium and micronutrients (ml.L^{-1})				Average	dry weight for the total vegetative gm potassium and micronutrients (ml.L^{-1})				Average
	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 = **0.84** , interaction= **1.68**					potassium and micronutrients = **6.75**, potassium and Sulfur = **6.75** interaction = **13.50**				

3- Average number of flowers in plant and the percentage of fruits set

Table (5) shows that there was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of number of flowers in plant and the percentage of fruits set compared to the control treatment. The treatment of potassium and micronutrients (8 ml.L-1) gave the highest value and achieving an increasing percentage to (11.26%, 24.09%), respectively, compared to

the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (14.84%, 24.54%), 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 on the increase in the average number of flowers in plant and the percentage of fruits set. The spraying treatment by a mixture of the two fertilizers (8 ml.L-1 + 4 ml.L-1) gave the highest values amounted to (62.7, 43.9%), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 5: Effect of the Type of Potassium Fertilizer and the interaction between them in Average number of flowers in plant and the percentage of fruits set for Plant.

Potassium& Sulphur ml.L^{-1}	Number of Flowers. plant^{-1} potassium and micronutrients (ml.L^{-1})				Average	fruits set for Plant% potassium and micronutrients (ml.L^{-1})				Average
	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 = **1.73** interaction = **3.46**					potassium and micronutrients = **1.58** potassium and Sulfur = **1.58** interaction = **3.16**				

4- Average chlorophyll content and the percentage of nitrogen in leaves

Table (6) shows that there was a 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. The treatment of potassium and micronutrients (8 ml.L-1) gave the highest value and achieving an increasing percentage (38.16%, 24.36%), respectively, compared to the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (19.79%, 36.73%), 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 on the increase in the average of chlorophyll content and the percentage of nitrogen in leaves. The spraying treatment by a mixture of the two fertilizers (8 ml.L-1 + 6 ml.L-1) gave the highest values amounted to (65.11 spad, 2.22%), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 6: Effect of the Type of Potassium Fertilizer and the interaction between them in the average of chlorophyll content and the percentage of nitrogen in leaves for Plant.

Potassium& Sulphur ml.L^{-1}	chlorophyll content (SPAD) potassium and micronutrients (ml.L^{-1})				Average	Nitrogen in leaves% potassium and micronutrients (ml.L^{-1})				Average
	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 = **3.07** interaction = **6.14**					potassium and micronutrients = **0.06** potassium and Sulfur = **0.06** interaction = **0.12**				

5- Average of the leaves content of phosphorus and potassium

Table (7) shows that there was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of the leaves content of phosphorus and potassium compared to the control treatment. The treatment of potassium and micronutrients (8 ml.L-1) gave the highest value and achieving an increasing percentage (21.87%, 20.27%), respectively, compared to the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (24.53%, 19.07%), 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 on the increase in the average of the leaves content of phosphorus and potassium. The spraying treatment by a mixture of the two fertilizers (8 ml.L-1 + 4 ml.L-1) gave the highest values amounted to (34.6, 108.3gm), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 7: Effect of the Type of Potassium Fertilizer and the interaction between them in the average of the leaves content of phosphorus and potassium for Plant.

Potassium& Sulphur ml.L^{-1}	P % in leaves				Average	K% in leaves				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 = **0.02** interaction = **0.04**					potassium and micronutrients = **0.21** potassium and Sulfur = **0.21** interaction = **0.42**				

6- Average number of fruits and weight of fruit

Table (8) shows that 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 value and achieving an increasing percentage (21.87%, 20.27%), respectively, compared to the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (24.53%, 19.07%), 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 on the increase in the average number of fruits and weight of fruit. The spraying treatment by a mixture of the two fertilizers (8 ml.L-1 + 6 ml.L-1) gave the highest values amounted to (34.6, 108.3 g), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 8: Effect of the Type of Potassium Fertilizer and the interaction between them in the average number of fruits and weight of fruit for Plant.

