

## HEXAVALENT CHROMIUM DYNAMICS IN ACIDIC AND LIMED SOILS AND ITS EFFECT ON *ORIGANUM VULGARE*

Anna A. Zanni, V. Antoniadis, E. Levizou, S Petropoulos, E.E. Golia, and A. Dimirkou

University of Thessaly, Department of Agriculture Crop Production and Rural Environment, Volos, Greece

[vasilisrev@yahoo.com](mailto:vasilisrev@yahoo.com)

**Keywords:** Oregano; contamination; organic matter; remediation

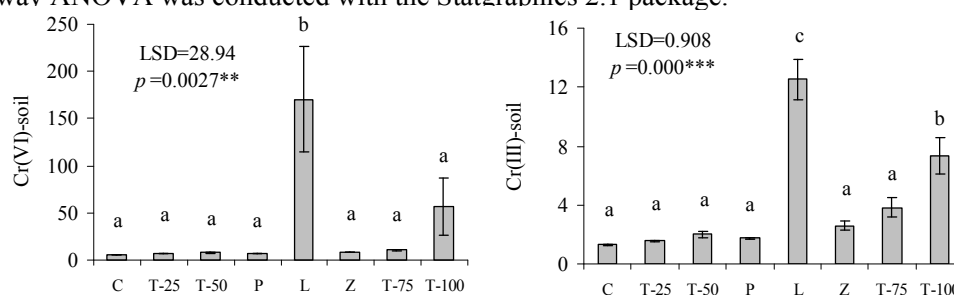
### Introduction

Hexavalent chromium (Cr(VI)), a well-known toxic element, is an anion species and thus its availability to plants increases with soil pH, meaning that if an acidic Cr(VI)-contaminated soil is limed, toxicity may be induced. Cr(VI) toxicity may be mitigated with: (a) Stabilization (e.g., by adding to soil a high-CEC sorptive material, such as zeolite), and (b) reduction to inert Cr(III) (e.g, by adding to soil organic matter). The aim of this work was (a) to evaluate Cr(VI) availability to oregano (*Origanum vulgare* L.) in acidic and limed soil and (b) to study the effect of added zeolite and organic matter in Cr(VI) dynamics in soil and plant. We chose oregano, because it is a known species with tolerance in harsh environmental conditions (e.g., relative lack of water and nutrients), and thus we suspected that it would exhibit tolerance to Cr(VI).

### Methods

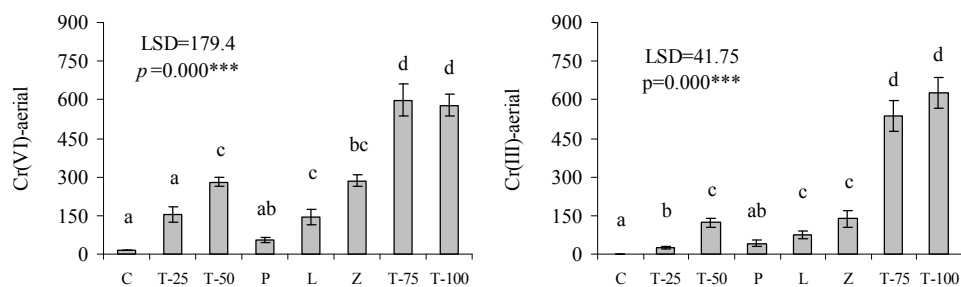
In an acidic soil (pH 4.6) we established 8 treatments: C: control (unamended soil), T-25: 25 mg Cr(VI) kg<sup>-1</sup>, T-50: 50 mg Cr(VI) kg<sup>-1</sup>, P: 1% peat + 50 mg Cr(VI) kg<sup>-1</sup>, L: 0.5% lime + 50 mg Cr(VI) kg<sup>-1</sup>, Z: 0.5% zeolite + 50 mg Cr(VI) kg<sup>-1</sup>, T-75: 75 mg Cr(VI) kg<sup>-1</sup>, and T-100: 100 mg Cr(VI) kg<sup>-1</sup>. Oregano seeds were sown in 1-L pots (8 treatments x 10 replicates=80 pots), and plants were harvested c. 50 days after sowing due to toxicity-caused reduction in plant vigor. In soil and plant (aerial parts and roots) we measured Cr(VI) and Cr(III). We also measured plant growth properties (dry weight of leaves—green and desiccated, and roots). One-way ANOVA was conducted with the Statgraphics 2.1 package.

