Silicon effect on growth dynamics, macro and microelements content in cadmium and arsenic treated poplar calli

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INTRODUCTION

Silicon (Si) is often reported as beneficial element for plant growth, helping the plants to overcome toxic metal effects (e.g. Al, Mn, Zn or Cd).

Cadmium (Cd) and arsenic (As) are known as non-essential elements, toxic for plants, animals and humans. Mining heaps and waste dumps are often colonized by poplars - trees showing fast growth and high biomass production.

Callus culture provides an interesting model system composed of parenchymatic cells without presence of other organisms such as fungi or bacteria. Therefore the data obtained are likely to well reflect plant cell metabolism.

The aim of our work was to evaluate the Si effect on growth dynamics, macro and microelements content, Cd and As uptake in poplar (*Populus alba* L., var. *pyramidalis*) callus cultures.

CONCLUSIONS

- Addition of silicon to media positively improved the fresh, dry mass, callus growth dynamics, and its effect varied according to toxic element added
- Differences in callus growth dynamics were dependent on culture duration, and on the toxic element added
- Silicon decreased Cd and As accumulation
- Contrasting tendencies of Si effect on Cd and As toxicity and accumulation were observed during the culture
- Differences between macro and microelements contents in calli under Cd, As and/or Si treatment may be linked with differences of plant defence mechanisms against toxic elements

RESULTS

Growth parameters

Cadmium and arsenic have decreased callus fresh and dry mass (Fig. 1,2). The differences in callus growth dynamics were dependent on culture duration, and on the toxic element used (Fig. 2). Addition of silicon to media positively improved the fresh, dry mass, callus growth dynamics of Cd and As treated calli and its effect was dependent on the toxic element used.

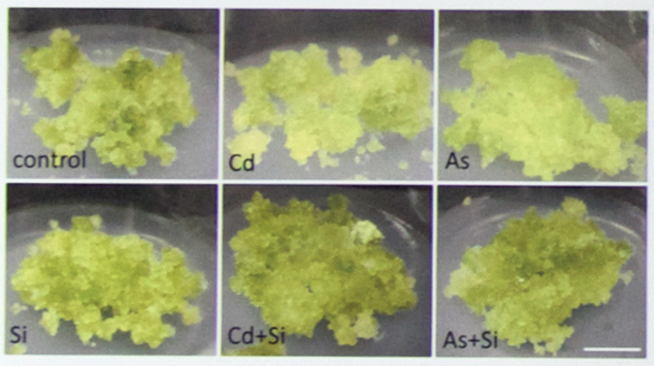

Fig. 1. Poplar calli on the agar media at the end of third subculture.
Growth reduction induced by Cd and As was accompanied by signs of chlorosis.
Scale bar = 1 cm.

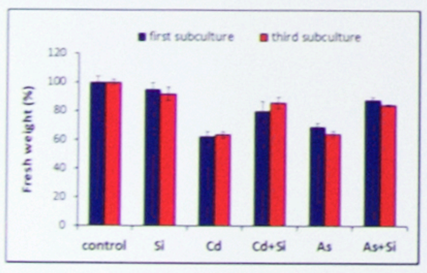

Fig. 2. Poplar calli relative fresh mass. Two subcultures were followed. Values are expressed as percentage from control. Error bars represent standard error from three replicates.

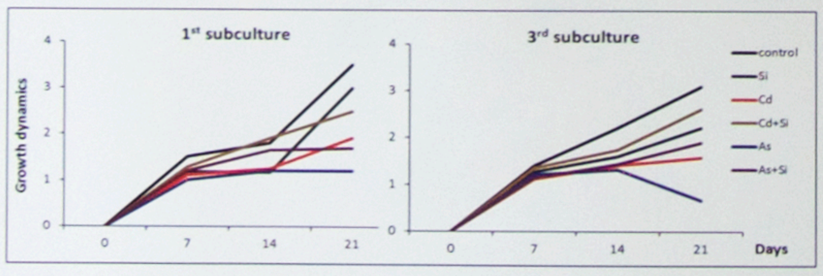

Fig. 3. Growth dynamics of calli during the first and third subculture showing differences linked with the element added and duration of the experiment.
Possitive effect of Si against toxic elements was observed.

Relative content of macro and microelements

Concentration of different elements was determined. For better comparison of the silicon effect, relative values are presented. Addition of Si, Cd, and As caused significant changes of other elements content. The addition of Si and As in form of sodium compounds has to be taken in account in interpretation of certain data (e.g. Fig. 4C). Contrasting tendency of Si effect on Cd and As toxicity and accumulation can be observed in Fig. 2, 4E-F.

