Investigation of proteomic and physiological responses of *Zygophyllum fabago* to cadmium treatment

Lefèvre I.[1, 2], Planchon S.[1], Oufir M.[1], Lepoint G.[3], Gobert S.[3], Hausman J.-F.[1], Renaut J.[1] and S. Lutts[2]

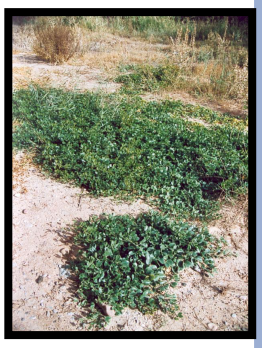
Lefevre@lippmann.lu

Introduction

• Heavy metals are widespread pollutants which can not be degraded. The aim of the research was to identify some new interesting accumulators which may associate an important biomass production with an effective absorption of heavy metals from contaminated substrates.

• The present study focused on *Zygophyllum fabago*. This species was shown to be able to accumulate quite high concentration of cadmium (Lefèvre et al., 2005). An important heterogeneity between individual plants exists within population of *Z. fabago* in response to Cd treatment; some plants are able to accumulate high amounts of Cd without exhibiting any detrimental symptoms in terms of growth or necrosis while some others are not (Lefèvre et al., 2008).

• A comparison between individuals originating from a same population but differing in their resistance to Cd could help us to understand mechanisms involved in response to this toxic ion.



Syrian beancaper *Zygophyllum fabago*

- Succulent perennial multibranched shrub
- Able to cope with long period of drought
- Associated with waste and rocky areas

Objectives

- to determine the metabolic and physiological parameters modified in relation to Cd accumulation.
- to identify if these modifications were related to a strategy of resistance or should be considered as symptoms of injury.

Material and methods

- Seedlings of *Z. fabago* exposed during 4 weeks to 10 µM $CdCl_2$ in nutrient solution.
- After 4 weeks : quantitative proteomic analysis of leaves performed by 2D Differential InGel Electrophoresis. Differentially expressed proteins identified by MALDI-TOF analysis.
- After 2 and 4 weeks : Morphological, physiological and biochemical characterization of characterization of *Z. fabago*.

Results and discussions

Table 1. Cadmium-induced differentially expressed proteins in *Zygophyllum fabago* leaves identified by MALDI-TOF analysis

n° Spot	Homologous protein	Protein fold change (Cd/control)
Photosynthetic apparatus-related proteins		
1399	type III chlorophyll a/b-binding protein	-1.64
1401	type III chlorophyll a/b-binding protein	-1.55
1427	Oxygen-evolving enhancer protein 2	-1.43
1253	oxygen evolving enhancer protein 1 precursor	-1.25
1192	chloroplast ferredoxin-NADP$^+$ reductase [Pisum sativum]	1.48
Protein biosynthesis		
841	Elongation factor TuB; chloroplast precursor	-1.35
Energy and metabolism-related proteins		
946	Phosphoribulokinase	-1.28
1118	plastidic aldolase	-1.25
564	ATPsynthase alpha subunit	1.63
Carbohydrate metabolism-related proteins		
573	beta-glucosidase	1.67
589	beta-glucosidase	1.74
Plant defense-related proteins		
1435	peroxiredoxin	-1.42
637	catalase	1.68
1106	endo-beta-1; 3-glucanase	1.95
1143	endo-beta-1; 3-glucanase	2.13
1126	endo-beta-1; 3-glucanase	2.17
1144	endo-beta-1; 3-glucanase	2.23
1125	endo-beta-1; 3-glucanase	2.25
1231	chitinase	2.26
1122	endo-beta-1; 3-glucanase	2.27
1230	chitinase	2.57
1121	endo-beta-1; 3-glucanase	2.81
1274	chitinase	3.18

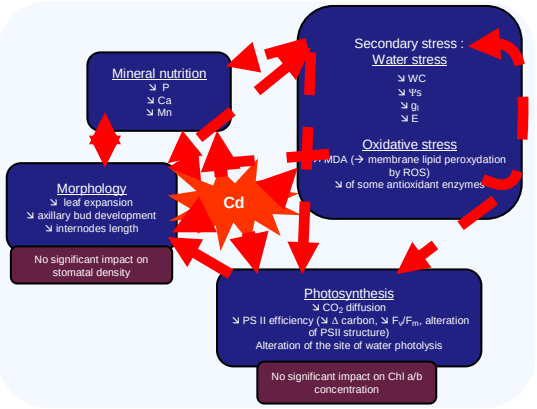


Fig. 1. Identified metabolic and physiological parameters modified in *Zygophyllum fabago* in response to Cd.

