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Effects of soil lanthanum on growth and elemental composition of plants

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In recent years, lanthanum (La) has been found effective in increasing crop productivity. This results in its growing application in agriculture. However, it is controversial whether lanthanum has beneficial or negative impact on plants (Kabata-Pendias, 2011). In the present study we carried out a pot experiment to understand how soil La affects barley (Hordeum vulgare L., 'Mikhaylovsky' cv.) growth and elemental composition.
The pot experiment was conducted in a growbox under artificial light in sod-podzolic soil. The soil was sprayed with LaCl3 solutions to achieve the following concentrations of exogenous La: 0 (control), 10, 20, 50, 100, and 200 mg/kg. The plants were grown for 40 days in 2-litre pots, 6 plants in each pot, with 4 replications per group (24 pots total), and were irrigated with distilled water. Fresh aboveground biomass was weighed, chlorophylls α and β and carotenoids were measured in fresh leaves. Dry leaves, stems and soil were subject to atomic emission (ICP-AES) elemental analysis. Statistical computations involved simulated Kruskal-Wallis and Jonckheere-Terpstra tests as well as Gao modification of Campbell-Skillings test for nonparametric multiple comparisons. Multiple regression and correlation analyzes were also performed. All differences were considered significant at α=0.05.
Our results indicate that both leaves and stems of barley readily accumulate La. Leaves accumulate up to 1.2% of soil La concentration, and significantly more La than stems. Significant accumulation of La by stems and leaves was observed in pots with La soil concentrations higher than 50 and 20 mg/kg, respectively. Plant biomass uniformly increases up to 13.5 % compared to the control, and significant increase in plant biomass was observed at concentrations 100 and 200 mg/kg La. Chlorophyll α and β and carotenoid content decrease significantly at 100 mg/kg La compared to the control group by 27.5, 41.5, and 18.9 %, respectively. Correlation and multiple regression analyses suggest that increased concentration of La in leaves is significantly associated with decreased concentrations of P, K, Mg, Cu, and Fe in leaves and increased concentrations of Ca in leaves and Si in stems.
Increased Ca level in leaves suggests that imbalance of hormonal (auxin) regulation may be involved in the observed effects. However, we assume that a decrease in P content in plants most likely takes place due to P binding by La in soil. We conclude that the effects of La on plants are contradictory. On the one hand, La increases plant biomass and possibly improves plant resistance to pathogens due to increased Si accumulation in stems. On the other hand, La disrupts photosynthesis, reduces content of important elements, and accumulates in plants.

Reference

Kabata-Pendias, A. (2011). Trace elements in soils and plants: CRC press.