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Foliar application of zinc and its effect on greenhouse grown cucumber

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Summary: The experiment was conducted to examine the effect of the foliar application of zinc on yield and crop quality and on fruit mineral composition of cucumber plants (*Cucumis sativus cv. Mustang*) which were grown in peat in containers under unheated conditions and were not showing visible signs of zinc deficiency.

In the trial the following 3 treatments were set up in 4 replications: Zn1 = 0.35 g/litre Zn, as foliar fertilizer; Zn2 = 0.7 g/litre Zn, as foliar fertilizer, control = no foliar fertilization. Foliar fertilization was applied 5 times with 10 day intervals. After their planting out the plants were fertigated daily with water soluble complex fertilisers. Fruits were harvested twice a week, 16 times in all, and were divided into three quality classes (class I, class II and substandard). Shoot length of the plants (plant height) was measured on 3 occasions. Zinc content of the fruits and leaves was analysed at two times.

From the results of the trials it can be concluded that the 0.35 g/litre Zn (0.35 mg/ml) foliar fertilisation had beneficial effect on cucumber both in terms of yield and quality. Under the conditions of the experiment (daily fertigation through drip irrigation) the effect of a more concentrated foliar application of zinc seemed less beneficial.

The zinc content of the fruits showed no evident increase in response to foliar fertilization, while a significant increase was seen in the leaves, particularly with the more concentrated Zn treatment. This indicates that in the case of cucumber zinc, through its assimilation in vegetative parts, has an indirect effect on fruit development.

Key words: cucumber, foliar fertilization, Zn, mineral composition, yield level, crop quality

Introduction, review of the literature

It is typical in traditional vegetable production to work farmyard manure in big quantities into the soil which provides a sufficient nutrient supply for the plants in most of the cases. In a more and more popular variety of isolated production rigid-walled containers (the so called bucket method) are filled with various sorts of peat and the nutrients are supplied by the application of water soluble fertilisers through drip irrigation systems. Some of these fertilisers contain smaller or bigger amounts of micro nutrients, too, however, despite the fact that growers are often compelled to encounter the symptoms indicating the deficiency of these micro nutrients, it is common to underestimate the role of micro nutrients and to omit micro nutrient fertilisation. In open-field production it is common to apply the micro nutrients in the form of foliar fertilisers, which in many cases will increase yields and improve quality even when no deficiency symptoms are visible on the plants (latent deficiency).

Zinc is an indispensable element of the carbohydrate metabolism of plants, being the specific metallic component of certain enzymes (*Szalai,* 1994). Individual crop species have very different susceptibility to zinc deficiency. Among the vegetables the Phaseolus beans are the most susceptible (*Mengel,* 1976), while cucumber is not considered as a zinc demanding plant by the literature (*Terbe* et al., 2004). 100 g fruit contains 0.1 mg zinc (*Borka,* 1959).

Symptoms of zinc deficiency tend to appear mainly on growing shoots and on their younger parts of the plant (*Bergman,* 1979; *Terbe,* 2002, 2004). In the case of zinc deficiency young leaves are small, internodes remain short (rosette formation), intervenal leaf tissues are whitish green in colour and occasionally small necrotic spots may appear on the shoots, leaves and fruits (*Terbe,* 2002).

With cucumber the growing point, together with the adjacent young leaves, is compressed and is rosetted and the shape of the leaves is also deformed, where the youngest leaves are arrow or spear-shaped, leaf shoulder is wide open, leaf blade edge is strongly indented and typically, intervein regions appear mosaic and chlorotic (*Bergmăn,* 1979; *Horinka,* 2000). The number of flowers is also reduced and fruit formation is poor (*Bergman,* 1979).

