ON THE ZINC EFFECT IN TOMATO PLANT NUTRITION

DESPRE EFECTUL ZINCULUI ÎN NUTRIȚIA PLANTELOR DE TOMATE

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Abstract. *The effects of zinc toxicity on the growth and the photosynthetic activities of tomato plants were studied using treatment solution of 5% concentration from $ZnSO_4*7H_2O$ and Zn (ac)* 2 H_2O salts. The seeds of tomato (Lycopersicon esculentum) were put into Petri dishes on double filter paper together with their treatment solution and they were kept here for 6 days. After that they were planted in pots in the Biophysics Laboratory where they developed in low conditions of temperature (16-20^{0}C). The dynamic of germination and the growth were monitorized and the pigment content (Chlorophyll A, Chlorophyll B and Carotenoids), which is essential for the photosynthetic apparatus, was analyzed spectrophotometrically with SPECORD 200. Our measurements showed an inhibitory effect only for Zn (ac)* 2 H_2O treatment. This means that Zn has not a fitotoxic effect on tomato plant growth in contradiction with other authors' results which suggest that zinc excess involves the stomata closing, the increase of CO_2 concentration in the leaves, the inhibition of certain enzyme of the Calvin cycle, a degradation of photosystem and the chlorophyll decomposition.*

Rezumat. *In această lucrare au fost studiate efectele de toxicitate ale zincului asupra creşterii şi a fenomenului de fotosinteză la plantele de tomate folosind solutii de tratament cu concentrația de 5% ale sărurilor $ZnSO_4*7H_2O$ şi Zn (ac)* 2 H_2O. Semințele de tomate (Lycopersicon esculentum) au fost puse în sticle Petri cu hârtie de filtru şi soluția de tratament unde au fost ținute timp de 6 zile. Apoi semințele au fost plantate în ghivece la laboratorul de Biofizică unde s-au dezvoltat în condiții de temperatură joasă (18-20^{0}C). A fost monitorizată dinamica germinației şi creşterea plantelor şi a fost analizat conținutul de pigmenți (clorofila a, clorofila b şi carotenoizi), care este esențial pentru aparatul fotosintetic, folosind un spectrofotometru SPECORD 200. Măsurătorile noastre arată un efect inhibitoriu numai pentru soluția ce conține Zn (ac)* 2 H_2O. Aceasta înseamnă că Zn nu are un efect toxic asupra creşterii plantelor de tomate, în contradicție cu rezultatele altor autori care sugerează că excesul de Zn implică închiderea stomatelor, creşterea concentrației de CO_2 din frunze, inhibiția anumitor enzime ale ciclului Calvin, degradarea sistemului fotosintetic şi descompunerea clorofilei.*

INTRODUCTION

Many authors examined the inhibitory effect of heavy metal compounds on growth and the performance of photosynthetic apparatus of plants. There are two aspects on the interaction of plants and heavy metals: (i) heavy metals show negative effects on plants, and (ii) plants have their own resistance mechanisms against toxic effects and for detoxifying heavy metal pollution. Many studies report that heavy metals affected germination percentage, root and shoot lengths and root and shoot dry matter, that heavy metals inhibit pollen germination, pollen tube growth and seed germination, causing ultra-structural changes (2),(3).

The effect of heavy metal Zn on plant growth is controversial.

Zn toxicity on soybean (*Glycine max* (L.) Merr.) is reported by Tracy Shyte and Sheila Macfie (7). The authors showed that the highest dose of zinc (2000 mg/kg) reduced plant height to 55% of control and dry weight to 70% of control. Concentrations of both metals were highest in root tissues (10-fold higher for cadmium, and up to 2-fold higher for zinc). The effects of high doses of one metal on the uptake of the other metal can be partially explained by the effects of one metal on the bioavailability of the other metal.

Rout and Das also have reported zinc toxicity (6). Author's studies concerning the physiology and biochemistry with regard to zinc zinc toxicity, uptake and transport of zinc showed that the major change was seen in the nucleus. The chromatin material was highly condensed and some of the cortical cells showed disruption and dilation of nuclear membrane. The cytoplasm became structureless, disintegration of cell organelles and the development of vacuoles were also observed; the number of nucleoli also increased in response to zinc.