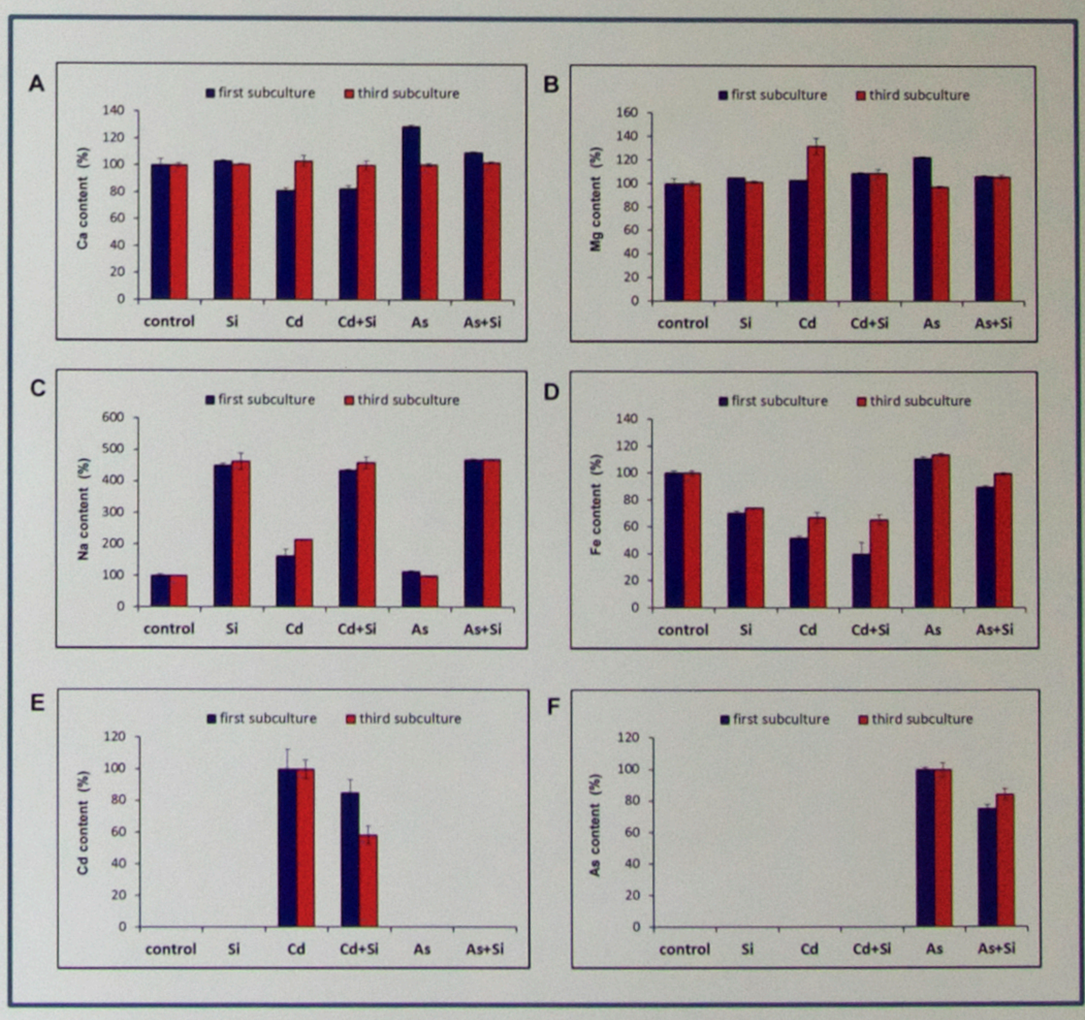

Fig. 4. Relative concentrations of selected elements in calli at the end of the first and third subculture. Values are expressed as percentage from selected variant (control, Cd, or As) for each subculture.
Error bars represent standard error from three replicates.

MATERIAL AND METHODS

- Poplar callus was cultivated in conditions *in vitro* on agar medium [1] with addition of $Cd(NO_3)_2 \cdot 4\ H_2O$ (10 mM) or $HAsNa_2O_4 \cdot 7\ H_2O$ (1 mM), and/or silicon (5 mM Si as sodium silicate solution) with pH adjusted to 5.8.
- Duration of the experiment was 9 weeks (with 3 weeks subculture). Fresh and dry mass were taken every week and growth dynamics was determined [2]. The first and third subcultures were compared.
- Content of selected elements (Ca, Mg, Na, Fe, Cd, As) in calli were determined by inductively coupled plasma mass spectroscopy (ICP-MS) analysis.

REFERENCES

[1] Diaz-Colon et al., Physiol. Plant., 1972, 27, 60-64.
[2] Hlinková E. and Bobák M., J. App. Biomed., 2004, 2, 101-109.

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