Effect of foliar application and fertigation on micronutrient absorption efficiency and productivity of sweet pepper in calcareous soil in Iraq

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Abstract

A field experiment was carried out in a private greenhouse farm located in Al-Madaen city / old Diyala Bridge / Western Tuwaitha village (N 44, 29,47-E 36, 33,11) in the agricultural season 2020/2021 to study the effect of micronutrient absorption efficiency and yield of sweet pepper was grown in calcareous soil, Dutch Olombus sweet pepper was planted and used the nutrients (manganese at a concentration of 30 $mg.l^{-1}$, copper at ca concentration of 25 $mg.l^{-1}$. Iron at a concentration of 50 $mg.l^{-1}$, zinc at a concentration of 60 $mg.l^{-1}$, The factorial experiment was carried out according to the split-plot design with two methods of nutrients application, one by spraying on shoots foliar application and the other with irrigation water, 16 treatments were used for each method of addition, which consisted of single, double, triple and quadruple addition of the nutrients that used in the experiment, with the control treatment for each method of addition and with three replicates for each treatment, there were 30 additions duration of the experiment, the first edition took place after two weeks of cultivation in the field, the period between each addition was one week, and the macronutrients N, P, K were used in concentrations (425 Kg N ha^{-1},175kg P ha^{-1} and 250 kg K ha^{-1}), the results of highest cumulative yield was for the Fe+ Zn+ Mn treatment which added by spraying on shoots, which amounted to 159.15 Mg h^{-1}., It also showed a highly significant superiority for all treatments of adding micronutrients sprayed on the shoot over the corresponding treatments of adding these nutrients with irrigation water on the efficiency of absorption of micronutrients in the fruits of the sweet pepper plant. The Fe+ Mn treatment gave the highest value for the iron absorption efficiency of 341.3%, while the Zn+ Mn+ Cu treatment gave the highest value for the zinc absorption efficiency of 113.17%. As for the manganese absorption efficiency, the Fe+ Mn treatment gave the highest value of 517.2%. As for the absorption efficiency of copper, the Fe+ Mn+ Cu treatment gave the highest value of 217.2%.

Keywords: Pepper, Micronutrients, Fertigation, Foliar, absorption efficiency, Calcareous soil.

Introduction

Micronutrients are no less important than macronutrients in increasing agricultural production and improving its quality, as they have an important role in plant growth, processes related to photosynthesis, chlorophyll formation, root cell development, respiration, water absorption, plant disease resistance, and activity of enzymes involved in primary and secondary metabolism and nitrogen fixatio.(1, 15, and 23). Iron, zinc, manganese, and copper are involved in several processes that control plant growth, mineral content, and yield quality and manifest different deficiency symptoms and in severe cases lead to plant death, (1 and 7), depending on the specific element, some of its specific functions and plant type (14). Most agricultural soils, especially calcareous, suffer from a deficiency in their available content of micronutrients for most plants. It was found that there are factors that affect their availability, including those related to the Soil properties, others related to the plant, and others related to the environment, cultivated crop, oxidation-reduction conditions, climatic conditions (rain, humidity, temperature, and others. (4, 9, and 22). Iraqi soils have a relatively high soil pH, which causes a decrease in the availability of many nutrients, including iron, zinc, manganese and copper, but the possibility of responding to their addition in the Iraqi soil is available (3) The sweet pepper plant, Capsicum annum L. belongs to the Solanaceae family (12) mentioned that the importance of sweet pepper is due to its high nutritional value as well as health because it contains high concentrations of vitamin C and vitamin A, micronutrients are added to plants in several ways, but the most common are spray on shoots which many researchers used to this method, including Al-Fadhly *et al.*,(2) because of its importance in the significant effect on plant characteristics, whether vegetative, specific or productive, Zeidan., *et al* (24) also resorted to spraying iron, zinc and manganese on wheat, and their results indicated that this led to an increase in the concentration of these nutrients in wheat grains, in addition to achieving an increase in production. Al-Shaheen *et al.*, (5) also used spraying micronutrients on corn, which achieved a significant increase in the traits that were studied in the research, the other method is by using micronutrients with irrigation water which called fertigation, some researchers resorted to using this method to show the effect of this on the studied plants, Moreira *et al.*, (16) used the ground addition of iron and manganese to the soybean plant, and they concluded that the ground addition of these nutrients led to an increase in the content of the yield of these minerals, in addition to an increase in some growth indicators, as well as an increase in the availability of some nutrients, as well as what Thingujam *et al.*, (21) did by adding iron and zinc to the eggplant crop with macronutrients, which led to an increase in its productivity as well as the positive effect in its content of these nutrients, as well as increasing the availability of them in soil, so the objective of study is to comparison method of addition micronutrients on its absorption efficiency and productivity of sweet pepper in calcareous soil.

