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Response of Pepper Plants (*Capsicum annuum* L.) to Foliar Spray with Fe, Mn, and Zn

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ABSTRACT

Two field experiments were conduct during the two summer seasons of 2005 and 2006 at the Experimental farm of the National Research Center at Nobaria (Behira Governorate) to investigated the response of pepper plants cv. California wonder to foliar application of some micro-elements Fe, Mn, and Zn. Results indicated that application of Fe 1 g/L + Mn 1 g/L + Zn 1 g/L treatment gave the maximum tallest sweet pepper plants and gave the highest number of leaves and branches. The same treatment gave the highest fresh and dry weights of leaves as well as gave the highest total yield. Moreover, the highest values of N, P and K (%) were achieved using the mixture of Fe, Mn and Zn treatment. However, the highest value of Fe and Mn (ppm) were true when used 2 g Fe/L in the first and second seasons, respectively. The highest significant N, P and K (%) as well as Fe, Mn and Zn were recorded by using (Fe 1 g/L, Mn 1 g/L, Zn 1 g/L) treatment.
Key words: *Capsicum annuum* L, Foliar spray, Growth, Iron, Manganise, Pepper, Zinc, Yield.

INTRODUCTION

Peppers grown in temperate regions are herbaceous annuals, but are herbaceous perennials where temperatures do not drop below freezing. It was spread and grown worldwide as a spice and medicine. So today, many countries grow it as a crop they are an excellent source of Vitamin C, Vitamin A, and Calcium.

Sweet pepper (*Capsicum annuum* L) is one of the most popular and favourite vegetable crop cultivated in Egypt for local market and exportation. Micronutrients play a very important role in vital processes of plants. They improve photosynthesis which intensifies the assimilating activity of the whole plants (Marschner, 1995). Zinc in plants involved in enzymatic reaction. One of the most important functions of zinc is its effect on the synthesis of tryptophan (Tsui, 1948).

El-Gizy (1990) pointed out that increasing the concentration of zinc increased vegetative growth and seed yield along with the quality of common beans plants. Also, zinc application clearly increased the seed content of N, P and K elements (El-Shamma, 1998). Concerning Fe, Perar *et al.* (1996) observed that, Fe foliar application significantly increased seed and straw yield of beans, plant height, number of pods and seed yield.

The necessity of microelements application to plants undoubted, especially after the decrease of these elements in Nile water (Nabhan, 1966). Moreover, the limited supply of manure used in vegetable growing nowadays and the intensive cropping of vegetable three time per year which remove more quantities of micronutrients from the soil. All these factors led us to give more attention to micronutrients application. The effects of spraying Fe, Zn and Mn on the physiological processes of vegetable crops were studied by many investigators. Hassan 1982 on pea and bean plants, Zaki *et al.*1981 and Youssef *et al.* 2001 on tomato, El-Fadaly 1992, and Alphonse and Saad 2000 on cucumber, Swierczewska and Sztuder 2001, and Manoj Raghav and Singh 2004 on potato and Muthumanickam 2003, and Ruchi-Sood and Sharma 2004 on pepper plants.

This study aimed to investigate the response of sweet pepper plants to foliar application of different microelements Fe, Zn, and Mn and its effect on growth, yield and chemical content of sweet pepper plants.

MATERIALS AND METHODS

The present work was carried out during the two successive seasons of 2005 and 2006 at the experimental station of the National Research Center in Nobaria (Behira Governorate), aimed to study the effect of 8 treatments, foliar application of Fe, Mn, and Zn (1g and 2g) and combination of three elements compared with control (spray with tap water).

Treatments

Foliar application of
1- Iron (Fe) at a rate of 1 g/L.
2- Iron (Fe) at a rate of 2 g/L.
3- Manganese (Mn) at a rate of 1 g/L.
4- Manganese (Mn) at a rate of 2 g/L.
5- Zinc (Zn) at a rate of 1 g/L.
6- Zinc (Zn) at a rate of 2 g/L.
7- Iron, Manganese and Zinc at a rate of (1 g Fe + 1 g Mn + 1 g Zn).
8- Spray with tap water (control).

