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EFFECT OF FOLIAR FERTILIZATION BY SOME ZINC SOURCES ON GROWTH AND CHEMICAL COMPOSITION OF PEA PLANT.

By

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ABSTRACT: A felid experiment was carried out in three replicates during summer season of 2009 to evaluate effect of the foliar application of zinc resources (Zn EDTA, $ZnSO_4$ and $ZnCl_2$) on plant growth and some nutrients uptake by pea plant. The application rates of zinc sources were 5, 10 and 15 mg/l˙ zinc with two sprays at vegetative stage (30 days after sowing) and at pod development period (50 days after sowing).

Results showed that, the dry matter yield (straw and seeds g/plant), N, P, K, Fe and Zn content and uptake by pea plant shoots were significantly increased due to application of zinc sources at all treatments; the highest values of the previous parameter were recorded with Zn EDTA followed ZnCl, and finally $ZnSO_4$. Values of Mn, Cu and B content and uptake by shoots were significantly increased with increasing application rates of Zn EDTA followed $ZnCl_2$ but decreased with $ZnSO_4$ treatments compared with the untreated control. Generally, the best values of all previous parameters were recorded with Zn EDTA treatments followed, mostly by $ZnCl_2$ then, $ZnSO_4$ treatments.

INTRODUCTION

Zinc is involved in wide varieties of metabolic processes, including carbohydrate, lipid, protein and nucleic acid synthesis and degradation. It does this through a large mosaic of zinc binding motifs that orchestrate all aspects of metabolism; three primary zinc-binding motifs are structural, catalytic and co-catalytic. In structural Zn sites, cysteine is the preferred ligand. In catalytic sites, Zn forms complexes with histidine and water. Co-catalytic sites have aspartic acid and histidine as preferred ligands. The fourth type of Zn-binding site (protein interface) suggests a role of Zn in the quaternary protein structure. (Auld , 2001). Also, Fox and Guerimot (1998) stated that, zinc plays an important role in many biochemical functions within plants. Zinc is an essential component of over 300 enzymes. In most of these enzymes, zinc makes up an zinc plays an important role in many biochemical functions within plants. Zinc is an essential component of over 300 enzymes. In most of these enzymes, zinc makes up an integral component of the enzyme structure. The role of zinc in DNA and RNA metabolism, in cell division, and protein synthesis has been documented for many years. Zinc is very closely involved in the nitrogen metabolism of plants. In plants with zinc deficiencies, protein synthesis and protein levels are drastically reduced whereas amino acids accumulate. The accumulation of amino acids occurs because zinc plays an important role in helping different combinations of amino acids link together to form enzymes and proteins.

Zinc plays a key role in pollination and seed set processes; so that their deficiency can cause decrease in seed formation and subsequent yield reduction. In this concern, Ziaeyan and Rajaie(2009)stated that the formation of male and female reproductive organs and pollination process are disturbed in Zn deficiency which may be attributed to the reduction of Indol acetic acid (IAA) synthesis., AbdEl-Hady(2007)stated that, the zinc is one of the essential micronutrients for the normal healthy growth and reproduction of crop plants. It is required in relatively small concentration in the plant tissues (5-100mg kg^{-1}).

Akhtar et el(2009)found that the three mg/l^{-1} zinc chloride solution for foliar treatment on *Mentha piperita* plant was most effective for vegetative growth as well as quantitative yield of its essential oil.

Gobaraf et al (2006) reported that, the foliar spraying of zinc significantly affected on chemical constituents including protein content, NPK%, as well as oil % ; they added that increasing zinc concentration from 0.5 to 1.0 g/l significantly increased the characteristics chemical constituents. Khan et al (2009) studied the residual, direct and cumulative effect of zinc application on wheat and rice yield under rice-wheat system; they concluded that, the application of zinc increased the yields of both the crops significantly over control. However, direct application of zinc was found to be significantly better than other fertilizer treatments in case of wheat. While for rice crop the cumulative effect of zinc application was found to be significantly better than the other treatments compared with the control.