Materials and Methods

A field experiment was carried out in Iraq / Baghdad - the area of the old Diyala Bridge /the western village of Al-Tuwaitha (in a greenhouse farm) during the agricultural season 2020/2021 on the sweet pepper crop, according to the following stages:

Field soil preparation:

The pre-planting process was prepared to start by carrying out the solar sterilization process, as the field soil was flooded with water on 7/10/2020 and then covered with a plastic cover made of polyethylene to sterilize it through the solar pasteurization process. The process continued for a period of sixty days and then after that the plastic cover was removed and the soil was left for five days to air-dry, then plowed with a reciprocating plow and left until planting

Soil Analysis**:**

The composite soil sample was taken from the field at depth of (0-30) Soil sample was air –dried and grinded and sieved with a sieve of 2 mm, physical, chemical, and fertility properties of the soil were done according to the methods mentioned in table 1.

Table 1. Some physical, chemical, and fertility characteristics of the soil before planting

Soil properties	Value	Unit	Reference
Electrical conductivity EC (1:1)	2.9	ds m^{-1}	Page *et al*, (17)
pH (1:1)	7.24	--------------	Page *et al*, (17)
Available nitrogen	35	mg kg^{-1} soil	Page *et al*, (17)
Available phosphorous	6.2		Page *et al*, (17)
Available Potassium	138.21		Page *et al*, (17)
Available iron	3.4145		Lindsay and Norvel, (13)
Available zinc	0.3413		
Available manganese	0.1731		
Available copper	0.1434		
Organic matter	7.2	gm kg $^{-1}$	Page *et al*, (17)
Carbonate minerals (CaCO3)	282.1		Hesse (10)
soluble calcium Ca^{2+}	8.62	mmol l^{-1}	Richards (19)
soluble magnesium Mg^{2+}	5.12		Richards (19)
soluble Sodium Na^{+}	3.21		Richards (19)

soluble bicarbonate HCO_3^-	1.1		Richards (19)
soluble chlorine Cl^-	21.04		Jackson (11)
soluble sulfates SO_4^{2-}	4.28		Page *et al*, (17)
soluble potassium	1.13		Richards (19)
Sand	530	gm kg soil-1	
Silt	90		Page *et al*, (17)
Clay	380		
Soil texture	Sandy Clay		

