BIOLOGIA PLANTARUM 39 (3): 463-466, 1997

BRIEF COMMUNICATION

Silicon and copper interaction in the growth of spring wheat seedlings

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Abstract

Shoot and root fresh and dry matters and their Cu content were determined in 7-d-old seedlings of *Triticum aestivum* L. cv. Alkora treated with Cu (10, 20, 40 μg cm^{-3}) and Si (500 μg cm^{-3}). Si significantly reduced the toxic effect of Cu on fresh and dry matter production of wheat seedlings. Moreover, plants treated with Cu and Si absorbed less Cu from the solution and had higher water content in shoots and roots than that treated with Cu only.

Additional key words: dry mass, fresh mass, *Triticum aestivum*, water content.

Copper is an essential element for plant growth. It is integrated in many enzymatic proteins among others: plastocyanin, amine oxidase, tyrosinase, ascorbate oxidase. It takes part in photosynthesis and affects cell membrane permeability (Sandman and Böger 1983) which may cause higher secretion of K^+ and PO_4^{3-} (Kennedy and Gonsalves 1987). The average content of Cu in agricultural plants ranges from 1 to 20 mg kg^{-1} of dry matter in dependence on species, cultivar, development stage and the part of plant (Kabata-Pendias and Pendias 1993).

The sources of excessive Cu in the environment are mostly: mines, copperworks, electronics and pharmaceutical industry. Cu is also emitted during coal burning. It is used for some pesticides and mixed fertilisers production (Kabata-Pendias and Pendias 1993). Plants from highly contaminated areas may contain considerably more Cu then those from non-polluted areas. This concentration may even exceed toxic limits *i.e.* 20 - 100 mg kg^{-1}(d.m.). Cu is submitted to very strong fixation with low molecular mass proteins and layered in intercellular space. It is most frequently retained by roots like other heavy metals, damages root cells and slow down root

Received 6 May 1996, *accepted* 11 September 1996.

growth (Nowakowski 1993). The toxic effect of Cu consists in inhibition of electron transport in photosystem (PS) 1 and PS 2 (Lanares *et al.* 1993, Singh *et al.* 1989) or decreased DNA synthesis (Doncheva *et al.* 1996).

Silicon is not toxic for plants and occurs very commonly in lithosphere. Physiological function of Si in plants is connected with tricarboxylic acid cycle, DNA and chlorophyll synthesis, and plant water balance (Darley and Volcani 1968, Werner and Roth 1983).

As detoxification of heavy metals is an essential problem in environmental protection, the experiments concerned interaction between Si and Cu could contribute to its solution.

Experimental material was spring wheat (*Triticum aestivum* L.) cv. Alkora. The experiment was carried out under laboratory conditions (temperature of 20 °C, relative humidity of 70 %, darkness). Every 50 seeds were placed on 10 cm Petri dishes with filter paper in distilled water (control) or in $CuSO_4 \cdot 5H_2O$ solution (Cu concentration 10, 20 and 40 $\mu g\ cm^{-3}$). Si was used as Na_2SiO_3 in single concentration of 500 $\mu g\ cm^{-3}$.

In 7-d-old seedlings fresh and dry masses of shoots and roots and their Cu content were measured. Plants were mineralised by HNO_3 and $HClO_4$ (2:1) at 600 °C and Cu was determined by atomic absorption spectrometry (*Perkin-Elmer 300*). Statistical analysis was done using Tukey's test.

The results indicated significant influence of increasing Cu content in solution (from 0 to 40 $\mu g\ cm^{-3}$) on shoot and root fresh and dry matter of spring wheat (Table 1). The severity of Cu toxicity was more evident in roots than in shoots. Root fresh mass was three and six times lower in plants treated with Cu at concentration 10 and 40 $\mu g\ cm^{-3}$, respectively, than in control (65.4 mg per plant, see Table 1). Cu also caused the decrease of water content in roots and shoots (Table 1).

Table 1. The influence of interaction between Si and Cu on fresh and dry masses and water content in 7-d-old seedlings of spring wheat cv. Alkora. Means ± S.E. (n = 4).