Potassium& Sulphur ml.L^{-1}	Number of Fruits. Plant^{-1} potassium and micronutrients (ml.L^{-1})				Average	Weight of Fruit (gm.) potassium and micronutrients (ml.L^{-1})				Average
	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 = **1.23** interaction = **2.46**					potassium and micronutrients = **6.44** potassium and Sulfur = **6.44** interaction = **12.88**				

7- Average of early and total yield for the plant

Table (9) shows that there was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of the early and total yield for the plant compared to the control treatment. The treatment of potassium and micronutrients (8 ml.L-1) gave the highest value and achieving an increasing percentage (50.46%, 45.96%), respectively, compared to the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (49.43%, 48.01%), 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 on the increase in the average of the early and total yield for the plant. The spraying treatment by a mixture of the two fertilizers (8 ml.L-1 + 4 ml.L-1) gave the highest values amounted to (0.790, 3.747 kg.plant-1), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 9: Effect of the Type of Potassium Fertilizer and the interaction between them in the average of the early and total yield for the plant.

Potassium& Sulphur ml.L^{-1}	Early yield Kg.Plant^{-1} potassium and micronutrients (ml.L^{-1})				Average	Total yield Kg.Plant^{-1} potassium and micronutrients (ml.L^{-1})				Average
	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 = **0.47** interaction = **0.94**					potassium and micronutrients =**0.205** potassium and Sulfur = **0.205** interaction = **0.410**				

8- Average of the fruits content from vitamin C and the percentage of total soluble solids

Table (10) shows that there was a significant difference between the levels of foliar spraying for the pepper plants with the potassium element on the traits of the fruits content from vitamin C and the percentage of total soluble solids compared to the control treatment. The treatment of potassium and micronutrients (8 ml.L-1) gave the highest value and achieving an increasing percentage (39.33%, 70.85%), respectively, compared to the control treatment, The same table showed that 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 excelled by giving it the highest values which achieved an increasing percentage (30.29% and

36.56%), 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 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 + 4 ml.L-1) gave the highest values amounted to (69.2 mg.100 ml-1, 10.4%), respectively, on the other hand, the lowest average for these two traits was at the treatment without spraying with fertilizers.

Table 10: Effect of the Type of Potassium Fertilizer and the interaction between them in the average of the fruits content from vitamin C and the percentage of total soluble solids for the plant.

Potassium& Sulphur ml.L^{-1}	Content of Vitamin C g.100ml^{-1} potassium and micronutrients (ml.L^{-1})				Average	Total Soluble solids % potassium and micronutrients (ml.L^{-1})				Average
	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 = **4.06** interaction = **8.12**					potassium and micronutrients = **0.67** potassium and Sulfur = **0.67** interaction = **1.34**				

The results of tables (3, 4, 5, 6, 7) showed that the levels of the study (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 levels of spraying (8 and 4 ml.L-1 for two fertilizers respectively) were significantly excelled in plant height, number of branches per plant, leaf area, dry weight of total vegetative, number of flowers in plant and percentage of fruit set, the leaves content of chlorophyll, percentage of nitrogen, phosphorus and potassium in leaves,. The reason is that the potassium element 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, Which 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 [20] in their study on the tomato plant and [21] in their study on the eggplant plant that the potassium fertilization significantly increased the height of the plant and its dry weight. The spraying process with the 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 CO2 gas necessary for the photosynthesis process and the formation of carbohydrates and proteins, then contribute to the transfer to fruits [2]. 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 (eg: carbohydrate and proteins), thus increase the dry weight of the plant [22]. 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. The presence of micronutrients associated with the potassium component may lead to a significant increase in the study indicators for the peppers plant, iron can contribute to increase the efficiency of the metabolism process, the formation of several important biological compounds such as Cytochromates and its contribution to the construction of proteins and carbohydrates and fats and the activation of some enzymes