On the other hand, the Zn effect is considerable on pollen during flowering (5). A deficit of Zn reduced the size of anthers, the pollen producing capacity and the size and viability of the pollen grains. Increasing the Zn supply from deficient to sufficient at the initiation of flowering decreased the severity of Zn deficiency effects on pollen and stigma morphology, pollen fertility and seed yield. Structural and functional changes induced in pollen grains and stigma of Zn deficient plants and associated decrease in seed setting of lentil indicate a critical requirement of Zn for pollen function.

MATERIAL AND METHODS

The seeds of tomatoes (*Lycopersicon esculentum*), were put into Petri dishes on double filter paper together with their treatment solution of 5% concentration from $ZnSO_4*7H_2O$ and $Zn(CH_3COO)_2$ and they were kept here for a week. Germinated seeds were planted in pots at the Biophysics Laboratory where they developed in low conditions of temperature (16-20^{0}C). Then we sorted the following variants:

1. untreated plants
2. treatment with $ZnSO_4*7H_2O$
3. treatment with $Zn(ac)_2$

After 6 weeks the biometric measurements and pigment analysis have been performed.

RESULTS AND DISCUSSIONS

The height of plant for control and the treatments with Zn are given in figure 1.

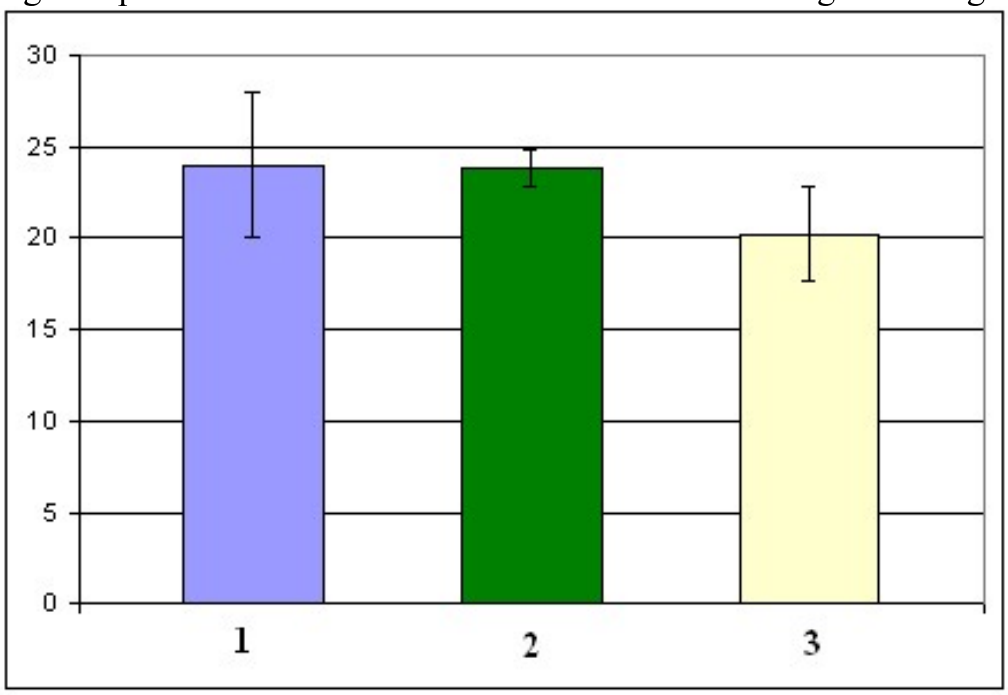

Fig.1 - The height of tomato plants. The error bars are the standard errors.

Figure 1 shows that Zn sulphate doesn't affect the plant growth. In addition plant roots treated with Zn sulphate are developed, especially the lateral roots as in figure 2.