As a result of phosphorous fertilization of peat, zinc uptake is often insufficient in root media and peat mixtures

Table 1 Frequency and concentration of trickle fertigation (Budapest, 2005)

Period	Frequency	Quantity of nutrition solution (l/day/ plant)	Composition of nutrient solution (g/1000 l)				
			N	P_2O_5	K_2O	Mg	Ca
07.04.2005-08.04.2005*	daily	0.5	300	600	300	–	–
11.04.2005-19.04.2005*	every two days	1	432.5	410	260	10	47
20.04.2005-08.06.2005**	daily	1	252.5	105	315	10	47
09.06.2005-07.07.2005*	daily	1–1.5	442.5	245	280	10	47

* other components (in 1000 l solution): Fe: 2.6g; Mn: 0.6g; Zn: 0.4g; Cu:0.26g; B: 0.06g; Mo: 0.04g

** other components (in 1000 l solution): Fe: 1.95g; Mn: 0.45g; Zn: 0.3g; Cu:0.195g; B: 0.045g; Mo: 0.03g

with high phosphorous content, thereby a relative zinc deficiency appears (*Terbe*, 2002). The same can be observed on chalky (alkaline) soils (*Tisdale & Nelson*, 1966; *Horinka*, 2000).

The occurrence of latent or manifest zinc deficiency, similarly to several other micro nutrients (Fe, Mn, Cu, B, Mo) can effectively cured by foliar application of zinc (*Kádár*, 2002). The effect of foliar fertilization is usually quick and its application is indispensable in the case when, for example, due to the heavily bound form, zinc is unavailable in peat soils (*Szalai*, 1994).

The experiment was conducted with cucumber plants grown in containers in greenhouse and showing no visible signs of zinc deficiency in order to examine the effect of the foliar application of zinc on yield and crop quality, as well as on fruit mineral composition.

Material and method

The experiment was set up in 2005 in a Filclair made plastic tunnel under unheated conditions at the Experimental Farm of the Faculty of Horticulture of the Budapest Corvinus University.

In the trial the following 3 treatments were applied:

- Zn1 = 0.35 g/litre Zn, as foliar fertilizer;
- Zn2 = 0.7 g/litre Zn, as foliar fertilizer;
- control = no foliar fertilization.

The product 'Zintrac' (of the fertiliser family Phosyn) was used as foliar fertilizer (Zn content: 700 g/l) and in deciding its concentration the upper limit of the recommendations of the producer was taken as grounds (0.05 and 0.1%).

Each treatment was applied in four replications and each plot contained three plants.

Production was carried out in 12 litre black buckets with rigid wall, in which 10 litres of peat had been put (50% highmoor peat and 50% lowmoor peat).

The variety Mustang (*Cucumis sativus* L. *cv. Mustang*) was chosen as the test plant, which has an early growing season, is weak in growth and produces dark green medium long fruits (*OMMI*, 2000).

Seeds were sown on March 3 2005 in 9 cm tall pots filled with a mixture of peat and sand. Transplants were planted out on April 7. Four plants were planted per square meter spaced at 160 x 32 cm apart. Shoots were trained on a string up to the wires stretched at 240 cm high. The stand was pruned in a way to concentrate fruit growth on the main stem.

After transplanting a regular fertigation was carried out according to *Table 1*. Fertigation was always carried out in the morning hours and if needed plants were irrigated in the afternoon hours with pure water or with nutrient solution while taking care not to leach the nutrient solution out of the medium.

Table 2 illustrates the time of the foliar applications as well as the amount of foliar fertilizer applied per square meter and per plant. In applying the fertilizer the amount of the nutrient solution, applied evenly to all of the plant leaves by means of a hand sprayer, was such as to cover them evenly in a thin layer (without dripping).

The first harvest of fruits was on May 16, the last on July 7. Fruits were picked twice a week, 16 times in all, at commercial ripeness. Three classes were distinguished: class I contained the healthy, intact and straight fruits, class II the curved but healthy and intact ones, while the substandard category contained the strongly deformed and abnormal

Table 2 Time of foliar fertigation and the amount of foliar nutrition (Budapest, 2005)

Time	Amount of nutrition solution		Zn amount applied as foliar nutrition			
	ml/plant	ml/m^2	mg/plant		mg/m^2	
			Zn1	Zn2	Zn1	Zn2
13.05.2005	41.7	81.3	14.595	29.190	28.455	56.910
25.05.2005	54.2	105.7	18.970	37.940	36.995	73.990
07.06.2005	62.5	121.9	21.875	43.750	42.665	85.330
17.06.2005	70.8	138.1	24.780	49.560	48.335	96.670
01.07.2005	70.8	138.1	24.780	49.560	48.335	96.670
Total	*300*	*585.1*	*105.000*	*210.000*	*204.785*	*409.57*

fruits. For each category records were kept of the total weight of the fruits harvested per plot (kg) with accuracy of 5 gr and of the number of fruits harvested per plot.

