Effects of Different Zn-Supply on Maize Seedlings

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INTRODUCTION

Zinc deficiency causes serious metabolic and developmental disorders in organisms. The physiological effects of Zn deficiency and high Zn supply on the early growth of maize were examined. There were no significant differences in dry weights. Growth of 7-days old maize seedlings increased when high Zn concentrations were applied, and symptoms of toxicity appeared at 14-days of age. Zinc and Fe uptake and distribution showed significant differences at different Zn-supplies. The leaf-structure of plants was modified depending on Zn status. We concluded that high Zn concentrations enhance the early development of plants. This may give seed-treatments the opportunity to prevent the decline of early growth in Zn-deficient soils.

METHODS

The test plants were cucumber (*Cucumis sativus L. cv. Delicates*) and maize (*Zea mays L. cv. Norma*). The seeds were germinated on moistured filter paper at 25 C° in the dark. Seedlings were transferred to continuously aerated nutrient solutions. Plants were grown under controlled conditions (light/dark regime 10/14 h at 24/20°C, 390 $\mu Em^{-2}s^{-1}$ at plant height). Zinc concentrations of the nutrient solutions were 0, 0.05, 0.25, 0.5 (control), 5, and 50µM. Ion concentrations were measured by Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) (OPTIMA 3300DV, Perkin-Elmer). Relative chlorophyll contents (SPAD-index) were analysed with a SPAD-501 chlorophyll meter (Minolta, Japan).

RESULTS AND DISCUSSION

The Zn nutritional status affected ion uptake and concentrations in maize roots. However, results are contradictory. The concentration of all examined elements in shoots and roots decreased with 0.05µM Zn in the nutrient solution in comparison with controls. Iron concentrations increased with Zn supply. There were no significant changes observed for other elements. The Zn concentration increased in shoots with Zn supply but less than in roots. The highest Zn supply and high Fe concentrations did not cause toxicity in 7-days old maize seedlings. There were no significant changes observed in dry weights at this plant age, but Zn toxicity was observed after 14 days. The toxicity symptoms were similar to those caused by Zn deficiency. The yellow and green stripes were darker in treatments with a 100-fold Zn supply. The youngest leaves of Zn-deficient plants died, while they were well developed at the 100-fold Zn dose. The plants seem to be larger when high Zn concentrations were applied, but a decrease in dry matter production was observed. The decrease of dry matter production of Zn-deficient plants can also be explained by leaf morphology (Fig. 2). There is a significant decrease in leaf thickness in absence of Zn. There was no such decrease observed, when Zn was given in high concentrations. The results indicate (Table 3) that plant SPAD-indices at control and different Zn-levels were not significantly different at the 5th day of treatment.

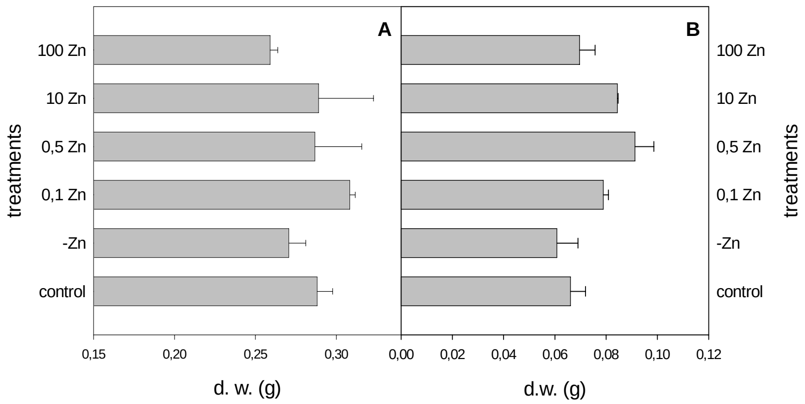

Fig. 1. Changes in dry weight (d. w.) (g) resulting from different zinc nutrition in shoots (A) and (B) roots of maize. (n=3-4 ± s. e.)