Zinc has high phloem mobility from leaves to roots, stems, developing grain, and from one root to another (Rengel, 2001). He added that, the zinc efficiency is the ability of plants to maintain high yield in soils with low zinc availability. A number of mechanisms may underlie zinc efficiency depending on experimental conditions and the pla~~ species, the most important mechanisms may be zinc utilization in tissues (Hacisalihoglu and Kochian, 2003) and zinc uptake (Genc et al, 2006) under zinc deficiency. Also, zinc deficiency occurs gener in agricultural soils of the world. According to FAO report of tm countries, more than 30 percent of these countries agricultural soils encounter zinc deficiency; most of this amount is unavailable for plants. High $CaCO_3$, high pH, low organic matter and moisture of soil and high bicarbonate of irrigation water have most effects on zinc absorbability, (Kalantari and Kazmeinkah, 2004). Also, foliar applications of Zn have been met with mixed success and it is general pted only be used as temporary and emergency treatments. McNall (1967) has done extensive research on foliar treatments of Zn. He found that foliar uptake of nutrients does occur but is no substitute for root uptake.

The objective of this investigation is to evaluate the effect of some resources of zinc on plant growth and some nutrients content and uptake by pea plant.

MATERIAL AND METHODS

A field experiment was carried out using a randomized complete block design with three replicates to evaluate the ct of some resources of zinc (Zn EDTA, $ZnSO_4$ and $ZnCl_2$) on plant growth and some nutrients content and uptake.

The experiment was conducted during summer season of 2009(at the Experimental Farm of Al-Azhar University- Nasr City- Cairo Governorate) on plots of 10.5 m long consisting of five rows (3.5 m length and 60 cm apart).The soil sample (0-30 depth) was r analyzed according to Chapman and Pratt(1951). T its presented in tables (1 and 2). Pea plant (*Pisum*) variety Cram 7 were sown in the first week of May and fertilized according to the general recommendation by Ministry of Agriculture; and zinc EDTA to soil equivalent 3 kg/f. for all treatments and control. Then, zinc a foliar spraying with (5, 10 and 15 mg zinc l^{-1}) as Zn EDTA, $ZnSO_4$ and $ZnCl_2$: and two foliar spraying for all treatments; at vegetative stage (30 days after sowing) and at pod developme eriod (50 da fter sowing) at rate of 400 l/f.

Table (1) Some physical and chemical properties of the investigated soil sample.

Particle size distribution %				Soluble ions in 1:2.5 soil water extract (meq /100g).								pH	OM %	EC dS m^{-1}	$CaCO_3$ %
Sand	Silt	Clay	Texture	Ca^{++}	Mg^{++}	K^+	Na^+	$CO_3^=$	HCO_3^-	Cl^-	$SO_4^=$				
72.31	19.76	7.93	S.loam	2.84	1.98	0.95	3.92	=	0.22	5.68	3.79	7.6	0.33	0.21	2.06

Table (2) some nutrients content in the investigated soil sample.

Macro-nutrients			Micro-nutrients							
Total(meq/100g)			Total (mg/kg)				Available(mg/kg)			
N	P	K	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
3.21	0.22	11.76	2527	796	1083	102	2.81	1.12	1.09	0.80

At end of the experiment the plants were harvested, washed with distilled water, dried at 70°c and ground, then representative portions were wet digested using a mixture of $HClO_4$ and H_2SO_4 at a rate of 1:1 to determine NPK and micronutrients; total N was determined by micro-Kjeldahl technique; total P was determined by ascorbic acid method; total K was determined using flame photometer; according to Page et al. (1982). The micronutrients (Fe, Mn, Zn, Cu and B) were determined by Inductively Coupled Plasma Spectrometer (ICP) plasma 400. Also the obtained data were statistically analysis according to the methods of Sendecor and Cochran (1980)

RESULTS AND DISCUSSION

A-Dry matter yield (straw and seeds).

Data presented in Table (3) show that the dry matter yields of straw and seeds were significantly affected by foliar application of zinc at all treatments; and the highest values of dry matter yield were recorded with zinc EDTA compared with the other treatments. Data revealed that the values of straw yield were 18.50 g/plant for the control and increased to 23.27, 20.68 and 19.87 g/plant obtained with 10 mg/l^{-1} zinc EDTA and

Table (3) Effect of foliar application of zinc resources on dry matter yield and values of macronutrients content (%) and uptake (mg/plant).

