

Introduction (Hypothesis)

I wanted to study the effects of zinc, cadmium and lead concentrations on tomato plants. My hypothesis was that the higher the concentration of each metal in the soil in which plants grew, the smaller would be the growth of the plant. Researchers have used stem growth, leaf area, dry weight of plants and visual observation to determine the affects of metal concentrations on plants. I also wanted to determine if nutrients in plant food were blocked from entering the plant by concentrations of cadmium and lead added to the soil in which the plants grew. More specifically, I wanted to know if the uptake of zinc concentrations by the plants contributed by Miracle Gro was affected by concentrations of cadmium and lead. I also wanted to determine if zinc concentrations incorporated in the plants was proportional to the zinc concentrations present in the soils in which the plants were grown.

Procedure

Twenty-four seedling tomato plants were purchased and each replanted in potting soil in 250 milliliter clear plastic containers with a small hole drilled in the bottom. All plants were watered and Miracle Grow added in equal amounts. All plants were grown in the Missouri State Greenhouse. After one week, the length of a particular stem was measured on each plant. The stem was that growing from the second node on the main stem of the plant located above the

cotyledon stem and leaf. The measurement was taken from the junction of main stem to the first leaf and recorded. Six plants represented the control for this project and were numbered, C1-C6. The remaining eighteen plants represented the test group to which the soil in which they grew were laced with metal concentrations of zinc, cadmium and lead. To the soils of each set of six test plants, the concentrations of only one metal was added. Test plants are labeled with the symbol of the chemical element followed by a number 1 to 6. Plant numbers 1 and 2 are those whose soils were adjusted to 500 ppm metal, 3 and 4 to 300 ppm metal, and 5 and 6 to 100 ppm metal.

After 2 weeks the measured stems on the plants grown in cadmium and lead concentrations became brittle and one stem representing a plant grown in 500 ppm lead (Pb2) fell off and broke in pieces. All remaining pre-measured stems were immediately measured to determine the growth of all control and test plants. These values were recorded. The length of the aforementioned stem from the plant labeled Pb2 could not be measured and was recorded as 0.

One month after the additions of metals to the soils representing the test plants, all control plants and test plants were photographed and cut 2.54 centimeters above the soil surface. This was done to prepare samples for dry weight determinations. It should be mentioned at this time that all control and test samples were maintained equally. The same amounts of water, Miracle Gro and fungicide were added to all plants and at the same time. Also, the plants were moved around to assure the same amount of sunlight and other conditions during their growth. Also, care was taken so water, Miracle Gro and fungicide added to all control and test plants, and metals added to the test plant soils were not lost through the drilled hole at the bottom of the plastic plant container. Each control and test plant was placed on a pre-weighed piece of

aluminum foil (recorded) and placed in an oven for 24 hours at a temperature of 80 degrees C. Each plant and piece of foil were weighed on an analytical balance. This value for each sample was recorded and subtracted from the weight of the piece of foil to obtain the dry weight of the plant.

Leaves from the dry-weighted plants were collected for ashing. The leaves from one plant representing each metal concentration from the test groups and three control plant samples were collected. The leaves were added to special porcelain ashing crucible and placed in an ashing furnace at 700 degrees C for 2 hours. Samples were cooled and weighed on an analytical balance and the weight recorded. Each ashed sample was transferred to a centrifuge tube. Ten milliliters of 3N HNO₃ was added to each tube and placed in a shaker bath for 12 hours at 80 degrees C. Each sample was centrifuged and the aqueous portion saved in an analysis bottle for determination of zinc concentrations using the atomic absorption instrument. The concentrations of zinc were determined in each of the plants with the aid of Atomic Absorption Analysis to show if samples whose soils were laced with cadmium and lead concentrations affected the incorporation of concentrations of zinc by the plants.

Results

The results of the growth length of the plant stems, dry weight of samples, and zinc concentrations in the ashed plant leaves are shown in the [PROJECT DATA TABLE](#) . Graphic plots of the above data were made. The results of the stem growth are shown in [Graph 1](#). The sum of the growth length for the stems in each of the six control plants (48mm) is similar to that

for the six plants grown in zinc concentrations (49mm). These values are greater than the same for plants grown in cadmium (26mm) and lead concentrations (8mm). These results seem to indicate that the zinc concentrations did not affect the growth of the plants. However, the concentrations of cadmium and lead appeared to affect the growth of the plants. Lead concentrations appeared to have the most toxic effect on the plants. The plants grown in cadmium concentrations are the only test group whose stems show a clear relationship of stem growth to concentration of metal in the soil. The stem lengths increase with decreasing concentration of metal in the soil.

The results of the dry weight are shown in [Graph 2](#) . There appears to be a similar total dry weight (sum) for the plants grown in the soils with zinc concentrations (11.56 grams) with that for the control (9.03 grams). A slightly higher dry weight number for the latter may show the plants grow slightly better in high zinc concentrations. This is consistent with the results from the stem lengths. Smaller dry weight numbers for the plants grown in cadmium (6.22 grams) and lead (6.76 grams) concentrations compared with that for the control indicates plants did not grow as well in these metal concentrations. The similar dry weight numbers for plants grown in cadmium and lead concentrations appear to show that plants grown in these metal concentrations grow at a similar rate. There appears to be a correlation between the growth length of stems and dry weight of samples in the control group. This correlation is not present in the plants of any of the test groups with that of the control plants.

As mentioned before, visual observation of the control and test plants was made on the same day that the plants were cut for dry weight activities. Color photos of the plants taken on that day are shown on pages 9 and 10. The six control plants plants whose soils were laced with metal

concentrations of zinc look healthy and similar in size. The similarity of growth magnitude of these 2 groups of plants is also apparent with stem growths and dry weights. Visual observation indicates cadmium and lead concentrations are toxic to the plants. Zinc concentrations do not show any toxicity to the plants. The information from the stem growth and dry weight data also indicates the same. Visual observation seems to indicate a correlation between toxic effects in the plant and the concentration of cadmium. The plants look progressively more healthy with decreasing concentrations of cadmium. This progressive magnitude of toxic affect is also indicated in the stem growth data for cadmium. Visual observation also indicates plants grown in soils laced with all lead metal concentrations are equally toxic to the plants.

Results of the zinc concentrations in the ashed leaves of the plants are shown in [Graph 3](#). The mean concentration of zinc in the ashed leaves of the control samples (325 ppm) is similar to that for plants grown in cadmium (268 ppm) and lead (329 ppm) concentrations. This appears to indicate the concentration of cadmium and lead in the soils did not inhibit the incorporation by the plant of zinc concentrations contributed by Miracle Gro. The concentrations of zinc in the ashed leaves of each of the control plants and each of the three plants from the test groups appears to be strongly correlated with the stem growth lengths for the same plants. This correlation is not present when comparing zinc concentrations of the ashed leaves with that of the dry weights for the same samples.

Summary and Conclusions

Elevated cadmium and lead concentrations added to the soils appeared to be toxic to the plants. This is evident from the smaller growth of the stems, smaller dry weights and visible observation of the plants. Elevated concentrations of zinc added to the soils showed a lack of toxicity to the plants and may have slightly increased plant growth. This is indicated when comparing both the dry weights and growth length of the control plants with that of the zinc test group.

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