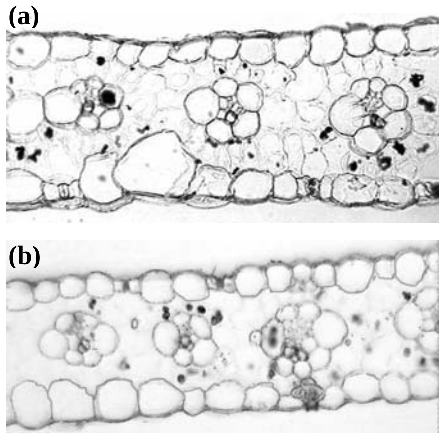

Fig. 2. Zinc-efficient (a) and deficient (b) leaves of 7-days old maize seedlings (20x magnification).

At the 6the day of treatment, the relative chlorophyll contents significantly decreased in 10 and 100-fold Zn treatments when compared to controls. These differences increased during the experiments. The SPAD-indexes of 10 and 100-fold Zn treatments were about 20% lower than controls.

Table 3. Relative chlorophyll contents (SPAD-index) at different Zn levels at different times. (n=80 ±s.e.)

	Control (0.5 µM)	0 µM	0.05µM	0.25µM	5µM	50µM
5th day	35.96±0.61	36.2±0.66	36.81±0.88	35.87±0.58	33.33±0.91	35.11±1.08
6th day	40.24±1.35	38.12±0.75	39.54±0.91	38.44±0.73	35.23±1.16*	36.06±1.04*
7th day	40.90±1.89	39.25±0.65	41.56±0.45	41.19±1.09	35.07±1.15*	34.68±0.95**
9th day	45.08±1.19	43.55±0.67	44.72±0.75	45.71±1.26	35.35±1.76**	35.19±1.17***

Significant differences compared to control values *p<0.05, **p<0.01, ***p<0.001.

Table 4. Effect of different Zn supply on Ca, Cd, Fe and Zn concentrations in maize roots and shoots of 14-days old plants (mg kg^{-1} dry matter).

SHOOT	**Zn**	**Fe**	**Ca**	**Al**	**Cd**
0µM Zn	41±1.56	79.6±5.37	8503±42.5	11.01±1.02	1.15±0.03*
0.05µM Zn	51.4±4.34	106±10.32	8935±58.81	17.99±3.03	1.51±0.04*
0.25µM Zn	51.5±0.02	67.6±20.17	9395±52.58	9.03±2.03	0.53±0.00
0.5µM Zn (control)	84±5.74	105±20.41	9364±64.18	16±0.02	0.01±0.00
5µM Zn	218±10.99***	48.8±10.36*	8267±57.29	6.99±1.06*	0.78±0.01
50µM Zn	743±30.89***	54.9±10.36*	8134857.29	10.39±2.11	1.11±0.02*
ROOT					
0µM Zn	35.5±3.40*	117±11.01*	5999±40.76**	13.98±1.06*	9.61±1.02
0.05µM Zn	55.1±2.43*	231±10.44*	9869±29.77*	18.17±3.20*	9.59±2.11
0.25µM Zn	79.9±0.05**	231±2.37*	7197±68.04	15.75±2.05*	11.64±2.13
0.5µM Zn (control)	154±1.17	457±20.65	10,126±22.91	36±3.25	8.00±0.00
5µM Zn	673±25.32***	385±20.92	10,050±86.76	22.22±2.05*	10.37±3.05
50µM Zn	2949±45.32***	1739±40.92***	8582±84.56*	144.6±12.05***	11.74±2.05

Significant differences compared to the control values *p<0.05, **p<0.01, ***p<0.001.

CONCLUSIONS

Zinc deficiency decreased leaf thickness. All Zn treatments increased dry matter accumulation. There was no toxicity in young maize plants observed when a 100-fold Zn treatment was applied. Based on this observation, the treatment of seeds with high Zn concentrations is recommended. Zinc supply affected Fe uptake significantly.