Treatments	Dry matter yield g/plant		Nitrogen		Phosphorus		Potassium	
	Straw	Seeds	Content	Uptake	Content	Uptake	Content	Uptake
Control	18.50	55.20	3.81	704	0.41	75.85	3.63	671
Zn EDTA								
5 mg/l^{-1}	20.11	60.12	4.23	850	0.42	84.46	3.81	766
10 mg/l^{-1}	23.27	66.71	4.78	1112	0.39	90.75	3.80	884
15 mg/l^{-1}	22.91	65.92	4.53	1037	0.40	91.64	3.91	893
Mean	22.09	64.25	4.51	999	0.40	88.95	3.84	847
$ZnSO_4$								
5 mg/l^{-1}	17.21	59.36	3.95	679	0.42	72.28	3.71	638
10 mg/l^{-1}	19.03	58.18	4.11	782	0.40	76.12	3.81	725
15 mg/l^{-1}	19.87	61.74	4.05	804	0.41	81.46	3.86	766
Mean	18.70	59.76	4.03	755	0.41	76.62	3.79	709
$ZnCl_2$								
5 mg/l^{-1}	18.15	58.52	3.96	718	0.39	70.78	3.80	689
10 mg/l^{-1}	19.34	61.22	3.84	742	0.41	79.29	3.72	719
15 mg/l^{-1}	20.68	62.18	3.92	810	0.40	82.72	3.79	783
Mean	19.39	60.64	3.90	756	0.40	77.59	3.77	730
LSD at 5%								
*	0.008	0.008	0.608	42.35	NS	0.0008	0.008	0.843
**	0.009	0.009	0.009	48.90	NS	0.009	0.009	0.97
***	0.017	0.016	0.017	84.69	0.016	0.017	0.017	1.68

* For zinc sources.
** For zinc concentration.
*** For interaction between zinc sources and concentration.
NS non significant

15 mg/l^{-1} zinc chloride and zinc sulfate, respectively. On the other hand, the lowest values of dry matter of straw yield were 20.11, 17.21 and 18.15 g/plant obtained with 5 mg/l^{-1} zinc EDTA, zinc chloride and zinc sulfate, respectively. Values which were obtained due to the other treatments for the same parameter were found to be in between. Also, data in Table (3) revealed that the mentioned trend of straw yield was observed for seeds yield. In this concern, some investigators reported that the foliar spraying with zinc could correct zinc deficiency, improve growth, yield, seed quantity and quality of plants. Darwish et al. (2002) found that the application of (48 kg) K_2O /f. combined with spraying 1000ppm zinc sulfate gave the highest seed and oil yields per fadden and protein percentage of groundnut plant. Also, foliar spraying with zinc encouraged

the vegetative growth and increased the plant capacity for building metabolites. Such response may be due to that zinc is known to as an activator of several enzymes in plants and is directly involved in the biosynthesis of growth substances such as auxin which produces more plant cells and more dry matter. Similar results were obtained by Tomar et al. (1990); Malewar et al. (1993); Tripathy et al. (1999) and Shankar et al.(2004). On the ather hand, Amrani et al. (1999); Gangloff et al. (2002); Mortvedt. (1992); Slaton et al. (2005) and Westfall et al. (2005) found that, the key to successful zinc fertility is water solubility. The water solubility of the zinc source will determine how effective it will be in meeting plant needs; water solubility allows Zn to move short distances in the soil and to be absorbed by the plant. It has been shown that Zn EDTA is the most effective source of Zn on the market. When Zn EDTA was used as a reference material on a plant uptake basis by Gangloff *et al* (2002), $ZnSO_4$ had a relative availability coefficient of 23%, followed by Zn lignosulfonate at 22%. Therefore there is a significant difference between zinc EDTA and all other sources.

B- Macronutrients content and uptake by pea plant.

