Metabolic profiling of *Chrysopogon zizanioides* (Vetiver) under lead stress

Venkataramana R. Pidatala* [1], Dibyendu Sarkar [2], Rupali Datta[1]

[1] Department of Biological Sciences, Michigan Technological University, Houghton, MI 49931, USA . [2] Department of Earth and Environmental Studies, Montclair State University, Montclair, NJ 07043, USA. E-mail: rupdatta@mtu.edu

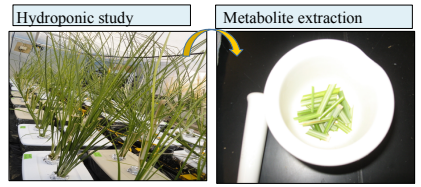
INTRODUCTION

- In the U.S., millions of homes built before 1978 have high levels of lead from lead-based paint deposited in the surrounding soil due to the paint deterioration.
- Children aged below six are more prone to lead toxicity.
- Phytoremediation is an economical and sustainable plant-based remediation technology.
- Vetiver is a hyperaccumulator of the lead. However, no information is available about molecular mechanisms of hyperaccumulation in vetiver.

METHODS

- Hydroponically grown plants were treated with lead as represented in the table.
- Metabolites were extracted with methanol: chloroform: water (2.5:1:1) as described in Roessner *et al.* (2006).
- Samples were analyzed using Agilent GC/MS 5973. Raw GC-MS data was deconvoluted by Automated Mass Spectral Deconvolution and Identification System (AMDIS) and metabolites were identified using The Golm metabolome data base Library (http://csbdb.mpimp-golm.mpg.de).
- Metabolic pathway analysis by Metaboanalyst 2.0(http://metaboanalyst.ca).

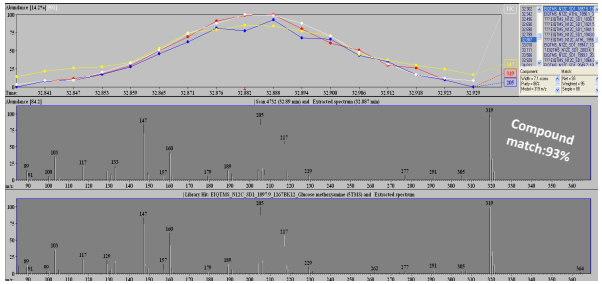
Treatment period	Lead Concentration			
	0 mg/L	400 mg/L	800 mg/L	1200 mg/L
0 days	3 plants	3 plants	3 plants	3 plants
10 days	3 plants	3 plants	3 plants	3 plants
20 days	3 plants	3 plants	3 plants	3 plants



Agilent GC/MS 5973

RESULTS

Sample chromatogram and spectrum of glucose methoxyamine



Software: MeV v.4.8

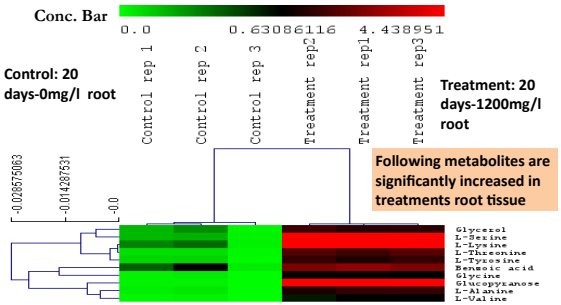
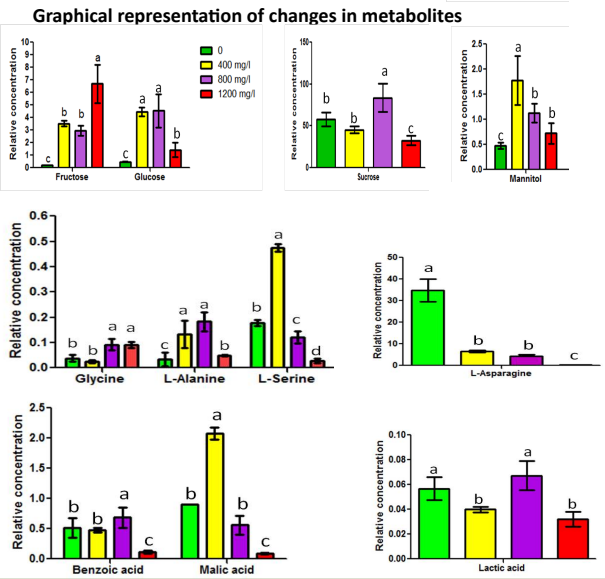


Fig 1: Hierarchical cluster analysis of relative concentrations of metabolites in vetiver root subjected to lead stress.

Graphical representation of changes in metabolites



Lead stress affected the following metabolic pathways in vetiver root:

- Alanine, aspartate and glutamate metabolism
- Aminoacyl-tRNA biosynthesis
- Photosynthesis
- Cyanoamino acid metabolism
- Galactose metabolism
- Glycine, serine and threonine metabolism
- Glycolysis or Gluconeogenesis,Pyruvate metabolism
- Starch and sucrose metabolism.

SIGNIFICANT OBSERVATIONS

- Soluble sugars enter the oxidative pentose phosphate pathway to curb the oxidative stress, as indicated by increased levels of glucose, fructose and sucrose. (1)
- Decreased levels of free L-Asparagine can be attributed to complex formation with lead (2). Similarly, large induction of malic acid at 400 mg/L lead followed by decline at 800 and 1200 mg/L lead treatments indicate possible complex formation.(3)
- Osmoprotectants such as glycerol, mannitol, sucrose and proline play an important role in plants under heavy metal stress.(1) While increased levels of sucrose, glycerol and mannitol was observed, proline levels did not show significant change.
- Increased glycine and serine concentrations was observed, which indicates possible induction of phytochelatin biosynthesis (4)

CONCLUSIONS

- Exposure to lead induces various metabolic changes in vetiver root and shoot tissue.
- Significant changes were observed in the levels of sugars, sugar alcohols, amino acids and organic acids.
- Comprehensive understanding of these biochemical changes will provide important clues to the mechanism of lead stress tolerance in vetiver grass.

REFERENCES

1.Ivan Coue´ et al., (2006) Involvement of soluble sugars in reactive oxygen species balance and responses to oxidative stress in plants, Journal of Experimental Botany, Vol. 57, No. 3:449–459

2.P.J. Lea et al., (2007) Asparagine in plants , Ann Appl Biol,150: 1–26.

3. Rengasamy Boominathan, Pauline M. Doran(2003) Organic acid complexation, heavy metal distribution and the effect of ATPase inhibition in hairy roots of hyperaccumulator plant species, Journal of Biotechnology,101: 131-146

4.Andra SS et al., (2008) Induction of lead binding Phtyochelatins in Vetiver Grass [*Vetiveria Zizanioides* (L.)].J.Environ.Qual.,38:868-877.

ACKNOWLEDGEMENTS

We would like to thank. U.S. Department of Housing and urban development for funding.