Is Aluminum Killing the Plants in Your Backyard?

A study of aluminum in Roland Park Country School's backwoods by: Daneey Makia, Lindsay Wilson, and Lily MacKenty

Abstract:

Aluminum in the soil affects the life of plants greatly. Where some plants are tolerant of the high levels of aluminum, others perish, or become ill, and aluminum usually affects plants by damaging their roots. We hypothesized that the reason why the aluminum levels in soil were significantly higher in one location on the Roland Park Country School campus than another was because the plants in one site did not absorb as much aluminum as the ones in the other, consequently keeping more aluminum in the soil then in the plants and allowing the plants to thrive. Our results showed that the Paw Paw plants and soil followed the same pattern as the Jewelweed, showing that when the aluminum levels in the soil were high the levels in the plant were too so our hypothesis was not correct. However, the English Ivy levels illustrated that when the aluminum level in the soil was high, the aluminum level in the plant was low. Therefore, if we could research this subject further we would probably focus more on the English Ivy and hypothesize about the different quantities of ivy in the two different sites in the Roland Park Country School backwoods.

Introduction:

Aluminum is one of the many factors that play a key role in the health of plants, and the impact of aluminum varies according to a given species of plants aluminum tolerance level. Although all plants can tolerate some amount of aluminum, some plants thrive when aluminum levels are high. For example, sugarcane can tolerate high levels of aluminum known to make soil uninhabitable for many plants. Most other plants, though become ill or die (Yost, 2000), and for those plants susceptible to it, high aluminum levels affect plant roots in a variety of different ways, the most harmful being plant root growth. The aluminum builds up in the tips of the plant's roots and places responsible for the growth of the roots, harming the formation of new plasma membranes (International Rice Research Institute, 2003). Therefore if plant roots cannot grow, it hinders plants from obtaining nutrients needed for healthy development.

When researching Site One (N 39.35794; W 76.63977), Site Three (N 39.35797; W 076.63836), and Site Four (N 39.35733; W 076.63840) of Roland Park Country School's Backwoods during the 2006 Environmental Science Summer Research Experience (Environmental Science Summer Research Experience, 2001), an anomaly was found between the three sites' aluminum levels and plant life. The largest anomaly was that between Site One and Site Four. Where soil from Site One averaged 121 ppm of aluminum, soil from Site Four only averaged 65 ppm (Environmental Science Summer Research Experience, 2006). These aluminum levels alone should prevent the growth of most plants, but an even greater anomaly was seen between actual aluminum levels and the density of plant populations in the two sites. The higher aluminum levels in Site One do not reflect the quantity of plants there. Site One with the higher aluminum level actually has a much larger population of plants than Site Four, when theoretically its lower aluminum levels should make it more inhabitable for plants.

A possible reason for this anomaly could be the fact that some plants are resistant to aluminum. Plants such as buckwheat have to ability to release chemicals that prevent them from taking in aluminum (American Society of Plant Physiologists, 1998), and this led us to hypothesize that the reason for why the aluminum levels in Site one's soil were so much higher could be that the plants in site one are able to protect themselves from absorbing as much aluminum as the plants in Site four. Therefore we decided to test the aluminum levels in the plants and their soils in the two sites to see if the appropriate inverse relationship exists.

Methods and Materials:

40 Samples of soil and plant material were collected from Site 1(N 39.35794; W 076.63977) and Site 4(N 39.35733; W 076.63840) on the Roland Park Country School campus from July 18-21, 2006. At each site, we took five 15 cm long, 2 cm diameter column samples of soil where English Ivy was located using the soil core. We simultaneously took 6 leaves of English Ivy along with the stems from where the soil was extracted. From Site 1, we collected five 15 cm long, 2 cm wide column samples of soil where a Paw Paw plant was located as well as 6 Paw Paw leaves from the plant. From Site 4, we collected five 15 cm long, 2 cm wide column samples of soil where a Jewelweed plant was located as well as 6 Jewelweed leaves from the plant. On all samples of soil, we performed the LaMotte STH-14 aluminum test to determine the levels of aluminum (ppm). Simultaneously, we performed Green Plant Tissue extractions on all

of the samples of leaves and then performed the aluminum test on these extracts, to determine the aluminum levels (ppm) in the plants.