The data presented in Table (3) show that the values of N and K content and uptake significantly affected by foliar application of zinc sources for all treatments. Only, P content was not affected significantly due to these treatments. The highest values of NPK content and uptake were recorded with zinc EDTA more than $ZnSO_4$ and $ZnCl_2$, respectively. Also the values of NPK content and uptake were increased due to increasing concentration from 5 to 15 mg/l^{-1} for all sources of zinc. The values of nitrogen content and uptake were 3.81 and 704 at the (untreated) control, and increased to 4.78 and 1112 with 10 mg/l^{-1} zinc EDTA, while these values for phosphorous content were 0.41 with 5 mg/l^{-1} zinc EDTA and $ZnSO_4$; and were 91.64 for phosphorous uptake at 15 mg/l^{-1} zinc EDTA. Also, the highest values of potassium content and uptake obtained with 15 mg/l^{-1} zinc EDTA compared with the other treatments and the (untreated) control. While the lowest values were 3.84% and 718 mg/plant for N content and uptake with 10 and 5 mg/l^{-1} concentration of $ZnCl_2$ treatments; for phosphorus content and uptake were 0.39% and 70.78 mg/ plant with 5 mg/l^{-1} concentration of $ZnCl_2$, and finally were 3.71% and 638 mg/plant for potassium content and uptake with 5 mg/l^{-1} $ZnSO_4$, respectively compared with the (untreated) control. Also, the values which obtained from the other treatments were found to be in between, Darwish et al (2002) stated that the foliar spraying of zinc increased chemical constituents including protein content NPK % as well as oil %; also, Abd El-Hady (2007) found that the NPK concentration and uptake mg/plant by barley plants increased with increasing zinc application from 0 to 30 ppm. While, Darwish (2003)stated that the application of zinc sulfate at a rate of 20 kg f, showed significant increase in values of ear weight, ear grains weight, number of grains/row, ear yield ton/f. as well as phosphorus and potassium concentration and its uptake of maize plant.

C- Micronutrients content and uptake by pea plant.

Table (4) show that values of the micronutrients content and uptake were increased due to foliar application of zinc sources and increasing concentration of treatments; the highest values of these nutrients were recorded with zinc EDTA then, $ZnCl_2$ and $ZnSO_4$, respectively.

Table (4) Effect of foliar application of zinc resource on micronutrients content (mg/kg^{-1}) and uptake (μg/plant).

Treatments	Fe		Zn		Mn		Cu		B	
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake
Control	410	7585	42.75	790	23.81	440	23.45	434	11.33	209
Zn EDTA										
5 mg/l^{-1}	639	12850	64.16	1290	25.00	502	21.02	422	11.01	221
10 mg/l^{-1}	598	13915	65.73	1529	24.11	561	20.81	484	11.98	278
15 mg/l^{-1}	581	13310	62.10	1422	23.72	543	22.61	517	12.10	277
Mean	606	13358	63.99	1413	24.27	535	21.48	474	11.69	258
$ZnSO_4$										
5 mg/l^{-1}	451	7761	45.91	790	20.00	344	17.16	295	10.41	179
10 mg/l^{-1}	480	9134	46.21	879	20.27	385	20.71	394	10.62	202
15 mg/l^{-1}	475	9438	47.70	892	22.81	453	21.32	423	11.71	232
Mean	468	8777	46.60	853	21.02	394	19.73	370	10.91	204
$ZnCl_2$										
5 mg/l^{-1}	457	8294	50.75	921	24.41	443	20.33	368	11.16	202
10 mg/l^{-1}	487	9418	51.11	988	24.23	468	22.16	428	12.30	237
15 mg/l^{-1}	465	9616	53.71	1110	22.71	469	21.13	436	12.51	258
Mean	469	9109	51.85	1006	23.78	460	21.20	410	11.99	232
LSD at 5%										
*	0.843	0.819	0.008	0.843	0.128	0.842	0.008	0.84	0.008	0.843
**	0.973	0.946	0.009	0.96	0.15	0.97	0.009	0.97	0.009	0.97
***	1.985	1.638	0.016	1.68	0.26	1.69	0.017	1.96	0.017	1.68

* For zinc sources.
** For zinc concentration.
*** For interaction between zinc sources and concentration.

The values of Fe content and uptake were 410 mg/kg^{-1} and 7585 µg/plant at the untreated control and a significant increased to 639 mg/kg^{-1} and 13915µg/plant obtained with zinc EDTA at 5 and 10 mg/l^{-1} respectively. Fayed and El-Moatasem (1995) stated that the Zn application increased Fe uptake compared with the untreated control and they added that, these increases were mainly attributed to the effect of zinc application on dry matter yield; also the zinc chelated forms increased Fe uptake in straw and grain more than mineral forms.