Transfer of seedlings to field soil and crop service operations

The seedlings were transferred to the soil of the plastic house on 11/11/2020 after it was sterilized to preserve them from fungal soil diseases. The soil of the field was divided into agricultural lines (terraces), and the width of one terrace was 50 cm, and two drip tubes were used for each tray, so that a dropper was made for each plant, and the distance between one plant and another was 40 cm on one side of the terrace, the distance between one experimental unit and another was 80 cm, and each experimental unit contains 14 plants. The number of experimental factors reached two factors, the first one is to add them with fertigation water, and the second is the foliar application of micronutrients on the plant with each of manganese at a concentration of 30 mg.l^{-1} as manganese sulfate ($MnSO_4$. H_2O) (Mn=32.54%), copper at a concentration of 25 mgl^{-1} as copper sulfate ($CuSO_4.5H_2O$), (Cu=25.45%), iron at a concentration of 50 mgl^{-1} as Ferrous sulfate ($FeSO_4.7H_2O$), (Fe=20%), and zinc at a concentration of 60 mgl^{-1} as zinc sulfate ($ZnSO_4.7H_2O$), (Zn=22.78%), and the addition of the micronutrients is single, double, triple and quadruple. The experiment was designed according to the split-plot design using the complete random design (R.C.B.D). The number of treatments with the two comparison treatments (32) with three replicates for each treatment, thus the number of experimental units is (96) experimental units, and the process of adding nutrients used after two weeks of cultivation, and the period between each addition for both methods was once a week until the end of the experiment, so that the number of times of addition reached 30 times, and drip irrigation was used and from the water of the Tigris River, urea fertilizer was also used (N= 46%) as a source of nitrogen, at rate of (425) kgh^{-1}, and urea phosphate fertilizer (P=20%, N= 18%) as a source of phosphorus, at rate of (175) kgh^{-1}, and as another source of nitrogen, potassium was added at rate of (250) kgh^{-1} as potassium sulfate (K = 41.5%), where these macronutrient fertilizers (N,P,K) were added in batches from the third week of cultivation in the field, and crop service operations continued until the end of the experiment on 6/25/2021 Which included hoeing, weeding, irrigation, disease prevention, incubation and harvesting operations.

Measurement processes and final analysis of the search terms:

The processes of estimation and measurement and what was reached in the research were carried out according to what is shown in Table (2) below:

Table 2. Estimating and measuring the results of the research

Analysis	measuring unit	method or device used	Reference
Micronutrients absorption efficiency	%	It was calculated according to equations below after calculating the concentrations by the atomic absorption device	Lindsay and Norvel , 1978
Calculating the total yield	Mgh^{-1}	It is calculated cumulatively	

Converting the concentration of micronutrients in fruits from mg kg-1 to a percentage

Micronutrient as percentage = concentration of micronutrient/10000

Amount of nutrients absorbed ($Kg\ h^{-1}$) = Dry weight of fruits per hectare * % of nutrients in fruits

Micronutrient absorption efficiency (%) =

$$\frac{\text{The absorbent in the fertilized treatment - the absorbent in the control treatment}}{\text{Amount of fertilizer added}} * 100\%$$

Results and Discussion

Total yield of sweet pepper:

It is noted from Table 3 that all treatments were superior to the control treatment, and both methods of addition had an effect on increasing the total cumulative yield of sweet pepper plants, as all treatments of adding nutrients spraying on shoots had significantly outperformed the control treatment, as it reached the highest effect of Fe+ Zn+ Mn treatment, which It amounted to 159.15 Mgh^{-1}, with an increase of 115.13% over the control treatment. The lowest value was for the Zn+ Cu treatment, which amounted to 95.82 Mgh^{-1}, with an increase of 29.52% over the control treatment. As for the addition treatments with irrigation water, all of them were also significantly superior to the control treatment, as it reached the highest effect also for the Fe+ Zn+ Mn treatment, which amounted to 139.47 Mgh^{-1}, with an increased rate of 91.63% over the control treatment. The lowest value was also for the Zn+ Cu treatment, which amounted to 88.7 Mgh^{-1} an increase of 21.87% compared to the control treatment. As for the comparison between the two methods of addition, all treatments of the method of spraying on the shoot were significantly superior to the corresponding treatments of the method of addition micronutrients by fertigation, except for the two treatments of Zn + Cu, Cu, which were superior in a non-significant way, as the highest superiority It was for a Fe+ Cu, which was 152.27 Mgh^{-1}, with an increased rate of 21.02% compared to the corresponding treatment of the addition method with irrigation water, while the lowest superiority was for the Cu treatment, which amounted to 115.19 Mgh^{-1}, with an increase over the corresponding treatment for the method of application with irrigation water, amounted to 1.17%, and the average addition of spray treatments to the shoot system was significantly superior to the average addition of treatments with irrigation water, with an increase of 13.02%. As for the averages of the nutrients, all of them were significantly superior to the mean of the control treatment the highest value was for the Fe+ Zn+ Mn treatment, which amounted to 149.31 Mgh^{-1}, with an increase of 103.48% over the average of the control treatment. The lowest value was for the Zn+Cu treatment, which amounted to 92.26 Mgh^{-1}, with an increase of 25.73% than the average control, it is noted from Table 3 that the lowest values were for treatments containing copper and for both methods of addition, especially those containing copper, zinc, and manganese, one or both of them, and this gives an indication of the existence of an antagonistic relationship between the aforementioned nutrients, and copper also has a negative effect on the availability of phosphorus, zinc and iron in the soil and thus its absorption by the plant and this led to a decrease in productivity compared to other treatments and as mentioned by Azeez *et al.*, (6). The results also showed the positive effect of adding micronutrients, whether by adding them with irrigation water or spraying on the shoot, in an increasing the production of different crops, and this was demonstrated by many researchers, including Zeidan *et al.*, (24) and was explained in detail by Dimkpa and Bindraban, (8), who explained that although the addition of macronutrients in a way that fills the plant's need, in many studies, these additions did not have a significant effect in an increasing the production of targeted agricultural crops due to the lack of available micronutrients, soil properties which affected micronutrients availability in calcareous soil such as high calcium carbonate content , lack of soil organic matter and high pH, which was reflected in the failure to achieve the expected increase in production from adding macronutrients, and quite the opposite when providing good concentrations of micronutrients for the plant, it will enhance its growth and thus significantly increase its productivity. 196.1%. Some of them outperformed each other in different proportions, as some treatments were significantly superior to other treatments, and

Table 3: Effect of micronutrients and method of addition on cumulative total yield of sweet pepper (Mgh^{-1})

Micronutrients	Addition method		Mean of nutrients
	Fertigation	Foliar application	
Control	72.780	73.980	73.380
Fe	127.090	138.910	133.000
Zn	136.830	153.020	144.925
Mn	137.690	155.180	146.435
Cu	113.860	115.190	114.525
Fe+Zn	131.650	147.990	139.820
Fe+Mn	135.010	153.620	144.315
Fe+Cu	125.820	152.270	139.045
Zn+Mn	136.670	154.510	145.590
Zn+Cu	88.700	95.820	92.260
Mn+Cu	92.570	107.070	99.820
Fe+Zn+Mn	139.470	159.150	149.310
Fe+Zn+Cu	126.840	146.640	136.740
Fe+Mn+Cu	128.750	147.510	138.130
Zn+Mn+Cu	122.360	138.440	130.400
Fe+Zn+Mn+Cu	129.750	146.640	138.195
LSD (5%)	7.682**		5.432**
Mean of method of addition	121.615	136.621	
LSD (5%)	1.879**		

Iron absorption efficiency in sweet pepper fruits:

Table 4 shows the effect of the method of adding iron and its interactions with other micronutrients on the efficiency of iron absorption in fruits of the sweet pepper plant and the difference according to the method of addition or interaction with other nutrients for the same method. It reached the highest value of additional ion treatments with the fertigation treatment which was 102.25%, while the lowest value was for the Fe treatment, which reached 65.87% on it. So it was significantly superior to the highest value of the micronutrient to this addition method over the lowest value in it by 55.23%. As for the other treatments of the mentioned addition method, they varied in their superiority among themselves, as shown in the table. As for the treatments of adding spray to the shoot, the highest value was for the treatment of Fe+ Mn, which amounted to 341.3%, while the lowest value was for the treatment of Fe+ Zn, which reached to some were superior in a non-significant manner, as indicated in the table 4. As for the comparison of the results between the two methods of adding treatments between them, all treatments of adding micronutrients sprayed on the shoot system were significantly superior to the treatments of addition with fertigation water, as it reached the highest superiority for the treatment of Fe+Mn, which reached to 341.3%, with an increase rate of 267.78% over the method of addition with fertigation water, while the least superiority was for the treatment of Fe+Mn+Cu, which was 246.7%, with an increase of 141.39% compared to the corresponding method of addition with fertigation water. As for the average nutrients, their effect differed for each treatment. The highest value was for the Fe+Mn treatment, which reached to 217.05%. As for the lowest value, it was for the Fe+Zn treatment, which was 137.35%. Thus, the value of the highest mean micronutrients significantly outperformed the value of the lowest mean of micronutrients significantly, with an increase of 58.03%. It is also noted from the table 4. the significant superiority of the average addition of micronutrients sprayed on the shoot, which reached to 249.188% over the average addition of micronutrients with fertigation water, which reached to 86.375%, with an increase of 188.5%. The results presented in the table 4 showed that the addition of iron spray on the shoot is much better in terms of its absorption efficiency in the fruits of sweet pepper, due to its lack of precipitation or oxidation-reduction reactions and other soil conditions, quite the opposite of adding it with fertigation, and this is consistent with the result of Rasht (18) concluded.

Table 4: Effect of iron-adding methods and its interaction with micronutrients on its absorption efficiency in sweet pepper fruits (%)

Micronutrients	Addition method		Mean of Micronutrients
	Fertigation	foliar application	
Fe	65.900	230.900	148.400
Fe+Zn	78.600	196.100	137.350
Fe+Mn	92.800	341.300	217.050
Fe+Cu	79.400	284.800	182.100
Fe+Zn+Mn	92.800	231.600	162.200
Fe+Zn+Cu	84.900	223.200	154.050
Fe+ Mn+Cu	102.200	246.700	174.450
Fe+Zn+Mn+Cu	94.400	238.900	148.400
LSD (5%)	**19.810		**13.160
Mean of method of	86.375	249.188	

addition	
LSD (5%)	**18.870

Zinc absorption efficiency in sweet pepper fruits:

It is noted in Table 5, presents the results of the effect of the method of adding zinc and its interactions with other micronutrients on the efficiency of zinc absorption in the fruits of sweet pepper variation in these results according to the method of addition or interaction with other nutrients for the same method, as it reached the highest value for the additional treatments with irrigation water for the treatment of Zn, which was 61.67%, while the lowest value was for the treatment of Zn + Cu, which amounted to 23.68%, so it was significantly superior to the highest value of the method of adding micronutrients to the lowest value in it by 160.43%, as for the treatments of spray addition on the shoot, the highest value was for the Zn+Mn+Cu treatment, which reached to 113.17%, while the lowest value was also for the Zn+Cu treatment, which reached to 50.36%. Thus, the highest value of this addition method was significantly superior to the lowest value in it by a percentage 100.8%. As for the rest of the treatments, their superiority varied among them in different proportions, as some treatments were significantly superior to other treatments, and some were insignificantly superior, according to what is shown in the table 5, As for the comparison of results between the two methods, all treatments of adding nutrients by spraying on the shoot were significantly superior to the corresponding treatments of addition with fertigation, as it reached the highest superiority for the treatment of Fe+Zn+Cu, which reached to 104.47%, with an increase rate from what corresponds to the method of addition with fertigation water was 174.34%, while the lowest superiority was for the Zn treatment, which was 111.6%, with an increased rate of 80.96% compared to the corresponding method of addition with fertigation. As for the average nutrients, its effect differed for each treatment, as it reached the highest value for the Zn treatment, which amounted to 86.635%, while the lowest value was For the Zn+Cu treatment, which was 40.02%, thus the value of the highest mean nutrient was significantly superior to the value of the lowest mean nutrient, with an increase of 116.48%. It is also noted from Table 5 the significant superiority of the average addition of nutrients by foliar application on the shoot system, which amounted to 102.641% over the average addition of micronutrients with fertigation, which reached to 46.134%, with an increase of 122.4%, table 5 showed that the results of adding zinc by spraying on the shoot were superior in terms of its absorption efficiency in the fruits of sweet pepper, due to several reasons, including the difficulty of transferring zinc to the surfaces of the roots and from there to other parts of the plant, as well as the interactions of zinc with other nutrients in the soil or even inside the plant, and this is what was discussed. RU, K., and Kunjadia (20). results presented in Table 6 of the effect of the method of adding manganese and its interactions with other micronutrients varied on the efficiency of manganese absorption in sweet pepper fruits, as the highest value was for the treatment with fertigation, which was for the Mn treatment 209.7%, while the lowest value was for the Mn + Cu treatment, which reached 97.4% and thus, the highest value of this method of addition was significantly superior to the lowest value in it by 115.3%. As for the other treatments of this