Results:

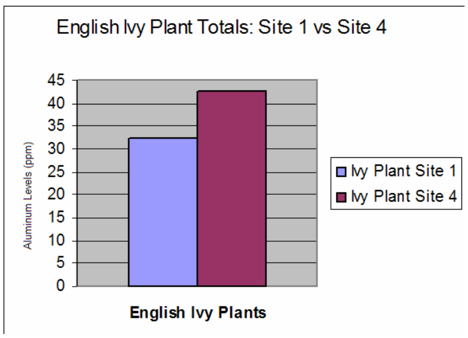

Figure One

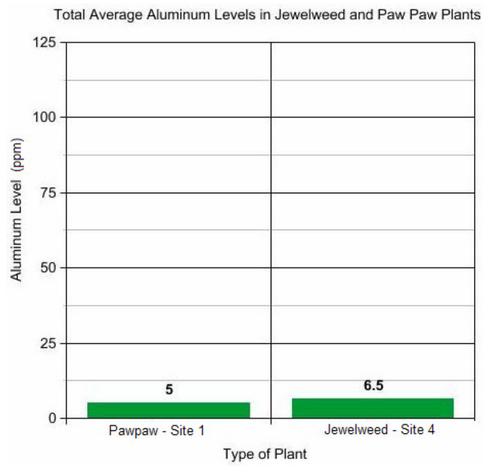

Figure Two

As can be seen in Figure One, it is clear that the amount of aluminum found in the English Ivy is more in Site 4, with 10 ppm of additional aluminum being found in plants from this location. A same relationship can also be seen between the Jewelweed and Paw Paw, with an additional 1.5 ppm of aluminum.

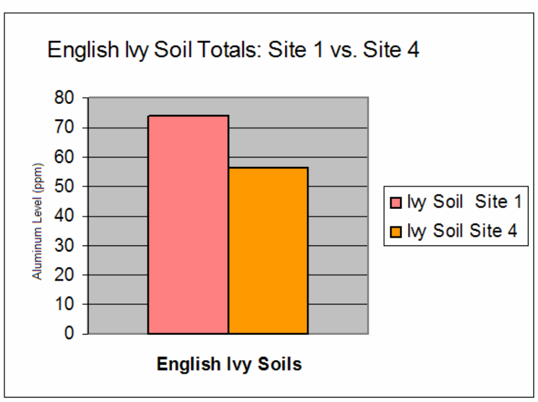

Figure Three

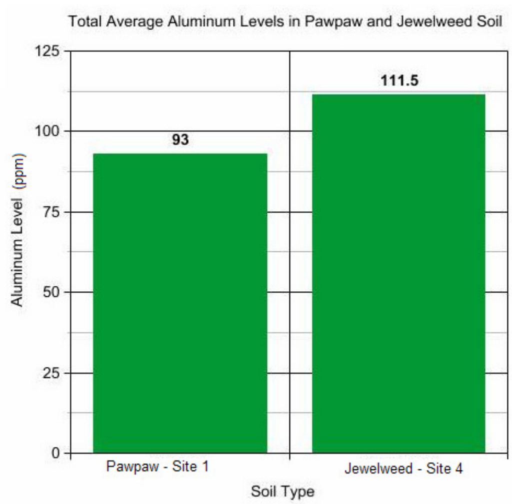

Figure Four

However, the same cannot be said of the amount of aluminum found in the soils. In Figure Three, it can be seen that the amount of aluminum found in Site 1 is 17.8 ppm more if the soil has English Ivy on it and 18.5 ppm less if Paw Paw is growing on it.

