Root Uptake of Chromium and Nickel in Common Plants and Vegetables

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ABSTRACT

The presence of cadmium, selenium, nickel, chromium, and arsenic in Asian and Canadian soil samples recently drew the attention of federal food and drug administration agencies as well as the World Health Organization due to the toxicity these elements produce. Excessive exposure to nickel is associated with severe stomach aches, increased red blood cells, and increased proteins present in urine. Exposure to chromium is linked to decreased hemoglobin content, decreased hematocrit content, and increased total white blood cell counts in humans. These elements contaminate and harm plant life--therefore decreasing sustainability in local ecosystems.

Through Lemont High School's Exemplary Student Research Program (2018-2019), students will work closely with Dr. Olga Antipova (Argonne National Laboratory) to examine the relationship between the contamination of these plants with heavy metals and their root uptake with a focus on nickel and chromium. Our student group will participate in testing, observation, and analysis of plant uptake of nickel to determine the long-term impacts of element toxicity and its relation to plant vitality. It's essential to understand the allowance of these elements in ground-rooted plants to produce a high confidence level to regulate these elements in consumer products.

MOTIVATION

In recent years, there has been a dangerous level of toxic elements present in Asian and European crops, in turn affecting the safe quantity that can be consumed.

METHODS

Arabidopsis, Carrot, Lettuce, Oregano and Tomato seeds were planted in agarose gels. After one week, the plants were harvested, mounted for XRF scanning, and evaluated using the Leica microscope located at Beamline 2-ID-E. After the initial scan to find baseline elements, the roots of the plants were soaked in a Nickel solution for 1 hour. After the hour, the roots were scanned to see any difference in elemental makeup of the root systems. Using X-Ray fluorescence microscopy with optimum flux and spatial resolution, the elemental analysis for each plant were compared to the others to determine plant uptake of the elements. Then this process is repeated multiple times over different time variances.

CONCLUSIONS

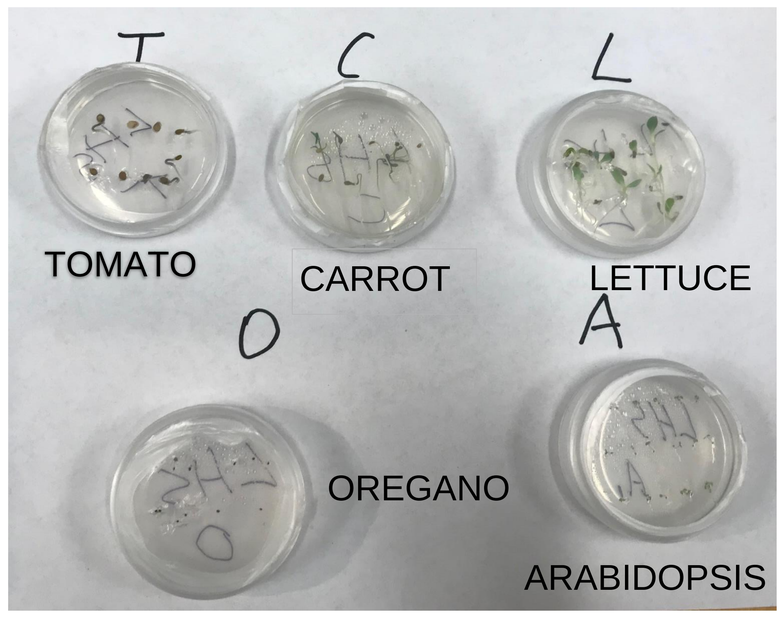
After calculations and comparisons of the ratio of Nickel to potassium, it can be seen that the Lettuce has the largest root length, as well as the second largest root surface area to the proportion Nickel to Potassium. Oregano had the smallest root length, second smallest root surface area, and the smallest proportion of Nickel to Potassium. The Arabidopsis seed has the second smallest root length, yet the third smallest surface area. Its surface area is greater of that than both carrot and oregano. Arabidopsis was also found to be thicker than carrot because of its larger surface area, despite carrot having a longer root. Tomato has the highest nickel to potassium proportion compared to the other samples; however, tomato has the third highest nickel to phosphorus proportion compared to the other samples. Overall, tomato had a high level of uptake of nickel when compared to the other samples in this set

Plant	Nickel/Potassium Proportion
Oregano	0.01787760691
Arabidopsis	0.02795349288
Carrot	0.04759828249
Lettuce	0.06683269884
Tomato	0.07545155163

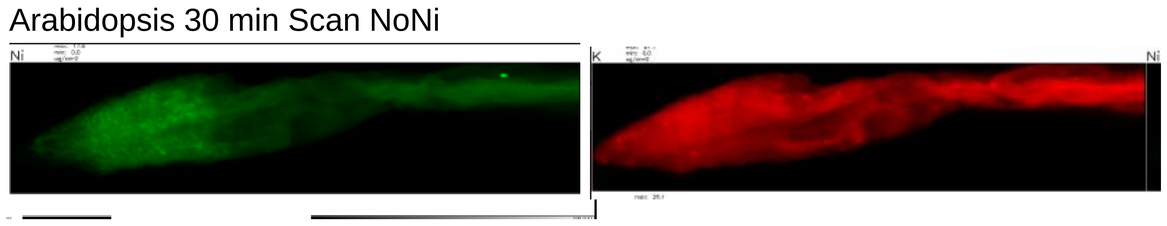
ROOT PICTURES

Root length ranking from smallest to largest:
1.Oregano,
2. Arabidopsis
3. Tomato
4. Carrot
5. Lettuce

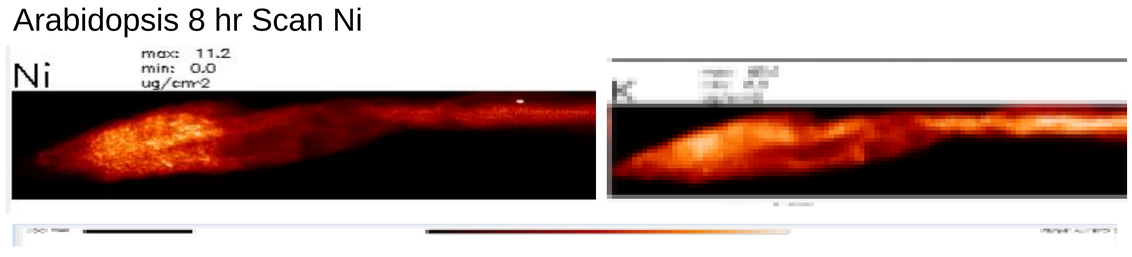
Root surface area ranking from smallest to largest:
1. Carrot
2. Oregano
3. Arabidopsis
4. Lettuce
5. Tomato



Arabidopsis 30 min Scan NoNi



Arabidopsis 8 hr Scan Ni



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