Plant shoot length (height) was measured three times (12.05.2005; 09.06.2005; 07.07.2005).

For the analysis of the Zn content of the leaves and fruits samples were taken on two occasions (23.05.2005, 27.06.2005) and the analysis was carried using an ICP-OES IRIS Thermo Jarrel ASH, Corp., Franklin, MA, USA.

Results of the measurements were processed using the programme Microsoft Excel 2000 SR-1. For the statistical evaluation we used the single factor variation analysis at significance levels of 99, 95 and 90%.

Results

Mean shoot length of the plants (*Figure 1*) was the greatest with the application of the more concentrated Zn fertilizer at all three times of measurement and was smallest in the control treatment, but our statistical analyses did not confirm the difference.

In the aspect of *fruit number* per square meter, it was the control treatment that gave the best result, however, concerning *yields* and the number of class I fruits (marketable fruits) in proportion to total yields the application of the less concentrated Zn foliar fertiliser (Zn1) proved favourable. This fact was also confirmed by our statistical analyses. The more concentrated foliar fertilisation with Zinc (Zn2), except for the number of fruits, gave better results in all treatments than the control, but gave poorer

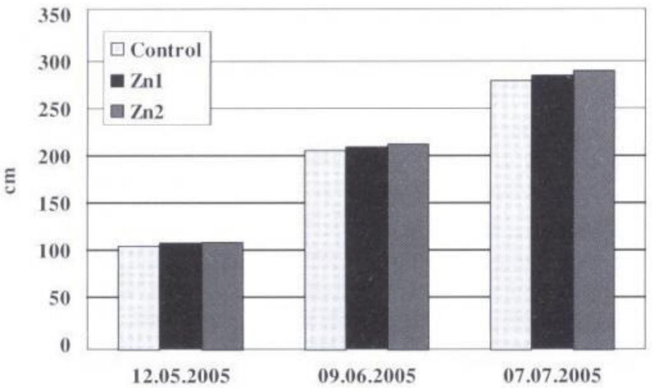

Figure 1 The height of plants (Budapest, 2005)

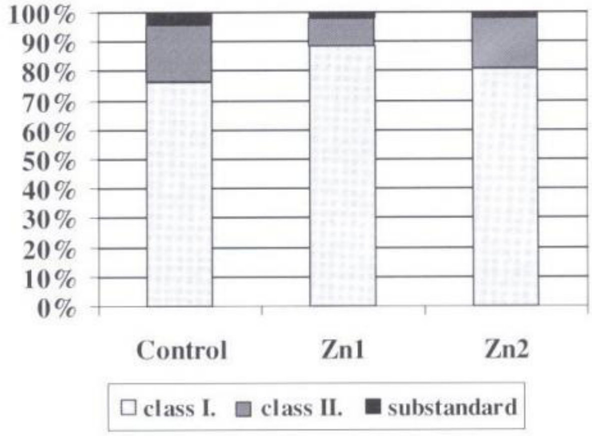

Figure 2 Quality distribution of fruits (Budapest, 2005)

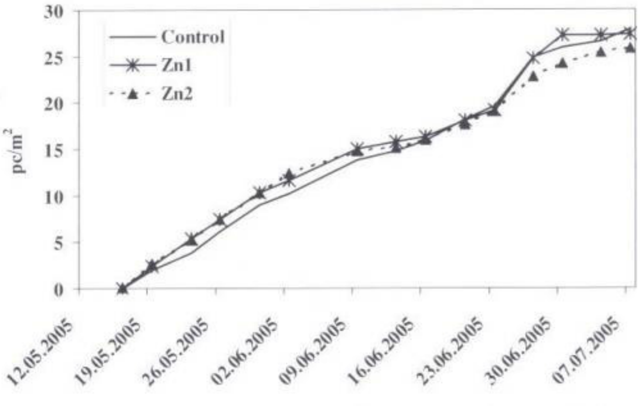

Figure 3 Fruit number over the growing season (Budapest, 2005)