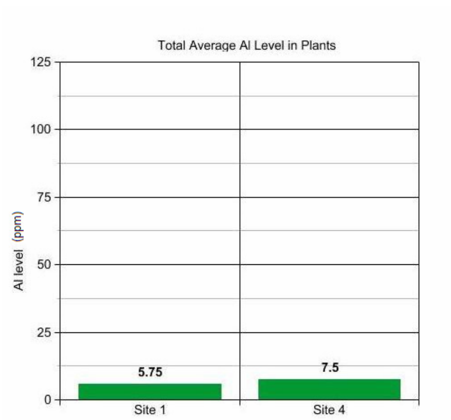

Figure Five

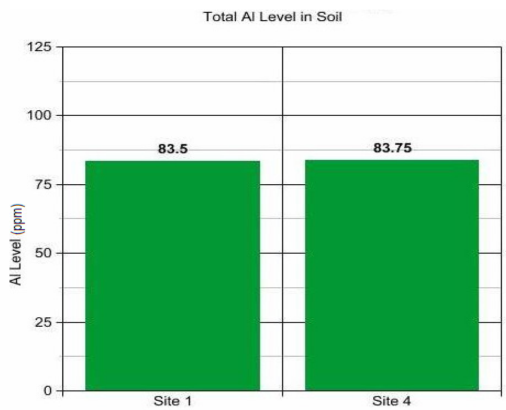

Figure Six

When looked at overall, there was no significant difference in aluminum levels in either the plants or the soil as can be seen in Figures Five and Six. In figure Five, there is only an average difference of 1.75 ppm of aluminum found in Plants in Sites 1 and 4. While as Figure Six clearly shows, there is only an average difference of 0.70 ppm between the amount of aluminum found in the soils of Average in Soil between Sites 1 and 4.

Discussion:

From our results, the pattern of our data shows that our hypothesis was not correct. We had hypothesized that the amount of aluminum in the Paw Paw plants and the jewelweed would have an inverse relationship with the amount of aluminum in the soils in which they grew because of potential differences in aluminum absorption rates between the two species. But in fact, as figure two and figure four show, both the Jewelweed plants and the soil in which they grew had higher amounts of aluminum than the Paw Paw plants and their soil by 1.5 ppm in plants and 18.5 ppm for soil.

Surprisingly the graph for our control plant, English Ivy, showed that when the aluminum level in the plants were low the aluminum level in the soil was high and when the aluminum level in the plants was high the aluminum level in the soil was low. This pattern was similar to what we had hypothesized. The only problem was that the p-values from t-tests on the data between the English Ivy plants from the two locations and the soil from the two locations were above 0.20. The p-value for aluminum in the English Ivy plant was 0.55 and the p-value for soil was 0.58. Because their p-values were both greater then 0.2, we decided to take additional samples of English Ivy and their soil to test for aluminum to see if the trend in figure 2 and 4 continued. However after further research, it was determined that the English Ivy did not follow the same pattern because the p-values for soil went down to 0.3, but the p-values for plants went up to 0.7, showing even more statistical irregularity.

Based on our findings with the English Ivy, though, we would hypothesize about the quantity of English Ivy in the two places where we gathered data. We would do this because in one of the sites where we gathered data, English Ivy covered the ground completely while in the other site that we picked the English ivy was scarce and had to be searched for. We think that this could have influenced our data because perhaps the different densities in English Ivy between the two sites might affect the amount of Aluminum in our findings, and we would like to explore this possible correlation next.

Acknowledgments:

We would like to thank Fuji Films, Sea World and Busch Gardens for funding us and allowing us to perform this experiment as well as giving us the opportunity to learn

more about the Roland Park Country School's backwoods. We would also like to thank Mr. Brock for always helping us think of new ideas, giving us this opportunity, and taking us back into the backwoods. Sophia Uddin and Rebecca McWilliams are two people who we could never have finished this project without. They were always there to help direct us into the right direction and always listened to our crazy stories and questions. Last, but not least we would like to thank everyone at Roland Park Country School, who let us use their land and their materials. Thank you all so very much. You have no idea how much you've helped us during this three week period. None of this would have been possible without you!

Bibliography:

1. American Society of Plant Physiologists (1998) High Aluminum Resistance in Buckwheat. Available On-Line. http://www.plantphysiol.org/cgi/content/abstract/117/3/745

2. Environmental Science Summer Research Experience (2001) "General Description of the E.S.S.R.E. Survey Sites" Available On-Line. http://faculty.rpcs.org/brockda/ESSRE%20Locations.htm

3. Environmental Science Summer Research Experience (2006) "E.S.S.R.E. Microclimate Databases" Available On-Line. https://faculty.rpcs.org/brockda/ESSRE%20Microclimate%20Survey.htm

4. International Rice Research Institute. (2003) Aluminum Toxicity. Available On-Line. http://www.knowledgebank.irri.org/ricedoctor_mx/default.htm

5. Yost, R. (2000) Plant Tolerance of Low Soil pH, Soil Aluminum, and Soil Manganese. Available On-Line. http://www.ctahr.hawaii.edu/oc/freepubs/pdf/pnm11.pdf