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Effect of Spraying Mineral Fertilizer and Sorbitol Sugar on Growth and Yield of *Capsicum frutescens* L.

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Abstract

This experiment was carried out in order to study the effect of Mineral fertilizer and Sorbitol Sugar on the growth, and yield produced by chili pepper plant Barbarian F1, A factorial experiment with two factors, Mineral Fertilizer concentration 0, 0.5, 1, 1.25 and 1.5 g L^{-1} and Sorbitol Sugar 0 and 10 g L^{-1} was used in the term of (RCBD) with three replications. The results showed significant superiority of Mineral Fertilizer at 1.5 ml^{-1} in the plant height (59.62 cm $plant^{-1}$), number of main branches $plant^{-1}$ (5.600 branch $plant^{-1}$), total leaf area (21.100 dm^2 $plant^{-1}$), number of fruits plant (88.25 fruit $plant^{-1}$). One plant yield (0.718 kg $plant^{-1}$) and total yield (23.94 tons $hectare^{-1}$). The result also showed a significant increase of Sorbitol sugar in concentration 10 g L^{-1} in the plant height, number of branches[1], total leaf area by balance, number of fruits, (58.63cm, 5.493 branch $plants^{-1}$, 21.98dm^2, 84.78 fruit $plant^{-1}$, 0.685 kg $plant^{-1}$, and 23.03 ton $hectare^{-1}$ respectively). The interaction indicated that both variables were significant for all the studied traits, indicated that the response of pepper to the first variable is related to the second one. Thus, the research has concluded that the Interaction of variables, mineral fertilizer (1.5 g L^{-1}) and Sorbitol Sugar 10 g l^{-1} has a great combination to increase the growth and the yield of chili pepper.

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Introduction

Chili Pepper (*Capsicum frutescens* L.) belongs to the Solanaceae family (Abu-Zahra; 2012). It is one of the important crops of the Solanaceae‘ family. Chili Pepper is grown in the middle and north of Iraq, cultivation area reached 13059 ha in 2019 with a yield of 23473 tons (Kadhim, 2017). The cultivated area in the world amounted to 674,948 hectares in 2018, and the production in the world reached 496,134 tons, led by Asia, with a production of 317,139 tons (Cheema, 2011). The usual period of its growth in Iraq at open fields at the beginning of spring, and in protected agriculture at the beginning of fall. Some scholars give more attention to develop and product and nutrition value of this crop. As it has many chemical compounds, they are one of the most important antioxidants to reduce the risk of chronic diseases, anti-inflammatory, anti-allergic and cirrhosis, carotenoids that are component of the non-enzymatic system of Antioxidants, Carbohydrate, Protein, Vitamin C (Zehra Khan, *et al.*, 2012); (Power, 1997); (EL-Bassiony, 2010); (Awuchl, 2017) .

Pepper contains a weak root system which causes the fall of flowers and fruits. Environmental factors also have a very important role in accelerating the rate of transpiration, which leads to the lack of water in the tissues and fruits, although it is available in the soil because Pepper has weak roots (Park and Kaura, 2012). Mineral Fertilizer is important and necessary for the growth and reproduction of plant to complete its life's cycle, It contains both

macro and micro nutrients, the absence of this element or lack of its available makes plant die before the completion of its life's cycle from seed to seed which it has a great role in the physiological processes of the plant (Ali, *et al.,* 2014). Therefore, it has an impact on physiological processes. Mineral fertilizer usually works for, vegetable growth, stimulates root, increase the number of leaves, foliar, area, and numberof branches, going up the impact of growth regulators, especially Auxin. It also has a great role in the formation of organic acid, amino acid and Nucleic acid (RNA, DNA). Energy compounds (ATP, NADP) and proteins in the plant. Therefore the macro and micro elements are necessary to complete the process of elongation and cell division plant to grow and complete the life cycle of plant (Abdel-Mouty *et al.,* 2011); (Al-Ibrahemi, 2011); (Silke, 2011); (Taiz, 2010). Sorbitol sugar is a carbohydrate ($C_6H_{14}O_6$). Suger sorbitol easily moves inside the plant. It was founded in 1996 with natural elements inside the phloem (Brown, 1996) (Central Statistical Organization, 2018) (Sposeto, 2012), Therefore, this increase in element movement within the phloem leads to an increase the growth and yield. This current study aims to investigate the effect of Mineral fertilizer and Sorbitol, which is a new generation of nutrients that fasten the absorption and nutrient movement from the source to the sink on the growth, yield and quantity of the seeds produced from pepper plants. The aim of this research study is:

1- Study of the effect of mineral fertilizer on leaves on the growth and yield of chili pepper.