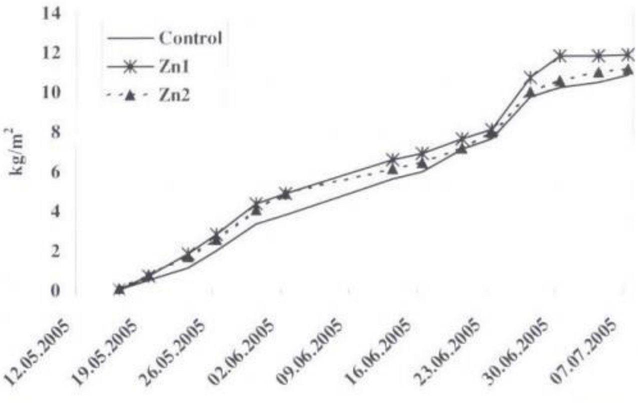

Figure 4 Yield distribution over the growing season (Budapest, 2005)

Table 3 Cucumber yields (Budapest, 2005)

Treatment	Total yield		Yield belong to the 1st class			
			number of fruit		yield	
	number of fruit, pc/m²	yield, kg/m²	pc/m²	number of fruits expressed in percentage	kg/m²	yield expressed in percentage
Control	27.93	10.71	21.26	76.16	8.62	80.41
Zn1	27.42	11.72	24.33	88.67	10.58	90.18
Zn2	25.88	11.05	20.83	80.16	9.34	84.28
SZD99%	—	—	—	—	—	—
SZD95%	—	—	—	7.90	—	6.59
SZD90%	—	—	—	6.40	1.26	5.34

Table 4: Zinc content of fruits and leaves (in 1 gr dry matter)

Part of plant	1st sampling (23.05.2005)			2nd sampling (27.06.2005)		
	Control (μg)	Zn1 (μg)	Zn2 (μg)	Control (μg)	Zn1 (μg)	Zn2 (μg)
Fruit	28.57	35.87	38.90	29.24	25.27	28.98
Leaf	25.83	159.40	169.87	39.18	138.52	214.30

results than the other foliar fertiliser treatment (*Table 3*). The highest number of substandard fruits as a percentage was picked from the control treatment with no Zn (*Figure 2*).

The *trend of fruiting* (the graphs of the accumulated yield) is illustrated in *Figures 3–4*. It can be seen that, as regards the number of fruits, in the first 2/3 part of the picking season the control treatment was slightly inferior to the foliar fertiliser treatments, which showed practically no difference during this period. The more concentrated Zn foliar application caused a yield decrease in the last part of the growing season compared to the less concentrated foliar fertiliser. Considering the amount of yields, the control treatment was inferior to the two foliar fertilization treatments all along the trial. The plots treated with the more concentrated Zn2 nutrient solution started to produce lower yields than the Zn1 treatment in the second half of the growing season.

Table 4 illustrates the results from the analysis of the zinc *content of the fruits and leaves*. At the first sampling the Zn content in the fruits showed an increase as a result of the foliar fertiliser applications, on the other hand, at the second sampling we were surprised to see no sign of it and in fact the control treatment gave slightly higher values. In the foliar fertilization treatments the zinc content of the leaves had been increased by several times higher compared to the control treatment. The highest values were recorded with the more concentrated Zn treatment, which phenomenon was particularly conspicuous at the second sampling.

Conclusions

Results of our experiments indicate that the treatment with the foliar application of 35 g/l (0.35 mg/ml) Zn had beneficial effect on cucumber both in terms of yield and quality. Under the conditions of the experiment (daily fertigation through drip irrigation) the effect of the more concentrated foliar application of zinc seemed less beneficial.

The zinc content of the fruits showed no evident increase in response to foliar fertilization, while a significant increase was seen in the leaves, particularly with the more concentrated Zn treatment. This indicates that in the case of cucumber zinc, through its assimilation in vegetative parts, has an indirect effect on fruit development.

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