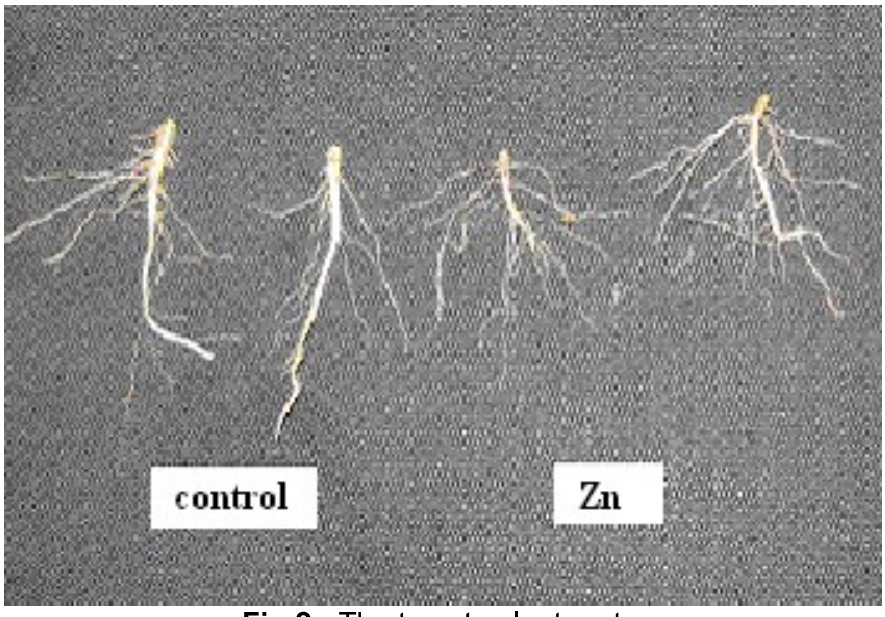

Fig.2 - The tomato plant roots.

The plant biomass is given in figure 3

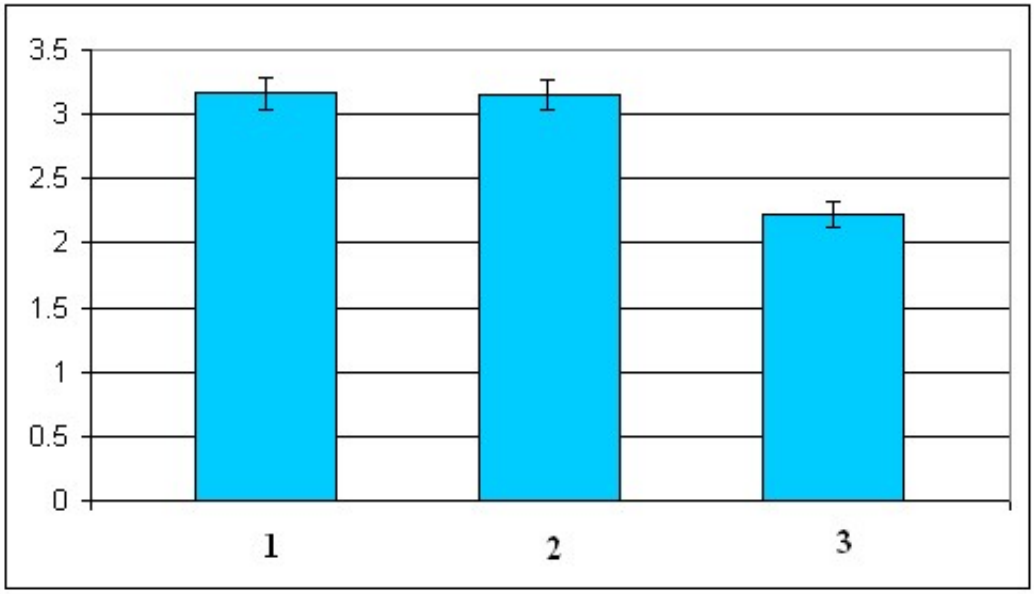

Fig.3 - The biomass of tomato plants. The error bars means standard errors

From these figures we can see that the $ZnSO_4*7H_2O$ has no effect on plant growth, but Zn acetate decrease biomass of tomato plant.
Student test shows only for plant biomass treated with Zn acetate statistic significant diferences (table 1).

Table 1.

Student test for tomato plant biomass

t-Test: Two-Sample Assuming Equal Variances		
	Variable 1	*Variable 2*
Mean	3.146	2.224
Variance	0.00908	0.00983
Observations	5	5
Pooled Variance	0.009455	
Hypothesized Mean Difference	0	
df	8	
t Stat	14.99236541	
P(T<=t) one-tail	1.93434E-07	
t Critical one-tail	1.85954832	
P(T<=t) two-tail	3.86867E-07	
t Critical two-tail	2.306005626	

From table 1 we can see that the probability $P=3.8686*10^{-7}<<0.001$, this means very significant differences. On the other hand Student test for Zn sulphate shows insignificant difference between control plants and treated plants.

The pigment analysis was performed with a spectrophotometer SPECORD M 42, immediately after the solutions were prepared.

The content of the photosynthetic pigments was calculated with the following formula:

Chl a = (9.784 * E662 - 0.99 * E644) * V* 100 / m

Chl b = (21.462 * E644 - 4.65 * E662) * V*100/ m

Car = (4.695 * E440 - 0.268 * (5.134 *E662 + 20.436 * E644) * V *100 /m

where:

- E662, E644, E440 is the absorbance,
- V is the volume of the solvent
- m is the mass tissue.

