The Relationship Between Potassium, Calcium, and Runoff in the Soil

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Abstract

Calcium and Potassium are two elements that play specific roles in soil to improve plant health. Calcium helps with cell division, cell wall development, enzyme activity and metabolism; while potassium plays a more vital role in soil and is essential for plant growth, disease resistance, and basic plant functions. It is known that calcium and potassium levels in the soil are usually inverse to one another. However, the 2017 E.S.S.R.E. biota survey showed that there was effectively no potassium present in any of the soils in the microclimates; while there was both calcium present in the soil and statistically significant differences in the levels found in the different microclimates. We believe that this disparity between the calcium and potassium amounts found was because the slope of the hill that runs parallel to the microclimates and the plant life on this slope were affecting the amounts of potassium and calcium found there differently. We hypothesized that the calcium and potassium amounts were not following their usual inverse relationship because when runoff flushes the potassium and calcium downhill, the calcium settles into the soil but the beech trees absorb the potassium. To test our idea, we took soil and plant samples going up a hill and tested for potassium in the plants and calcium in the soil. Our hypothesis was proven correct in terms of calcium. However, our hypothesis was proven incorrect for the potassium. For further research, we would examine the relationship between the amount of small trees and other plants in the undergrowth and the levels of potassium because the microclimate we tested has a variety of undergrowth in certain locations and that could have affected our results.

Introduction

Potassium is a mineral that is essential for vigorous plant growth, disease resistance, and general plant function (Veggie, 2009). It makes plants become more resistant to stresses such as extreme temperatures, droughts, and pests by providing the means for regulating water consumption (E.S.S.R.E, 2003) and for flower producing plants, it is also very important for fruit and vegetable development (Understanding, 2009). Potassium is generally most available in warm, moist conditions in soils that are well aerated with a neutral or slightly acidic pH (Noble 2004). However, when these conditions are not present, it can be highly problematic for the plants living there. For example, if there are low levels of potassium, the leaves of the plants will be comprised of older leaves with brown spots and yellow edges as well as yellow and brown veins, displaying their unhealthy state (Rhoades, n.d.).

The element calcium, although not as important as potassium for day to day plant health, does have special roles necessary for survival such as helping with cell division, cell wall development, enzyme activity and metabolism (Spectrum, 2016). Hence, the availability of calcium in the soil is also essential for plants. However high levels of other cations such as magnesium, ammonium, iron, aluminum and especially potassium, will reduce the calcium uptake in some crops (TETRA, 2005), and “water stress” or drought conditions can also cause low soil calcium levels (SMART, 2017).

Because potassium and calcium have an inverse relationship in soils, when potassium is at low levels in the soil, calcium can be expected to be at high level (Gardening, 2016). Therefore, when the 2017 E.S.S.R.E Biota Survey (E.S.S.R.E, 2017) revealed that the potassium levels across all four microclimates was 0 and yet the calcium levels were showing statistically significant fluctuations from 516ppm in E.S.S.R.E. Microclimate 1 (N 39.35794; W 076.63977) to 109ppm in Microclimate 3 (N 39.35797; W 076.63836), we were puzzled. Furthermore, the plants in all of the sites had no signs of potassium deficiency; hence, no relationships between potassium, calcium, and plant health were evident.

A possible explanation for this anomaly is the slope of the hills adjacent to the four of the usual microclimates that affects the rate of runoff and erosion following rain events. Each of the microclimates is on a steep incline, and therefore, we believe that when it rains, the available potassium and calcium found in the soil at the top of the hill is being leached and deposited in the microclimates. But due to the mild drought conditions in July 2017, perhaps the potassium is being absorbed by the plant life in these microclimates at a higher rate. To test our hypothesis, our group conducted an experiment to test the levels of calcium in the soil and potassium in the plants at five different locations on the slope of the Microclimate 1 hill.

Methods

In the E.S.S.R.E. Microclimate 1 (39.35789 northwest to 39.35817 northeast to 39.35805 southeast to 39.35815 southwest), 5 soil core samples (15 cm with a 2 cm diameter) were collected from the hillside located there. Each sample was separated by 10 meters, and the sampling was done climbing up the slope of the hill out of Microclimate 1 in a straight line moving North. Simultaneously, leaves were collected from 5 beech trees at each of the soil sampling locations. Using LaMotte STH- 14 Soil Test Kit [SL1] each soil sample was tested for calcium (ppm), and each plant sample was tested for potassium (ppm). The collecting and chemical testing was repeated each morning for a total of 6 more days in July 2017 (7/19/17-7/27/17), with each soil core sample taken a half meter to the East from the previous plot than the day before; the plant samples were taken from the same Beech tree every day.