Chl, chlorophyll; E, transpiration rate; g_l, leaf stomatal conductance; F_v/F_m, maximum quantum yield of PSII; MDA, malondialdehydes; PSII, photosystem II; ROS, reactive oxygen species; WC, water content; Δ carbon, carbon isotope discrimination; Ψs, osmotic potential

In relation to the modifications in *Z. fabago* proteome (**Table 1**), a physiological and biochemical characterization has been performed in order to determine some parameters modified in response to 10 µM Cd, as shown by **Fig. 1**.

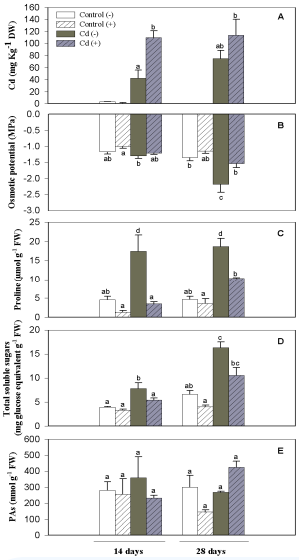


Fig. 2. Cd concentration (A), osmotic potential (B), proline (C), free soluble sugars (D) and polyamines (E) concentration in *Zygophyllum fabago* elongating leaves in the absence (control) or in the presence of 10 µM Cd for 2 categories of individuals: Cd-treated plants exhibiting a low or high resistance are designated as (-) or (+), respectively, and control plants exhibiting a low or high growth rate are designated as control (-) or control (+), respectively, in order to assess if plant resistance could be linked or not to a constitutive difference in growth.

A strong heterogeneity in Cd accumulation and tolerance was observed between individuals. A comparison performed between the most promising individuals and the most sensitive ones helped us to determine the main physiological differences and allowed to understand a part of the underlying mechanisms involved in the resistance of this species to Cd toxicity, as shown by **Fig. 2** and **3**.

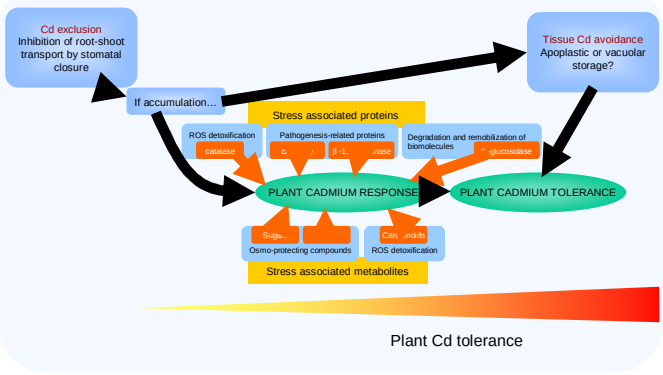


Fig. 3. Identified mechanisms involved in *Zygophyllum fabago* resistance to cadmium .

Lefèvre I., Correal C., Lutts S., 2005. Cadmium tolerance and accumulation in the noxious weed *Zygophyllum fabago*. *Journal of Environmental Quality*, 33: 1271-1279.

Lefèvre I., Correal C., Faz-Cano Á., Zanuzzi A., Lutts S., 2008. Structural development, water status, pigments concentration and oxidative stress of *Zygophyllum fabago* seedlings in relation to cadmium distribution in the shoot organ. *International Journal of Plant Sciences*, In Press.

Acknowledgements
This work was supported by the Fonds National de la Recherche Scientifique (FNRS-Belgium, convention n° 2.4565.02).

[1] Centre de Recherche Public - Gabriel Lippmann
Department Environment and Agrobiotechnologies

[2] Université catholique de Louvain
Groupe de Recherche en Physiologie végétale

[3] Laboratoire d'Océanologie
Université de Liège

Centre de Recherche Public Gabriel Lippmann

UCL Université catholique de Louvain