Impact of Zinc on *Dicentra eximia*

Measuring the effects of zinc on *Dicentra eximia* plants growing in a controlled environment with varying treatments of zinc in the soil.

**Introduction & Objective**

Phytotoxicity is a toxic effect of a compound on plant growth when the uptake of that compound increases past the plants “normal” threshold (Chaney, 1993). In some plants, this threshold can lie between 300 – 1000 mg/kg, and in diagnostic leaves the typical levels are 500 mg/kg (Chaney, 1993). Some plants can tolerate high levels of zinc in the soils, however, they can do this by rapidly transporting zinc to the shoots, or excluding zinc by the roots (Chaney, 1993).

*Dicentra eximia*, or fern leaf bleeding heart, is a species that is rare to find growing in large patches in PA, which is what is seen behind Penn State Beaver Campus. The objective of this research is to determine the tolerance of *Dicentra* in varying zinc levels. In Pennsylvania, two large zinc smelting sites: the Pulmerton Zinc Pile Site and the Monaca Zinc Smelter, are locations where *Dicentra* are commonly found.

These sites contribute to environmental contamination of heavy metals in the soil and were among the highest contributors to zinc emissions in PA (Bleiwas, 2010). The map indicates nearby areas where *Dicentra* are found (in green).

**Materials and Methods**

To determine the effects of zinc on *Dicentra*, 30 plants were collected from the Penn State Beaver campus on October 10, 2018 and weighed before planting into individual pots. The plants were set up in two blocks in the Penn State Beaver Greenhouse with 1.25 kg of soil (premixed with garden soil and sand). The plants were treated with varying levels of zinc (derived from ZnSO₄) including 0, 500, and 1000 mg of zinc/kg of soil. They were then allowed to grow until March 26, 2019. After five months, the Licor 6800 was used to measure photosynthetic data and the leaves of the 0 and 1000 mg Zn/kg soil treatments were sectioned and stained for enzymes that participate in zinc stress responses.

**Data**

- **Figure 1.** Graph of mean pigment levels in a sample fresh tissue leaf. The y-axis shows the mean in µg/gram of fresh weight and the x-axis shows the treatment level of zinc.
- **Figure 2.** Graph of photosynthetic rate in 0, 500, and 1000 mg Zn/kg soil treated plants. The x-axis shows light intensity (PPFD) and the y-axis shows photosynthetic rate (A). These measurements were taken and graphed by Dr. Sarah Nilson.
- **Figure 3.** Transverse section (10x magnification) of *Dicentra eximia* leaf that was treated with 1000 mg of Zn/kg of soil, stained with Dithizone in acetone.
- **Figure 4.** Transverse section (10x magnification) of *Dicentra eximia* leaf that was treated with 0 mg of Zn/kg of soil, stained with Dithizone in acetone.
- **Figure 5.** Experimental plants after growing for six months. From left to right 0, 500, and 1000 mg Zn/kg soil treatments.

**Literature Cited**


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**Results**

- After growing for six months, all the plants grew well under every zinc treatment condition. There was no significant number of plant death under any specific treatment, nor was their any consistent visible symptoms for any specific treatment.
- After using a spectrophotometer to measure the different pigment levels in a cleared leaf sample, the means for each treatment were calculated and graphed and statistically analyzed. No significant difference was found between the pigment levels in each treatment.
- After using the Licor 6800 to measure the photosynthetic rate on mine leaves on each plant, the light curve produced as a result of the averages of the photosynthetic rate of each treatment shows a decreased photosynthetic rate in the 500 and 1000 mg Zn/kg soil treatments, when compared to the 0 mg Zn/kg soil treatments. This may indicate some level of stress caused by the zinc.
- After staining leaves from various plants on both blocks from both old and young leaves, we received a positive result (brown coloration after staining) for zinc in the leaf tissue in the 1000 mg Zn/kg soil treatments.
- After staining leaves from various plants on both blocks from both old and young leaves, we received a negative result (absence of brown coloration after using stain) for zinc in the leaf tissue in the 0 mg Zn/kg soil treatments. However, the 1000 mg Zn/kg treated plants showed color, indicating that zinc was present. The measurement of zinc content is pending.

**Conclusions**

The presence of zinc in the plants treated with high levels of zinc was confirmed via brown staining within the transverse sections. The zinc in the soil was taken up in the plant and stored in the leaf tissue. The cell type of the zinc storage was undetermined. The insignificant differences in pigment levels indicate that the plants are not showing signs of stress responses that we would expect with zinc toxicity. The inclusion of heavy metal zinc in the soil can lead to side effects on *Dicentra eximia* plants such as reduced photosynthetic rate in the leaves. Further analysis is being performed on the shoot tissue to quantify the level of zinc in the leaves and also to measure the activity of different enzymes that participate in zinc stress responses.