The microelements were sprayed at flowering stage 2 times intervals 10 days between them. Seedlings of sweet pepper were planted on ridges of 60 cm width and 8 m length and 25 cm apart. Each plot included 4 ridges and plot area was 19.2 m^2. This experiment was arranged in randomized block design in three replicates. Normal agricultural practices common in the area were followed. The physical properties and chemical analysis of the experimental soil are presented in Table (1).

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Table (1): Physical properties and chemical analysis of the experimental soil.

Physical properties								
Sand	Clay	Silt	Texture		Field capacity		Welting point	
90.08	9.26	0.66	Sandy		16.57		5.25	
Chemical analysis								
E.C. Mmoh/cm		pH	Meq./L					
			Ca	Mg	Na	K	HCO_3	Cl
10.7		8.2	7.	0.5	0.982	0.310	1.3	0.566

Three plants of each plot were chosen randomly at 90 days after transplanting and the following data were recorded

1. Vegetative growth

1- Plant height (Cm).
2- Number of branches/plant.
3- Number of leaves/plant.
4- Fresh weight of leaves (g.).
5- Dry weight of leaves (g.).

2. Fruit yield.

Pepper pods were harvested twice every week. At harvest time the total weight of pods in each treatment was recorded and the total yield as ton/fed was calculated.

3. Chemical content:

Samples of leaves and fruits were oven dried to a constant weight at 70 ◦C then fine grounded and wet digested

Total nitrogen, phosphorus and potassium concentration in the tissues of plant leaves and fruits were determined according to the methods described by Jackson (1985), Troug and Mayer (1939) and Brown and lilleland (1946), respectively. Some micro-elements, i.e. Fe, Mn and Zn were determined using Atomic Spectrophotomrter (phillips) according to Chapman and Pratt (1961).

All collected data were subjected to statistical analysis according to the method of Gomez and Gomez (1984).

RESULTS

Vegetative growth and yield

Vegetative growth of sweet pepper plants expressed as plant height, number of leaves, number of branches, fresh and dry weight of leaves was affected by Fe, Mn and Zn as a foliar application in both seasons are shown in Table (2).

There were significant increases in all vegetative growth characters. These results held good in the two experimental seasons. In general, the highest plant height, number of leaves and number of branches of sweet pepper plants were recorded by plants sprayed by Fe, Mn and Zn at a rate of (1g Fe/L + 1g Mn/L + 1g Zn/L) in the two seasons of study except for number of branches in the first season. The highest number of braches was recorded by treatments of Zn at 2 g/L.

On the contrary, the lowest plant growth expressed as, plant height, number of leaves and number of branches was recorded by control (foliar spray with tap water) in the first season and foliar spray of Zinc at a rate of 1g/L with plant height and treatment of foliar spray with Mn at the rate of 1g/L with other data.

With regard to fresh and dry weight of leaves results reported in Table (2) showed that, there were significant differences in the fresh and dry weight between the different treatments of foliar application of microelements. Moreover, the highest fresh and dry weight was recorded by mixture of 1g Fe/L + 1g Mn/L + 1g Zn/L treatment compared with other treatments in the first and second season. On the contrary, the lowest values of fresh and dry weight were recorded by spray with tap water (control treatment).

Table (2): Effect of Fe, Mn, and Zn foliar application on vegetative growth and yield of pepper plants during 2005 and 2006 seasons.

Treatmants	Plant length (cm)	No. of leaves /plant	No. of branch /plant	Leaf weight (g)		Total yield
				Fresh	Dry	
			2005			
Control	44.17	63.00	3.33	53.36	9.67	6.32
1 g Fe	45.17	136.00	5.00	93.07	14.95	8.41
2 g Fe	54.43	258.00	5.00	237.54	35.36	10.62
1 g Mn	50.00	143.00	5.33	108.58	17.82	9.14
2 g Mn	50.67	158.67	5.33	147.34	23.63	9.83
1 g Zn	51.33	181.67	5.00	148.83	23.65	9.75
2 g Zn	52.17	252.33	6.33	214.01	33.99	10.02
1:1:1	64.13	288.67	4.67	241.93	36.81	11.12
LSD at 5%	*10.54*	*64.37*	*1.44*	*60.55*	*10.68*	*0.36*
			2006			
Control	43.00	143.00	7.00	55.76	9.54	5.96
1 g Fe	45.50	196.00	8.00	98.65	17.67	7.24
2 g Fe	48.00	284.00	8.50	161.49	31.55	9.37
1 g Mn	49.00	136.00	5.50	113.20	17.39	9.07
2 g Mn	50.00	346.50	9.00	179.30	23.3	9.66
1 g Zn	42.00	175.00	9.00	158.43	26.62	9.83
2 g Zn	43.50	204.50	10.00	195.16	28.17	10.17
1:1:1	50.50	354.00	10.50	212.81	34.43	10.67
LSD at 5%	*4.37*	*89.52*	*2.68*	*20.37*	*4.02*	*0.54*