### Results



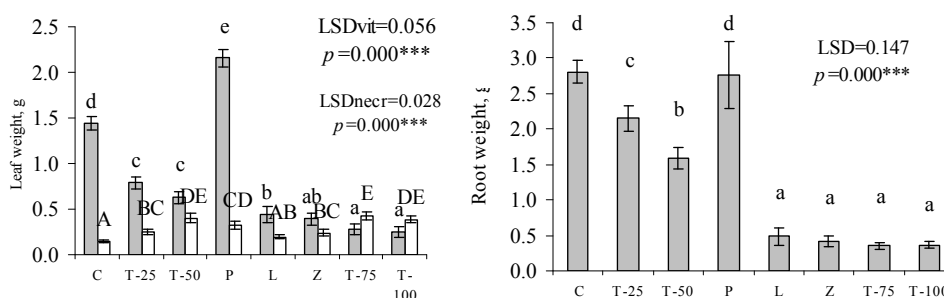
**Figure 1.** Cr(VI) and Cr(III) in soil.

Cr(VI) in soil increased considerably at L, even higher than at T-100 (Fig. 1). This occurred due to liming, which caused an increase in soil pH (data now shown), which in turn increased Cr(VI) solubility (Banks et al., 2005). Cr(III) in our study appears only due to Cr(VI) reduction (Villacis-Garcia et al., 2015), since we added no Cr(III). We found that at L Cr(III) levels were the highest and there was an increasing trend as Cr(VI) addition increased, but Cr(III) was significantly different from the control only at T-100.



**Figure 2.** Cr(VI) and Cr(III) in the aerial parts of oregano.

Added Cr(VI), as expected, increased plant Cr(VI) (Wang et al., 2012); the increase was significant up to T-75, but no further increase at T-100 was observed (Fig. 2). Similarly to soil, Cr(III) in plant increased with added Cr(VI), confirming the fact that it originated from the transformation of Cr(VI), which was then absorbed by plants. This is only confirmed by the fact that Cr(III) at C were zero.



**Figure 3.** Leaf (green and desiccated) and root dry weight.

Green leaf weight (Fig. 3) had a decreasing trend with increased added Cr(VI), while desiccated leaves (but still remaining attached to plant shoots) increased with Cr(VI) due to the induced toxicity (Gill et al. 2015). However, it is noteworthy that leaf weight at P was the highest, even significantly higher than the control. Similarly in root weight, although there was a decreasing trend with added Cr(VI), at P root had the same weight as in unamended control. This shows that probably organometallic complexes formed due to the added peat-borne organic matter immobilized Cr(VI) in the rootzone, causing thus the significant Cr(VI) decrease in plant (even to the levels of the control, Fig. 2). Also added organic matter increased plant vigor, and thus reduced Cr(VI) toxicity symptoms.

## Conclusion

Added Cr(VI) increased the levels of Cr(VI) and Cr(III) in soils and plants, especially in the lime-amended treatment. However, oregano grown in the peat-added soil had significantly less toxic effects, due to the protective role of added organic matter.

## References

- Banks, M.K., Schwap, A.P., Henderson, C. (2005). Leaching and reducing of chromium in soil as affected by soil organic content and plants. *Chemosphere*, 62, 255-264.
- Gill, R.A., Zang, L., Ali, B., Farooq, M.A., Cui, P., yang, S., Ali, S., Zhou, W. (2015). Chromium-induced physiochemical and ultrastructural changes in four cultivars of *Brassica napus* L. *Chemosphere*, 120, 154-164.
- Villacis-Garcia, M., Villalobos, M., Gutierrez-Ruiz, M. (2015). Optimizing the use of natural and synthetic magnetites with very small amounts of coarse Fe(0) particles for reduction of aqueous Cr(VI). *J. Hazard. Mater.*, 281, 77-86.
- Wang, A.Y., Huang, S.S., Zhong, G.F., Xu, G.B., Liu, Z.X., Shen, X.B. (2012). Effect of Cr(VI) stress on growth of three herbaceous plants and their Cr uptake. *Environ. Sci.*, 33, 2028-2037.