2- The response of pepper plants to spraying with sorbitol sugar in the growth and yield of chili pepper plants.

3- Knowing the effect of the interaction between the studied workers, mineral fertilizer, and sorbitol sugar alcohol, which are a new generation of foliar nutrients due to the rapid absorption, and the movement of nutrients easily to their arrival from their places of impact from the source to the estuary, on the growth and yield of pepper seeds.

Materials and Methods

This experiment was carried out at the open field, College of Agriculture, University of Diyala, at open field, in agriculture between 2/2/2021 to 1/7/2021. It aims to study the effect of spraying Mineral fertilizer and Sugar Sorbitol on growth, yield of chili pepper cultivar Barbarian F_1. The production of used seed is by Origin (India company) according to (Al-Shammari, 2018) after 75 days of transplantation , with germination rate 90%, off type 1.00% and purity 99.00%, date of production 1/7/2020. Then, the seeds planted in cork dishes on 20/12/2020. The seedlings transferred to the field on 2/2/2021. The practical factorial experiment included two factors, Mineral fertilizer (MPK) with five concentrations (0, 0.5, 1,1.25, and 1.5 g L^{-1}) Sorbitol Sugar ($C_6H_{14}O_6$) at two concentrations (0,10 g L^{-1}), in addition to the control treatment (spraying with distilled water). Plants were sprayed three times in 30/3/2021, 15/4/2021 and 30/4/2021. The experiment was performed in RCBD with three replications consisted 30 experimental units and each unit contained 10 plants with 6 m in length 0.75 m width and 0.4 m space between plants, At the end season, 5 plant, from each experimental unit, are randomly collected in order to structural features , such as height of plant (cm $plant^{-1}$), number of branches (branch $plant^{-1}$), total leaf area (dm^2 $plant^{-1}$) , weight and number of fruits, one plant and total yield (ton $hectare^{-1}$), The experiment result was analyses using (SAS) . The LSD calculates the smallest significant between two means below the 0.05 probability level (Matlob, *et al.,* 1989). The vegetative total was sufficient when the first spraying was carried out, and the first spray was carried out after (15 days) of planting the seedlings, at a rate of three batches.

Plant height (cm)

The height of the pepper plant was measured using the measuring tape, starting from the position of the plant in contact with the soil to the highest peak between the growing branches after 75 days of planting the seedlings, the height of five plants from each randomly selected experimental unit was measured and the average was calculated.

Number of main branches (plant branch^{-1})

This trait was calculated at the end of the season, and five plants were randomly tested.

Number of Leaves (leaf plant^{-1})

The average number of leaves per plant at the end of the season was calculated for five plants selected from each experimental unit.

Total leaf area (dm^2 plant^{-1})

A sample of five leaves was taken from every five plants in the experimental unit, and the leaf area was measured by the gravimetric method by measuring the weight of the leaves and then a disc of known area (1.5 cm in diameter) was taken, its weight was measured by a sensitive scale, and the readings were recorded Extracting the paper space according to the following law:

Paper area = Weight of whole paper (g) × Disc area (cm^2)/ Weight of disc cut (g)

Determination of Total Chlorophyll Content in Leaves (SPAD)

The amount of chlorophyll was estimated by a chlorophyll meter type (Spad-504m) based on (Jemison, William, 2006).

Average number of fruits (fruit of a plant $^{-1}$)

According to the number of fruits for the experimental unit for all the fairies in a cumulative way and extracting the average according to the following equation:

The number of fruits. Plant $^{-1}$ = the number of fruits of the experimental unit / the number of plants in the experimental unit.

Yield per plant (kg plant^{-1})

According to the plant yield of the cumulative multiple fairies 12 pounds per experimental unit throughout the season from the first fairy on 4/11/2121 until the last fairy on 6/25/2021, the result of the experimental unit / number of fruits for the experimental unit.

Early yield (tons hectare^{-1})

According to the early yield by calculating the yield of the first three fairies in the experimental unit, the data was recorded and attributed to the hectare.

The total yield (ton hectare $^{-1}$)

Total yield (ton hectare^{-1}) 1000 m^2

According to the total yield of the experimental unit, from the start of the genie on 4/11/2021 to the last pound on 06/25/2021, at a rate of 12 pounds, and according to the cumulative yield of the fairies, and then attributed to

Total yield = yield of experimental unit (tons) × hectare area (10000 m^2) / area of experimental unit (4.5 m^2)

Results and Discussion

Plant height (plant cm)

It is evident from Table 1 that spraying mineral fertilizer led to a significant increase in the rate of plant height, and it was the best treatment A5 (59.65 cm) compared to control which was 50.04 cm.