[2], Manganese in biological processes and its large role in the processes of oxidation and reduction and lead to increase the activity of enzymes as dehydrogenase and has a role in the formation of chlorophyll and the carbohydrate fixation in the leaves of the plant, The copper elements is also involved in the synthesis of Cytochrome oxidase and Ascorbic acid oxidase enzymes and is involved in the proteins fixation through stimulating RNA and DNA [23]. The zinc elements contributes to the formation of the amino acid (Tryptophan), which consists of indole acetic acid necessary in the division and elongation of cells [24], as well as the importance of sulfur, which plays many roles and important for the plant, including the entry of the formation of three amino acids (Methionine, Cystine and Cysteine), the formation of the protein as well as its importance in the oxidation and reduction processes that occur in the plant, It is also important to obtain important energy for plant metabolism, and there are three compounds containing sulfur and is important in the Decarboxylation process of Pyruvic acid to form active acetate, which is the starting point in the Krebs Cycle for respiration [2]. The tables (8, 9, 10) indicated a 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 [2 , 25]. 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 [26]. The results of the statistical analysis showed that the interaction between the factors led to a significant increase in all indicators of vegetative and flowering growth, which may be due to the combined effect of potassium fertilizers used in the experiment.

Conclusion

It is concluded that 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) led to a significant increase in all indicators of vegetative and flowering growth, yield and its quality in experimental conditions.

CONFLICT OF INTERESTS.

- There are no conflicts of interest.

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استجابة نبات الفلفل الحلو *Capsicum annuum* L. صنف قرطبة للرش بنوعين من الاسمدة البوتاسية والمزروع في البيوت البلاستيكية

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الخلاصة

نفذت تجربة حقلية في البيت البلاستيكي غير المدفأ في الكلية التقنية المسيب للموسم الخريفي 2016 لدراسة مدى استجابة نبات الفلفل الحلو *Capsicum annuum* L. صنف قرطبة للرش الورقي بنوعين من الاسمدة البوتاسية الورقية التجارية في تربة رملية مزيجة لدراسة تأثير اربعة مستويات من سماد البوتاسيوم والعناصر الصغرى (صفر، 4، 6، 8 مل.لتر$^{-1}$) واربعة مستويات من سماد البوتاسيوم والكبريت KTS (صفر، 2، 4، 6 مل.لتر$^{-1}$) وتداخلهما على بعض مؤشرات النمو الخضري والزهري والحاصل ونوعيته، صممت التجربة وفق تصميم القطاعات تامة التعشية RCBD وقورنت المتوسطات باختبار اقل فرق معنوي LSD وبمستوى معنوية 5%.

اشارت النتائج الى تفوق معاملة الرش بسماد البوتاسيوم والعناصر الصغرى بمستوى (8 مل.لتر−1) معنويا في زيادة متوسطات طول النبات وعدد الافرع المثمرة والمساحة الورقية للنبات والوزن الجاف للمجموع الخضري وعدد الازهار في النبات ونسبة العقد ومحتوى الاوراق من الكلوروفيل والنتروجين والفسفور والبوتاسيوم وعدد الثمار ووزن الثمرة والحاصل المبكر والكلي ومحتوى فيتامين C ونسبة المواد الصلبة الذائبة الكلية وبنسب زيادة بلغت 19.47، 29.54، 16.68، 30.01، 11.26، 24.09، 38.16، 24.36، 16.67، 34.00، 21.87، 20.27، 50.46، 45.96، 39.33، و70.85% بالتتابع قياسا بمعاملة المقارنة، وهو نفس سلوك معاملة الرش بسماد البوتاسيوم والكبريت اذ تفوقت المعاملة (4 مل.لتر−1) في جميع الصفات اعلاه اذ بلغت نسب الزيادة 31.72، 53.53، 49.88، 15.82، 14.84، 24.54، 19.79، 36.73، 21.05، 47.55، 24.53، 19.07، 49.43، 48.01، 30.29 و36.56% بالتتابع قياسا بمعاملة المقارنة. اما معاملات التداخل فقد اظهرت تفوق معاملة الرش بخليط من (8 مل. لتر−1 + 4 مل. لتر−1) واعطائها اعلى القيم لجميع الصفات اعلاه وبلغت 109.5 سم، 6.4 فرع، 25.3 دسم2، 132.7 غم، 62.7 زهرة، 43.9%، 65.11 spad، 2.22%، 0.75%، 2.55%، 34.6 ثمرة، 108.3 غم، 0.790 كغم. نبات−1، 3.747 كغم. نبات−1، 69.2 ملغم.100مل−1، و10.4% بالتتابع.

الكلمات الدالة: الفلفل الحلو، قرطبة، الاسمدة البوتاسية، البيت البلاستيكي.