Results

Table 1:

Potassium T-Test

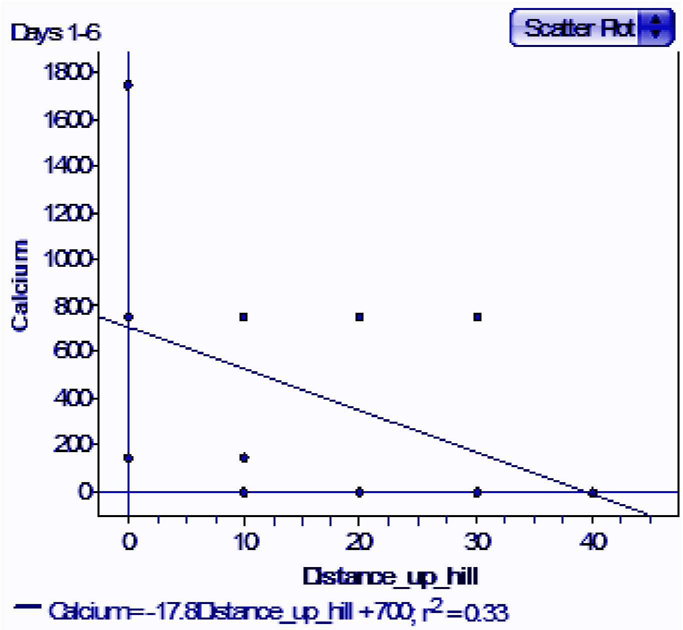
Distance compared to control	P-Value
0m-10m	.453
0m-20m	.873
0m-30m	.370
0m-40m	.501

Table 2:

Calcium T-Test

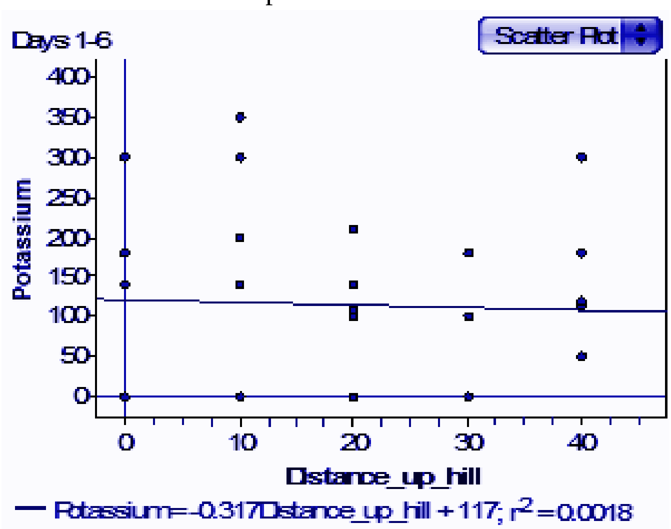
Distance compared to control	P-Value
0m-10m	.099
0m-20m	.016
0m-30m	.016
0m-40m	.003

Graph 1: Shows the Correlation between Location on Hillside and the Amount of Calcium (ppm) Found in the soils sampled there.