As for the use of sorbitol sugar, it led to a significant increase in the rate of plant height. As the S_2 treatment gave the highest

value of 58.63 cm plant^{-1} compared to the control treatment, which gave the lowest plant height of 51.24 cm plant^{-1}. The interaction of sorbitol spraying with the mineral fertilizer S_2+A_5 on the leaves gave the highest average plant height and reached 63.03 cm plant^{-1}, while the measurement treatment S_0+A_0 gave the lowest average plant height which reached 44.33 cm plant$^{-1.}$

Table 1. Effect of spraying mineral fertilizer and sorbitol sugar and their interaction on the height of chili pepper plants cm plant^{-1}

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5g L^{-1}**	**A_4 1.25g L^{-1}**	**A_3 1g L^{-1}**	**A_2 0.5g L^{-1}**	**A_1 0**	**Sugar alcoholic**
51.24^{b}	56.27^{cd}	54.53^{ed}	52.34^{d}	48.75^{e}	44.33^{f}	**S_1**
58.63^{a}	63.03^{a}	60.09^{ab}	57.72^{c}	56.55^{cd}	55.76^{cd}	**S_2**
LSD value of interference=3.82						
LSD value for Sugar alcohols =1.71	59.65^{a}	57.31^{ab}	55.03^{bc}	52.65^{cd}	50.04^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer =2.70					

Number of branches (plant branch^{-1})

It is noted from the results of Table 2 that the spraying of mineral fertilizer led to a significant increase in the number of branches of the plant. A_5 was significantly outperformed all treatments but did not differ significantly with the treatment of A_4 in the number of branches, which reached 5,600 plant branches^{-1}, while A_0 treatment gave the lowest rate 4.200 plant^{-1}branches. The treatments of spraying sorbitol sugar showed a significant increase in the average number of main branches of the chili pepper plant compared to the control treatment, and Sorbitol S_2 treatment gave the highest number of main branches and it reached 5.493 branches of the plant^{-1}, compared control treatment that gave the lowest rate 4.400 branches of the plant^{-1}. The interaction between sorbitol sugar and mineral fertilizer showed a significant effect, especially on S_2+A_5, which reached to 6.066 plant branch^{-1}, while the control S_0+A_0 gave the lowest average number of branches, which amounted to 3.666 plant branches^{-1}.

Table 2. Effect of spraying mineral fertilizer and sorbitol sugar and their interaction on the number of main branches of pepper plants plant branch^{-1}

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5 g L^{-1}**	**A_4 1.25g L^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.5 g L^{-1}**	**A_1 0**	**Sugar alcoholic**
4.40^{b}	5.13^{cd}	4.80^{ed}	4.46^{d}	3.93^{e}	3.66^{f}	**S_1**
5.49^{a}	6.06^{a}	5.80^{ab}	5.53^{c}	5.33^{cd}	4.73^{cd}	**S_2**
LSD value of interference=0.43						
LSD value for sugar alcohols =0.19	5.60^{a}	5.30^{ab}	5.00^{bc}	4.63^{cd}	4.20^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer =0.30					

Total leaf area (dm ^{2} plant $^{-1}$)

The results of Table 3 showed that the treatments of mineral fertilizer spraying show up to a significant increase, as the treatment of spraying mineral fertilizer A_5 outperformed the treatment of mineral fertilizer A_5 and amounted to 219.0 dm^2 plants^{-1}, while the control treatment gave the lowest average in the total leaf area, which amounted to 108.9 dm^2 plants^{-1}. As for the sorbitol spraying treatments, it had a significant effect on the average leaf area of chili pepper plant compared to the control treatment, as the S_2 treatment was significantly superior in giving the highest leaf area amounted to 219.6 dm^2 plant^{-1}, compared to the control treatment that gave the lowest rate in the total leaf area amounted to 135.5 dm^2 plant^{-1}. The interaction between sorbitol and mineral fertilizer S_2 + A_5 on leaves gave the highest average of the total leaf area and amounted to 245.7 dm^2 plant^{-1}, while the control treatment gave the lowest rate in the total leaf area amounted to 57.83 dm^2 plant^{-1}.