Treatment [mg dm^{-3}]		Fresh mass [mg $seedling^{-1}$]		Dry mass [mg $seedling^{-1}$]		Water content [%]	
Cu	Si	shoot	root	shoot	root	shoot	root
0	0	74.0±5.3	65.4±5.0	5.8±0.5	3.9±0.6	92.2	93.9
0	500	79.9±5.2	5.1±1.8	6.1±0.2	2.9±0.1	92.3	94.4
10	0	68.5±7.4	20.8±4.0	6.0±0.6	1.8±0.5	91.2	91.3
20	0	58.4±4.6	15.7±1.7	5.7±0.4	1.6±0.2	90.2	90.1
40	0	44.5±3.9	10.1±0.8	4.9±0.4	0.9±0.2	89.0	90.2
10	500	82.5±1.2	33.6±0.3	7.3±0.2	2.5±0.4	91.2	92.5
20	500	77.8±4.3	28.5±1.0	6.9±0.4	2.3±0.1	91.2	92.1
40	500	90.3±8.5	24.2±1.2	7.1±0.3	2.0±0.1	92.1	91.9
$LSD_{0.05}$		20.7	10.0	1.3	1.0		

Addition of Si (500 $\mu g\ cm^{-3}$) increased root and shoot fresh and dry masses of spring wheat plants treated with Cu. The increase in shoot fresh mass was 120.4 %

and root fresh mass 161.5 % at Cu concentration of 10 μg cm^{-3} and 202.9 % and 239.6 %, respectively, at Cu concentration of 40 μg cm^{-3} (Table 1). Depending on Cu concentration in solution Si increased shoot dry mass from 121.6 % up to 144.9 % and root dry mass from 138.8 % to 222.2 % (Table 1). A noticed increase of water content in shoots and roots of spring wheat was observed in the presence of Si, especially at higher concentration of Cu (Table 1).

Wagner in 1940 (cited by Werner and Roth 1983) proved a detoxification influence of Si on rice, barley, cucumber and tobacco grown on medium with high iron concentration. Vlamis and Williams (1967) and Horst and Marschner (1978) revealed that an addition of Si increased growth under toxic concentration of manganese.

Cu in roots of examined wheat seedlings varied from 4.1 (control) to 1372.7 μg g^{-1}(d.m.) (Cu concentration 40 μg cm^{-3}) (Fig. 1). Addition of Si caused a decrease of Cu content in wheat roots from 48.8 % to 52.2 % (Fig. 1). Shoots of the same plants contained from 8.1 to 127.9 μg(Cu) g^{-1}(d.m.). Si also reduced Cu content in shoots according to Cu concentration in medium (Fig. 2).

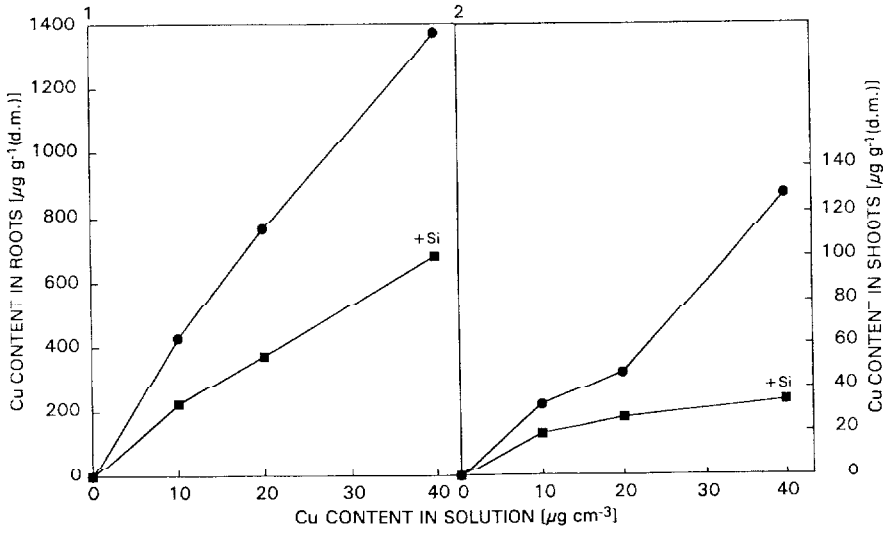

Fig. 1. Cooper content in roots of 7-d-old seedlings of spring wheat cv. Alkora exposed to different concentrations of Cu or Cu + 500 μg cm^{-3} Si in solution.

Fig. 2. Cooper content in shoots of 7-d-old seedlings of spring wheat cv. Alkora exposed to different concentrations of Cu or Cu + 500 μg cm^{-3} Si in solution.

Interaction between Si and Cu caused a significant reduction of toxic effect of Cu on 7-d-old seedlings of spring wheat cv. Alkora and so Si might be very important for alleviation of toxic effects of heavy metals on plant growth.

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