Results reported in Table (2) showed that there were significant differences in the total yield. The highest total yield of sweet pepper plants was produced by using (Fe 1 g/L + Mn 1 g/L + Zn 1 g/L) treatment. On the contrary, the lowest total yield of sweet pepper plants was recorded by control treatment (spray with tap water). These findings held well in both true experimental seasons.

Chemical content of leaves of sweet pepper plants

Foliar application of some trace elements results in slight increases in sweet pepper leaves content of N, P, K, Fe, Mn and Zn elements (Table 3). The data presented in Table (3) indicated that there was a statistical significant effect of the foliar application treatments on the content of N, P, K, Fe, Mn and Zn elements in leaves of sweet pepper plants. Moreover, the highest amount of N, P and K were recorded by 1g Fe/L + 1g Mn/L + 1g Zn/L treatment. The highest values of Fe and Zn were recorded by (1+1+1). There were no significant increase between (1+1+1) and (1 g Fe) or (2 g Fe) according to Fe elements and no significant effect between (1+1+1) and (1 g Zn) or (2 g Zn) in zinc element. The highest amount of Mn content was recorded by (1+1+1) and (2 g Mn) treatments.

On the contrary, the lowest amount of there elements was recorded by spray with tap water (control).

Chemical content in fruits of sweet pepper plants

Data in table (4) demonstrated that, these were significant differences in N, P and K % and Fe, Zn and Mn ppm in pepper fruits. Zn (1 g/L) + Fe (1 g/L) + Mn (1 g/L) treatment gave the highest amount of N, P and K % and Fe, Zn and Mn ppm in pepper fruits. On the contrary, the lowest amount of all elements was recorded by controlled plants.

Table (3): Effect of Fe, Mn and Zn foliar application on chemical composition of pepper leaves during 2005and 2006 seasons.

Treatments	N %	P%	K%	Fe ppm	Zn ppm	Mn ppm
				2005		
Control	2.59	0.67	3.13	60.11	23.85	50.36
1 g Fe	2.87	0.76	3.53	88.57	40.58	67.66
2 g Fe	2.93	0.85	3.72	95.66	48.22	87.33
1 g Mn	2.63	0.74	3.40	70.88	33.26	61.57
2 g Mn	2.77	0.80	3.38	74.63	37.21	66.89
1 g Zn	2.57	0.72	3.24	65.33	54.36	59.68
2 g Zn	2.82	0.77	3.35	68.74	60.29	65.47
1:1:1	3.95	0.91	4.20	95.12	70.18	76.87
LSD at 5%	*0.45*	*0.09*	*0.25*	*7.72*	*22.15*	*12.22*
				2006		
Control	2.41	0.62	2.85	55.85	21.69	47.81
1 g Fe	2.67	0.71	3.21	82.29	36.91	64.24
2 g Fe	2.73	0.79	3.38	88.88	43.85	82.92
1 g Mn	2.45	0.69	3.09	65.86	30.25	58.46
2 g Mn	2.58	0.74	3.07	69.34	33.84	63.51
1 g Zn	2.39	0.67	2.95	60.70	49.44	56.66
2 g Zn	2.63	0.72	3.05	63.87	54.83	62.16
1:1:1	3.70	0.85	3.82	97.67	55.82	71.97
LSD at 5%	*0.32*	*0.11*	*0.28*	*12.33*	*17.14*	*9.13*

Table (4): Effect of Fe, Mn, and Zn foliar application on chemical composition of pepper fruits during 2005 and 2006 seasons.