Table 3. The effect of spraying mineral fertilizer and sorbitol sugar and their interactions on the total leaf area of chili pepper plants dm ^{2}. Plant^{-1}

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5 g L^{-1}**	**A_4 1.25g L^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.5g L^{-1}**	**A_1 0**	**Sugar alcoholic**
135.5^{b}	192.2^{cd}	184.0^{ed}	175.1^{d}	68.63^{e}	57.83^{f}	**S_1**
219.6^{a}	245.7^{a}	237.3^{ab}	235.3^{c}	219.6^{cd}	160.1^{cd}	**S_2**
LSD value of interference = 47.60						
LSD value for sugar alcohols = 212.9	219.0^{a}	210.6^{ab}	205.2^{bc}	144.1^{cd}	108.9^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer = 33.66					

The number of leaves (leaf plant^{-1})

The results were shown in Table 4, that mineral fertilizer spraying did not have a significant effect on the number of leaves. The results of spraying sorbitol sugar showed that there was no significant effect on the number of leaves. and there wasn't any interaction between two factor on the number of leaves in plant.

Table 4. The effect of spraying mineral fertilizer and sorbitol sugar and their interaction on the number of leaves of chili pepper leaf .plant^{-1}

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5 g L^{-1}**	**A_4 1.25 g L^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.5g L^{-1}**	**A_1 0**	**Sugar alcoholic**
119.8^{b}	123.0^{cd}	123.3^{ed}	116.3^{d}	114.0^{e}	122.6^{f}	**S_1**
125.9^{a}	134.6^{a}	130.6^{ab}	129.3^{c}	128.6^{cd}	106.3^{cd}	**S_2**
LSD value of interference=26.72						
LSD value for sugar alcohols =11.95	128.8^{a}	127.0^{ab}	122.0^{bc}	121.3^{cd}	114.5^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer =18.9					

Determination of total chlorophyll content in leaves (SPAD)

The results of Table 5 showed that the application of mineral fertilizer had no significant effect on the total chlorophyll content of leaves. But sorbital suger had significant differences in total chlorophyll content of leaves, as S2 gave 62.64 SPAD, compared to the control treatment, which gave the lowest total chlorophyll content of 60.03 SPAD. The spraying of mineral fertilizer and sorbitol had a significant effect, the treatment of spraying mineral fertilizer A_5 with sorbitol S_2 excelled with the highest value of 65.36 SPAD, compared to the interaction between mineral fertilizer A_0 and sorbitol S_0 , which gave the lowest value of 54.83 SPAD.

Table 5. The effect of spraying mineral fertilizer and sorbitol sugar and the interaction between them on the total chlorophyll content in the leaves of chili pepper plants (SPAD)

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5 g L^{-1}**	**A_4 1.25 g L^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.g L^{-1}**	**A_1 0**	**Sugar lcoholic**
60.03^{b}	64.30^{cd}	61.23^{ed}	59.93^{d}	59.86^{e}	54.83^{f}	**S_1**
62.64^{a}	65.36^{a}	63.36^{ab}	62.76^{c}	62.00^{cd}	59.86^{cd}	**S_2**
LSD value of interference=5.27						
LSD value for sugar alcohols =2.36	64.83^{a}	62.23^{ab}	61.35^{bc}	60.93^{cd}	57.35^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer =3.73					

The number of fruits (fruit of a plant $^{-1}$)

The results in Table 6 showed that the spraying of mineral fertilizer A number of fruits of chili pepper plants reached 88.25 fruits of plant, compared to the control A_0, which gave the lowest number of fruits of chili pepper in plants 65.61 fruits of plant^{-1}. Sorbitol showed a significant increase in the number of fruits of chili pepper plants, which was 84.78 fruits of plant^{-1}, compared to the comparison control, which gave the lowest value of the number of fruits of pepper plants, which were 61.50 fruits of plant^{-1}.

Table 6. Effect of applying mineral fertilizer and sorbitol sugar and the interaction between them on the number of fruits of chili pepper plants. Fruit of a plant $^{-1}$

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5g L^{-1}**	**A_4 1.25g L^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.5g L^{-1}**	**A_1 0**	**Sugar alcoholic**
72.24^{b}	81.06^{cd}	76.30^{ed}	72.50^{d}	69.83^{e}	61.50^{f}	**S_1**
84.78^{a}	95.43^{a}	93.36^{ab}	85.50^{c}	79.90^{cd}	69.73^{cd}	**S_2**
LSD value of interference = 4.06						
LSD value for sugar alcohols = 1.18	88.25^{a}	84.83^{ab}	79.00^{bc}	74.86^{cd}	65.61^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer = 2.87					

The yield of one plant (kg plant^{-1})

We noticed from Table 7 that the application of mineral fertilizer in A5 treatment had significant difference in the yield of one plant of chili pepper plants compared to the rest treatment by value 0.718 kg plant^{-1}. There was a significant increase in the yield of one plant of chili pepper plants by use sorbitol sugar by S2

which reached to 0.688 kg plant^{-1}, while the control gave the lowest yield of one plant of 0.572 kg plant^{-1}. The interactions between mineral fertilizer A_5 and sorbitol sugar sprayed S_2 .was the best treatment by value 0.776 kg.plant^{-1}.

