A MÖSSBAUER SPECTROSCOPIC STUDY OF THE EFFECTS OF Cd ON THE IRON UPTAKE AND STORAGE IN CUCUMBER

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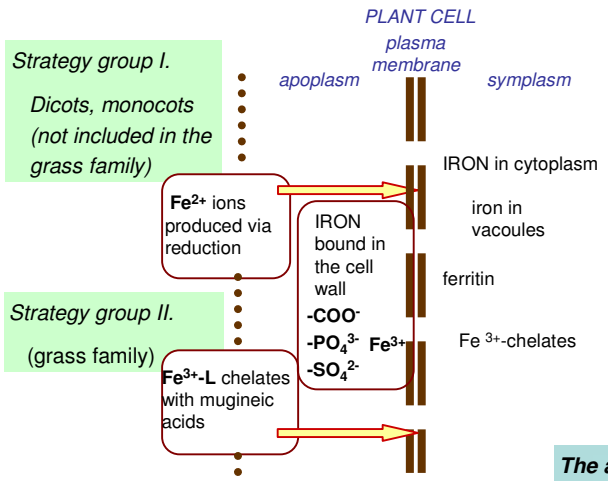
BACKGROUND

Iron uptake mechanism in plants [1]:



Influence of heavy metals on the iron homeostasis [2]:

- Plants accumulate heavy metals in roots and shoots, causing physiological disturbances in growth, water balance, photosynthesis, nutrient uptake, allocation and assimilation.
- Among the nutrients, showing interactions with heavy metals, Fe is one of the most frequently studied in many aspects. Heavy metals influence Fe adsorption and availability in the root apoplasm, uptake into root cells, transport to the shoot and utilization in leaves.
- Iron deficiency may also modify heavy metal uptake and accumulation.
- In iron sufficient cucumber roots, we have identified different iron compounds by Mössbauer spectroscopy: ferric-carboxylates, hydrous ferric oxides, sulfate-hydroxides. In iron deficient roots ferrous-hexaaqua complex was also found [4].

OBJECTIVES

The aim of the present work was

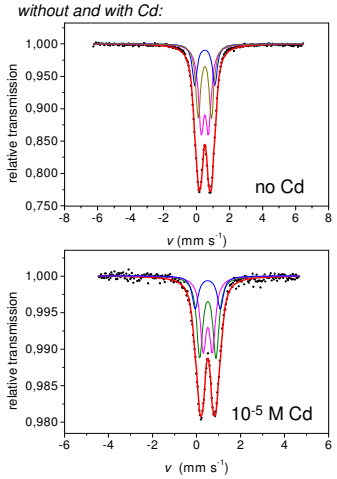
- to **detect the chemical forms of iron** occurring in the root tissue of cucumber (*Cucumis sativus*) by **applying Cd contamination** during the growth
- to investigate the **effect of Cd on the iron-uptake mechanism** in iron deficient conditions
- to **compare the results with normal conditions** where no Cd is present

with the help of Mössbauer spectroscopy.

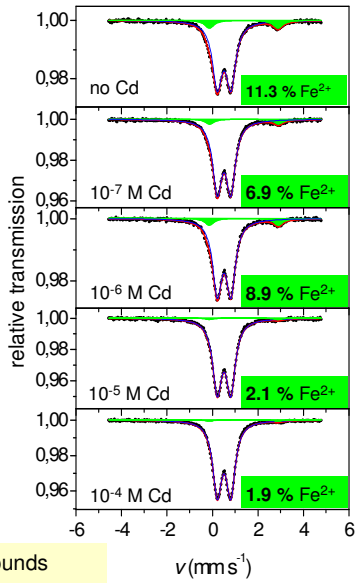
Experimental: Cucumber was grown both in iron sufficient and iron deficient media. In all cases, the nutrient solutions contained Cd contaminants in different concentrations from 10^{-7} M up to 10^{-5} M. In the iron deficient case, the $5*10^{-4}$ M $^{57}Fe^{III}$-citrate was added only before the harvest for 30 min. ^{57}Fe Mössbauer measurements were carried out at 80 K.

RESULTS AND DISCUSSION

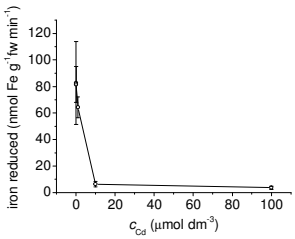
Mössbauer spectra of the iron sufficient roots without and with Cd:



Mössbauer spectra of the iron deficient roots without and with Cd:

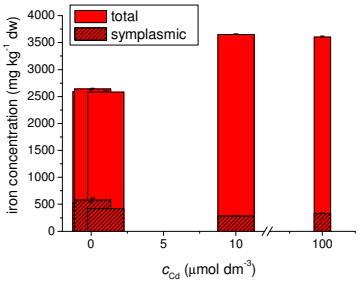


- the Cd does not change the iron(III) compounds found in the root tissue of iron sufficient cucumber [3]
- the iron deficient samples show an iron(III) and an iron(II) component
- the amount of the reduced iron (δ=1.3 mms^{-1} Δ=3.1 mms^{-1}, Fe^{II}-hexaaqua complex) is decreasing upon Cd-treatment



- the ferric-chelate reductase activity of the iron deficient roots is decreasing as the Cd concentration was increased

- the Cd inhibits the ferric-chelate reductase enzyme activity
- the Cd inhibits iron uptake from the apoplast which results in an iron(III) accumulation in the cell-wall



- the total iron content of the roots is increasing while the iron content of the symplast is decreasing as the Cd concentration was increased

CONCLUSIONS

- The results obtained for iron sufficient cucumber show that **Cd uptake does not change** significantly **the main iron(III) compounds** occurring in the root tissue.
- In the iron deficient plants, **Cd inhibits iron reduction** during iron uptake.
- **Cd inhibits iron uptake** into the symplasm which results in apoplasmic iron(III) accumulation.
- The results presented help to understand the competitive effects of different metals on the uptake and translocation

REFERENCES

[1] V. Römheld, A. Marschner, In: Advances of Plant Nutrition (B. Trinker, A. Lauchli, Eds.), Preager Scientific, New York, (1986) Vol. 2, pp 155-204.
[2] F. Fodor, In: Iron Nutrition in Plants and Rhizospheric Microorganism, Springer, The Netherlands, (2007) pp 129-152.
[3] K. Kovács, E. Kuzmann, F. Fodor, A. Vértes, A. A. Kamnev, Hyp. Int. 165 (2005) 289-294
[4] K. Kovács, E. Kuzmann, E. Tatár, A. Vértes, F. Fodor, Planta DOI 10.1007s00425-008-0826-x (accesible at "online first")

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