Treatmants	N %	P%	K%	Fe	Zn	Mn ppm
				2005		
Control	2.23	0.24	2.39	56.46	21.44	40.71
1 g Fe	2.49	0.32	2.77	83.20	36.47	54.70
2 g Fe	2.63	0.36	2.82	89.86	43.34	70.60
1 g Mn	2.32	0.29	2.43	66.58	29.89	49.78
2 g Mn	2.53	0.32	2.73	70.10	33.44	54.08
1 g Zn	2.33	0.30	2.38	61.37	48.86	48.25
2 g Zn	2.47	0.31	2.59	64.57	54.19	52.93
1:1:1	2.72	0.42	2.98	98.74	63.08	78.32
LSD at 5%	*0.23*	*0.04*	*0.12*	*16.51*	*13.23*	*21.54*
				2006		
Control	2.03	0.23	2.22	51.35	20.35	37.83
1 g Fe	2.26	0.30	2.57	75.66	34.63	50.82
2 g Fe	2.39	0.34	2.62	81.72	41.15	65.60
1 g Mn	2.11	0.28	2.26	60.55	28.38	46.25
2 g Mn	2.30	0.30	2.54	63.76	31.75	50.25
1 g Zn	2.12	0.28	2.21	55.81	46.39	44.83
2 g Zn	2.25	0.29	2.41	58.72	51.45	49.18
1:1:1	2.47	0.40	2.77	89.80	59.89	72.77
LSD at 5%	*0.16*	*0.03*	*0.18*	*25.11*	*18.85*	*19.65*

DISCUSSION

Vegetative growth and yield

These results were in agreement with those obtained by Ruchi-Sood and Sharma (2004) on pepper plants.

These findings held good in both true experimental seasons. The obtained results were in accordance with those reported by Yadav *et al*. (2001) on tomato plants.

With regards of yield these findings held well in both true experimental seasons. The obtained results were in accordance with the results of Ruchi-Sood and Sharma (2004) on pepper plants.

The obtained results were in accordance with the results of Ruchi-Sood and Sharma (2004) on pepper plants.

These results may be due to foliar sprays are widely used to apply micronutrients, especially iron, manganese and zinc for many crops. Advantages of foliar sprays are: (1) application rates are much lower than for soil application; (2) a uniform application is easily obtained; and (3) response to the applied nutrient is almost immediate so deficiencies can be corrected during the growing season.

Chemical content of leaves of sweet pepper plants

These findings are completely similar during the two seasons. These results are similar to those reported by Kaya and Higgs (2002) on tomato plants.

Chemical content in fruits of sweet pepper plants

There results held good in the two experimental seasons. The obtained results were in accordance with those reported by Kaya and Higgs (2002) on tomato plants.

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إستجابة نباتات الفلفل الحلو للرش ببعض العناصر الصغرى

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الملخص العربـــى

أجريت هذه الدراسة في محطة التجارب الزراعية التابعة للمركز القومي للبحوث في النوبارية بمحافظة البحيرة خلال الموسم الصيفي لعامي ٢٠٠٥ و٢٠٠٦ لدراسة إستجابة نباتات الفلفل صنف كاليفورنيا وندر للرش بتركيزات مختلفة من بعض العناصر الصغرى (حديد، زنك، منجنيز).

أوضحت النتائج أن معاملة الرش بالحديد ١جم/لتر + زنك ١جم/لتر + منجنيز ١جم/لتر أعطت أفضل نمو خضرى (طول النبات – عدد الأوراق – عدد الأفرع) وأعلى وزن طازج وجاف للأوراق وكذلك أعلى محصول كلى للفدان وأفضل جودة متمثله فى طول القرن وقطر القرن ومتوسط وزن القرن. وفى أوراق نباتات الفلفل كانت أعلى قيم للنيتروجين والفوسفور والبوتاسيوم عند الرش بالحديد ١ جم/لتر + زنك ١ جم/لتر + منجنيز ١جم/لتر. بينما كانت أعلى نسبة للحديد و المنجنيز فى أوراق نباتات الفلفل عند الرش بالحديد ٢ جم/لتر فى كلا موسمى الزراعة.

أما فى ثمار الفلفل أعطى الرش بالحديد ١جم/لتر + زنك ١جم/لتر + منجنيز ١جم/لتر أعلى القيم للنيتروجين والفوسفور والبوتاسيوم والحديد والزنك والمنجنيز وكذلك فيتامين ج وحمض الأسكوربيك والمواد الصلبة الذائبة فى كلا موسمى الزراعة.