Table 7. Effect of spraying mineral fertilizer and sorbitol sugar and the interaction between them on the yield of one pepper plant per kg plant^{-1}

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5 g L^{-1}**	**A_4 1.25gL^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.5g L^{-1}**	**A_1 0**	**Sugar alcoholic**
0.57^{b}	0.65^{cd}	0.64^{ed}	0.58^{d}	0.53^{e}	0.43^{f}	S_1
0.68^{a}	0.77^{a}	0.74^{ab}	0.71^{c}	0.65^{cd}	0.55^{cd}	S_2
LSD value of interference=0.05						
LSD value for Sugar alcohols = 0.02	0.718^{a}	0.691^{ab}	0.650^{bc}	0.596^{cd}	0.496^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer =0.03					

Early yield (tons hectare^{-1})

It is noted in Table 8 that the application of mineral fertilizer with concentration A_5 was significantly superior in the early yield of chili e pepper plants, which amounted to 4.962 tons hectare $^{-1}$, compared, which gave the lowest early yield of pepper plants amounted to 3.641 tons hectare $^{-1}$. The spraying of sorbitol sugar had a significant effect on the early yield of pepper plants compared to the control treatment, which gave the lowest average yield of 4.059 tons hectare $^{-1}$in S1treatment, but S_2 treatment gave the highest rate of early yield of chili pepper plants, which amounted to 4.756 tons hectare^{-1}. The interaction treatments between mineral fertilizer and sorbitol sugar showed that spraying the leaves had a significant effect compared to all treatments. Which reached to A_5 with S_2 was 5.720 tons. hectare^{-1} while the control gave the lowest early yield of plants. 3.264 tons hectare^{-1}

Table 8. The effect of spraying mineral fertilizer and sorbitol sugar and the interaction between them on the early yield of pepper plants 1 ton hectare^{-1}

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5 g L^{-1}**	**A_4 1.25g L^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.5g L^{-1}**	**A_1 0**	**Sugar alcoholic**
4.05^{b}	4.20^{cd}	4.85^{ed}	4.28^{d}	3.69^{e}	3.26^{f}	**S_1**
4.75^{a}	5.72^{a}	4.98^{ab}	4.52^{c}	4.53^{cd}	4.01^{cd}	**S_2**
LSD value of interference=0.58						
LSD value for Sugar alcohols =0.26	4.96^{a}	4.92^{ab}	4.40^{bc}	4.11^{cd}	3.64^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer =0.41					

The total yield (ton .hectare^{-1})

The results in Table 9 showed that the application of mineral fertilizer with concentration A_5 was significantly superior in the total yield of chili pepper plants, which reached to 23.94 tons .hectare $^{-1}$, without differ significantly compared to A_4, while the treatment A_1 had the lowest value

which was 23.05 tons .hectare $^{-1}$. In the other hand the interaction between the fertilizers and sorbitol sugar sprayed had a significant effect, which was the highest at concentration A_5 with sorbitol S_2 25.89 tons .hectare $^{-1}$, while the control had the lowest value 14.58 tons .hectare $^{-1}$.

Table 9. Effect of spraying sorbitol and chemical fertilizer and the interaction between them on the total yield of chili pepper plants 1 ton hectare^{-1}

mineral fertilizer						
sugar effect alcoholic	**A_5 1.5 g L^{-1}**	**A_4 1.25g L^{-1}**	**A_3 1 g L^{-1}**	**A_2 0.5g L^{-1}**	**A_1 0**	**Sugar alcoholic**
19.08^{b}	21.99^{cd}	21.37^{ed}	19.67^{d}	17.81^{e}	14.58^{f}	**S_1**
23.03^{a}	25.89^{a}	24.73^{ab}	24.08^{c}	21.94^{cd}	18.55^{cd}	**S_2**
LSD value of interference=1.77						
LSD value for sugar alcohols =0.79	23.94^{a}	23.05^{ab}	21.87^{bc}	19.87^{cd}	16.56^{d}	**fertilizer effect metal**
	LSD value of mineral fertilizer =1.25					

Conclusion

In this study, the interaction between the two factors was important for all the traits under the study, Indicated that the reaction of chili pepper to the first factor is related to the second one. Thus, the research has concluded that the Interaction of both variables; Mineral fertilizer (1.5 g L^{-1}) and Sorbitol 10 g L^{-1} has a great combination to increase i the growth and the yield of chili pepper.

Conflict of Interest

There is no conflict of interest between authors**.**

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