The content of photosynthetic pigments is presented in figure 4

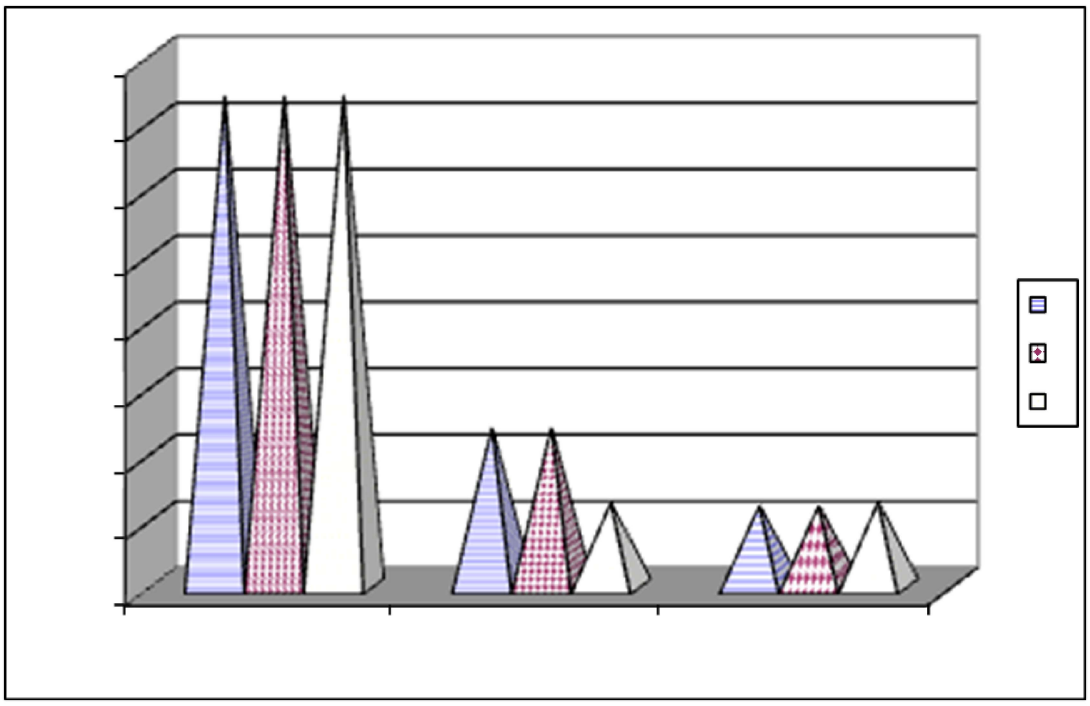

Fig.4 - Content of photosynthetic pigments

From figure 3 we can see that Zn treatments did not affect the content of photosynthetic pigments (only Zn acetate slowly decreases the content of chlorophyll b).

Our results are sustained by Mirzapour and Khoshgoftar. The authors showed that addition of 20 kg Zn ha^{-1} as $ZnSO_4$ significantly increased seed production and shoot dry-matter yield of sunflower, while other Zn treatments had no significant effect on shoot dry-matter yield, or decreased it (2). Goldur and colab reported an argument for our results that sustains the favorable effect of Zn. (1). The authors identified a very important effect of Zn at molecular level, modification of ASR1 (abscisic acid stress ripening) protein. Overexpression of the ASR1 in transgenic plants increases their salt-tolerance. The ASR1 protein possesses a zinc-dependent DNA-binding activity. Addition of zinc ions resulted in a global change in ASR1 structure from monomer to homodimer. Upon binding of zinc ions, the protein becomes ordered. Tomato leaf soluble ASR1 is unstructured in the absence of added zinc and gains structure upon binding of the metal ion.

CONCLUSIONS

Our results regarding Zn effect prove the fact that Zn as Zn sulphate has no fitotoxic effect on plant growth (on rate of germination, height of plant, photosynthetic pigment). In addition Zn suply produces the development of the plant roots, especially lateral roots. This is a consequence of the fact that Zn is a nutrient for plant, like Fe and Mn and it activates many enzimes. It implies triptophan synthesis, a component of auxine, the fytohormone which produces the plant growth.

In this phase of research we didn't performe measurements concerning Zn toxicity al cellular level.

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