Concerning the zinc content and uptake data in this table revealed that the mentioned trend of Fe was observed for Zn. In this concern, Hergert et al (1984) studied that the field evaluations of zinc sources (Zn EDTA, Zn-NH_3 complex, ZnO, $ZnSO_4$ and Zn $(NO_3)_2$) and they found that the uptake of zinc from zinc EDTA was superior to all other sources at calcareous soils.

Regarding the effect of zinc sources on Mn content and uptake, data in the same table reveal that the highest values were recorded with Zn EDTA followed by $ZnCl_2$ treatments then the (untreated) control; while the lowest values were obtained with the $ZnSO_4$ treatments at all rates of applied $ZnSO_4$.

On the other hand, the highest value of Cu content was recorded at the untreated control and decreased with application of zinc sources at all application rates. While, the values of Cu uptake was 434 µg/plant obtained at the (untreated) control and increased to 517 and 436 µg/plant with 15 mg/l^{-1} of Zn ETDA and $ZnCl_2$ concentrations, respectively. While the lowest values of Cu uptake were obtained with the zinc sulfate treatments at all concentrations compared with the (untreated) control. Finally the data in the same table revealed that the mentioned trend of Fe content and uptake was observed for boron content and uptake. Similar results were obtained by Rajaie et al (2009) found that the application of $ZnSO_4$ decreased the concentration of Mn and Cu in plant shoots of lemon plant; they added that, since there was no significant decrease in plant uptake of Mn and Cu with Zn addition, reduction in the shoot concentration of these nutrients may be due to dilution effect or antagonistic relationship between Zn and other micronutrients. Loneragan and Webb (1993) reported that antagonistic relationship between Zn and other cationic micronutrients (Mn and Cu) appears as a result of competition at the absorption sites of plant root.

Thus, it can be concluded that foliar application of some zinc sources to pea plant, significant by improved plant growth and increased dry matter yield as well as values of N, P, K, Fe and Zn content and uptake. The best achieved values were due to Zn EDTA treatments followed, mostly, by $ZnCl_2$ then, $ZnSO_4$ treatments.

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الملخص العربى

تأثير التسميد الورقى ببعض مصادر الزنك على النمو والتركيب الكميائى لنبات اللوبيا .

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أقيمت تجربه حقلية لدراسة تأثير التغذيه الورقيه باضافة بعض مصادر الزنك المختلفه(الزنك المخلبى ،كبريتات الزنك وكلوريد الزنك) مرتين بتركيزات ٥ ،١٠ و١٥ مليجرام/ لتر زنك. الاولى بعد ثلاثين يوما من الزراعة(مرحلة النمو الخضرى) والثلنية بعد خمسين يوما من الزراعة(فترة تحسين القرون) وتقييم تأثيرها على نمو نبات اللوبيا وكذلك امتصاصه لبعض العناصر الغذائيه خلال موسم نمو ٢٠٠٩.

وتتلخص أهم النتئج المتحصل عليها فيما يلى:.

أثرت المعامله بمصادر الزنك المختلفه معنويا على جميع التقديرات المدروسه، حيث كانت أفضل النتائج المتحصل عليها بالنسبه لانتاج الماده الجافه(القش والبذور جم/للنبات) وكذلك التركيز والممتص من عناصر النيتروجين، الفوسفور، البوتاسيوم،الحديد والزنك مع استعمال الزنك المخلبى بالمقارنه بالمصادر الاخرى والكنترول.

أمابالنسبه لعناصر المنجنيز، والنحاس والبورن فقد زاد أيضا التركيز والممتص معنويا مع أستعمال الزنك المخلبى وكلوريد الزنك بينما كانت هذة القيم أقل من القيم المتحصل عليها من الكنترول مع أستعمال كبريتات الزنك ،غالبا مع جميع التركيزات المختلفه.

عموما تم الحصول على أفضل القيم مع أستخدام الزنك المخلبى بالنسبة لانتاج المادة الجافة وامتصاص العناصر يليه استخدام كلوريد الزنك ثم كبريتات الزنك بالنسبة لنبات اللوبيا تحت ظروف البحث.