Table 5: Effect of zinc-adding methods and its interaction with micronutrients on its absorption efficiency in sweet pepper fruits (%)

Micronutrients	Addition method		Mean of Micronutrients
	Fertigation	foliar application	
Zn	61.670	111.600	86.635
Fe+Zn	47.120	105.070	76.095
Zn+Mn	51.200	106.620	78.910
Zn+Cu	23.680	56.360	40.020
Fe+Zn+Mn	48.140	112.040	80.090
Fe+Zn+Cu	38.080	104.470	71.275
Zn+Mn+Cu	47.250	113.170	80.210
Fe+Zn+Mn+Cu	51.930	111.800	81.865
LSD (5%)	**7.020		**4.556
Mean of method of addition	46.134	102.641	
LSD (5%)	**7.067		

Manganese absorption efficiency in sweet pepper fruits:

additional method, they varied in superiority among themselves and as shown in Table 6. As for the treatments of spraying on shoots, the highest value was for the Fe+Mn treatment, which reached 517.2%, while the lowest value for this method of addition was for the Mn + Cu treatment too, which amounted to 181.6%. Thus, the highest value of this method of addition was significantly superior to the lowest value in it by 184.8%, As for the rest of the treatments, some of them outperformed each other in different proportions, as some of them were significantly superior to others, and the other part had a non-significant superiority over each other, as shown in table 6, As for the comparison of the results between the two methods of adding to the corresponding treatments, all treatments of adding nutrients sprayed on the shoot were significantly superior to the corresponding treatments of addition with fertigation water As it was the highest superiority of treatment. Fe+Mn, which amounted to 517.2%, with an increased rate over its counterpart of the method of addition with fertigation water reached 177.17%, while the least superiority was for the treatment of Zn+Mn, which was 313.3%, with an increased rate of 82.05% compared to the corresponding method of addition with fertigation water. As for the mean of the addition method, its effect differed for each treatment, as the highest value was for the

Fe+Mn treatment, which reached 351.9%, while the lowest value was for the Mn+Cu treatment, which was 139.5%. Thus, the value of the highest average treatment significantly outperformed of the value of the lowest average treatment with an increase of 152.26%. It is also noted from the table the significant superiority of the mean of nutrients sprayed on the shoot system, which reached 354.213% over the average addition of micronutrients with fertigation

Table 6. Effect of manganese adding methods and its interaction with micronutrients on its absorption efficiency in sweet pepper fruits (%)

Micronutrients	Addition method		means of Micronutrients
	Fertigation	foliar application	
Mn	209.700	385.600	297.650
Fe+Mn	186.600	517.200	351.900
Zn+Mn	172.100	313.300	242.700
Mn+Cu	97.400	181.600	139.500
Fe+Zn+Mn	173.700	352.200	262.950
Fe+Mn+Cu	183.600	405.000	294.300
Zn+Mn+Cu	156.500	331.500	244.000
Fe+Zn+Mn+Cu	184.900	347.300	266.100
LSD (5%)	**22.430		**16.710
Mean of method of addition	170.563	354.213	
LSD (5%)	**8.610		

Copper absorption efficiency in sweet pepper fruits:

water, which reached 170.563%, with an increase of 107.67%.

results presented in Table 7 which are of the effect of the method of adding copper and its interactions with other micronutrients on the efficiency of copper absorption in sweet pepper fruits show the difference in that effect according to the method of addition or interaction with other nutrients, as the highest value of the addition treatments with fertigation water was for the Fe+Mn+Cu treatment, which reached to 91.2%, while the lowest value was for the treatment of Zn+Cu, which reached to 41.3%. Thus, the highest value of this method of adding micronutrients was significantly superior to the lowest value in it by 120.82%. As for the other treatments of this addition method, they differed in their superiority among themselves in a significant or insignificant manner, as shown in the table 7. As for the treatments of spraying the shoots, the highest value was also for the treatment of Fe+Mn+Cu, which reached to 217.2%, while the lowest value was also for the treatment of Zn+Cu, which reached to 105.2%, Thus, the highest value of this addition method was significantly superior to the lowest value by 106.46%. As for the rest of the treatments, some of them outperformed each other in different proportions. As for the rest of the treatments, some of them outperformed each other in different proportions, as some treatments were significantly superior to other treatments, and some were insignificantly superior to other treatments, according to what is shown in the table7, as for the comparison of the results between the two methods of addition between them, all treatments of adding nutrients by spraying on the shoot were significantly superior to the corresponding treatments of addition with fertigation water, as the highest superiority was for the Zn+Mn+Cu treatment, which reached to 181.3%, with an increased rate on the contrary of the method of addition with fertigation water amounted to 194.32%. As for the lowest superiority, it was for the treatment of Cu, which was 135.5%, with an increasing rate over the other treatments of the method of addition with fertigation water, which reached 102.24%. As for the averages of the method of addition, its effect differed for each treatment, as it was the highest value For the Fe+Mn+Cu treatment, which reached 154.2%, while the lowest value was for the Zn+Cu treatment, which was 73.25%. Thus, the value of the highest average treatment was significantly superior to the value of the lowest average treatment, with an increase of 110.51%. It is also noted from the table the significant superiority of the average addition of nutrients sprayed on the shoot, which reached 166.463% over the average addition of micronutrients with irrigation water, which amounted to 65.213%, with an increase of 155.26%.

Table 7: Effect of cooper adding methods and its interaction with micronutrients on its absorption efficiency in sweet pepper fruits (%)

Micronutrients	Addition method		Mean of Micronutrients
	Fertigation	foliar application	
Cu	67.000	135.500	101.250
Fe+Cu	58.900	165.800	112.350
Zn+Cu	41.300	105.200	73.250
Mn+Cu	47.500	118.000	82.750
Fe+Zn+Cu	71.200	197.200	134.200
Fe+Mn+Cu	91.200	217.200	154.200
Zn+Mn+Cu	61.600	181.300	121.450
Fe+Zn+Mn+Cu	83.000	211.500	147.250
LSD (5%)	**11.880		**8.970
Mean of the method of addition	65.213	166.463	

LSD (5%)	**1.510

Conclusion

The results showed the positive effect of the studied treatments and the achievement of highly significant differences from the comparison treatment in all the studied traits, as well as achieving high concentrations of micronutrients in the fruits of sweet pepper, which is evident from the rates of absorption efficiency of these nutrients by the fruits for all treatments and for both methods of addition, and this will contribute significantly effective in providing a product with high nutritional value that can contribute to fighting what is called hidden hunger and achieving food security.

Conflict of interest

The authors have no conflict of interest.

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