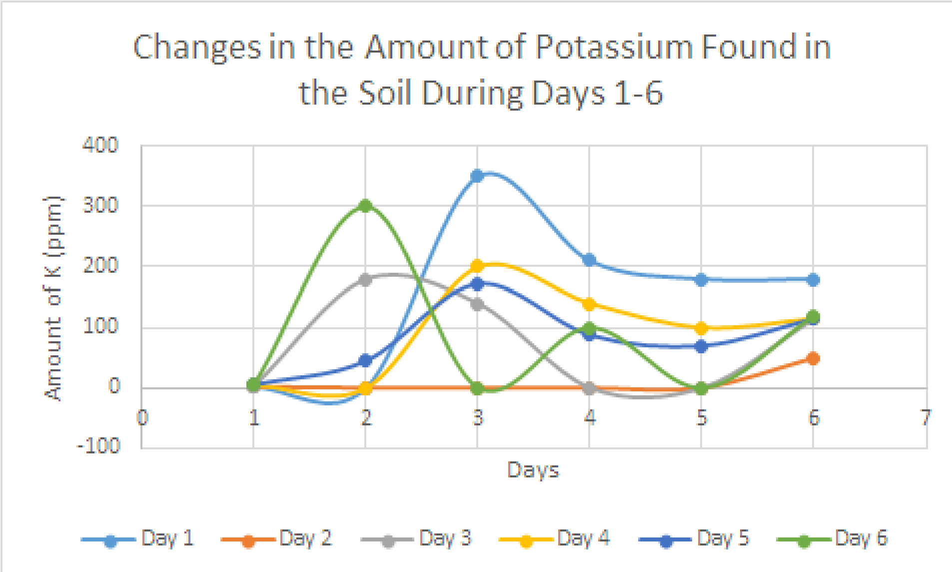
Days 1-6: R^2 value= 0.33

Graph 2: Shows the Correlation between Location on Hillside and the Amount of Potassium (ppm) Found in the soils sampled there.

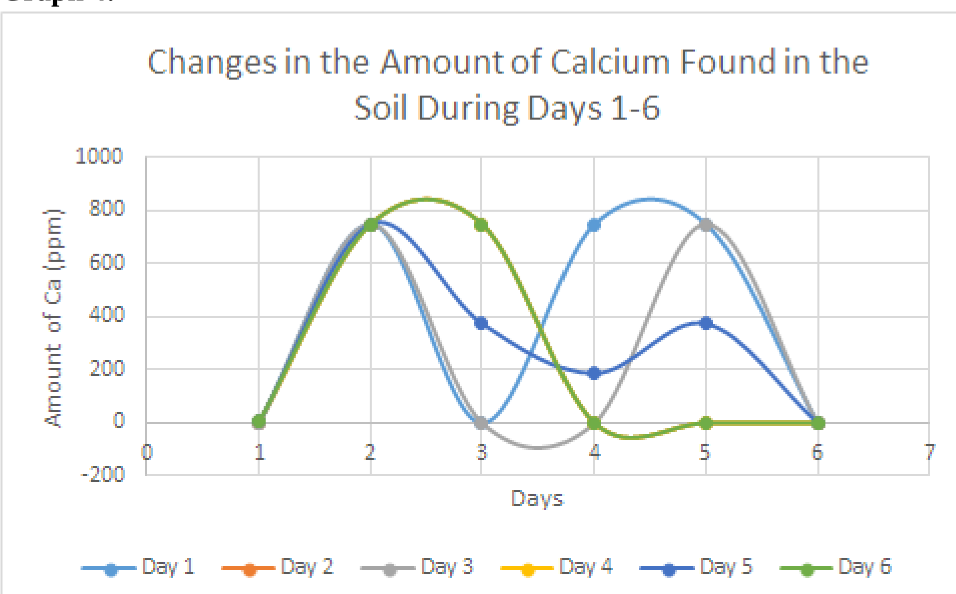


Days 1-6: R^2 value= 0.0018

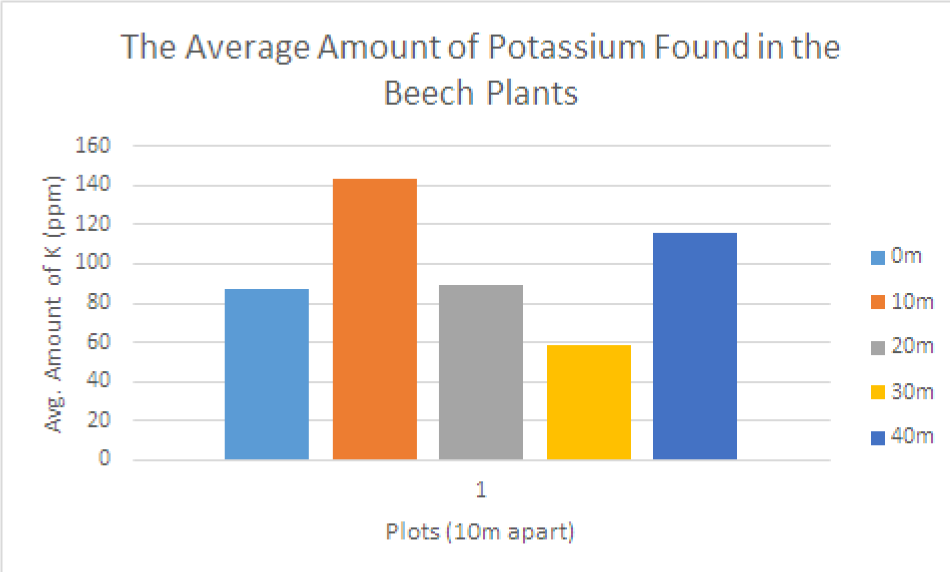
Graph 3:



Graph 4:



Graph 5: (Days 1-6)



Discussion

As Graph 1 shows, our original belief that the slope of the hill in Microclimate 1 may be causing the calcium levels to be greater at the bottom of the hill due to the leaching process that occurs when it rains was correct. The concentrations of calcium increase in soil samples as they are taken from the top of the hill to the bottom, with the highest concentrations being found at the base of the hill (Ca= 750 ppm) and the lowest concentrations being found at the top of the hill (Ca= 0 ppm). Furthermore, this correlation is statistically significant ($r2= 0.33$; $p=0.003$-0.099); hence we can be confident in our assessment.

However, as Table 1 shows, our original belief that the plants are consuming the potassium was not proven. There was no statistical difference in potassium values in the beech tree leaves that were collected at each plot along the hill ($p=0.37$-0.873), and therefore we can make no claims about the plants absorbing the potassium as it runs off and leaches down the hill.

However as Graph 5 indicates, there is a significant spike in potassium values at the 10m plot, and if one looks at the density of plant life of the beech leaves sampled between the 0m and the 10m plots (see Photo A) versus the density of plant life between the 10m to 20m plots (see photo B), it is apparent the hillside between our 10m and 20m plots contains more plant growth (see Photo B). These smaller plants are all young beech trees, and we speculate that the abundance of them could contribute to the higher levels of potassium found in plant material tested in this location. The young beech trees need more potassium than old beech trees because they are growing and developing and, therefore, they may be absorbing more potassium than the beeches at the other locations because young beech trees need large amounts of potassium for “tree metabolism” and various processes related to growth (Academic, 2010). In the future, we would test young beech trees versus older beech trees for potassium levels to see if our idea that younger beech trees take up more potassium is correct or not.

References

1. Better Crops. (1998). Potassium Interactions with Other Nutrients. Retrieved July 19, 2017, from International Plant Nutrition Institute (IPNI) website: http://www.ipni.net/publication/bettercrops.nsf/0/DD30AA083C1F782A8525798000820361/$FILE/Better%20Crops%201998-3%20p12.pdf

2. E.S.S.R.E 2017 Biota Survey Groups. (n.d.). Retrieved July 24, 2017, from Essre website: http://essre.rpcs.org/2017/Index2.html

3. The Importance of Calcium. (n.d.). Retrieved July 19, 2017, from Tetra Chemicals website: http://www.tetrachemicals.com/Products/Agriculture/The_Importance_of_Calcium.aqf

4. Johansen, C., Edwards, D. G., & Loneragan, J. F. (1968, May 17). Interaction Between Potassium and Calcium in their Absorption by Intact Barley Plants. I. Effects of Potassium on Calcium Absorption. Retrieved July 19, 2017, from Department of Soil Science and Plant Nutrition, Institute of Agriculture, University of Western Australia, Nedlands, Western Australia 6009 website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1087064/pdf/plntphys00489-0125.pdf

5. Kaiser, D. E., Rose, C. J., & Lamb, J. A. (n.d.). Potassium for Crop Production. Retrieved July 19, 2017, from University of Minnesota Extension website: http://www.extension.umn.edu/agriculture/nutrient-management/potassium/potassium-for-crop-production/

6. Lovejoy, R. (n.d.). Ways to Treat High Potassium in Soil. Retrieved July 20, 2017, from SF Gate website: http://homeguides.sfgate.com/ways-treat-high-potassium-soil-102992.html

7. Moss, A., Miller, L., & Simmons, A. (2003, July). The Effect of Worm Population on the Rise and Fall of Levels of Aluminum in Soil. Retrieved July 24, 2017, from ESSRE website: http://essre.rpcs.org/2003/ESSRE%202003%20Student%20Webs/Aluminum.pdf

8. Rhoades, H. (n.d.). Plants and Potassium: Using Potassium and Potassium Deficiency in Plants. Retrieved July 19, 2017, from Gardening Know How website: https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/plants-potassium.htm

9. Sela, G. (n.d.). Potassium in Plants. Retrieved July 19, 2017, from Smart! Fertilizer Management website: http://www.smart-fertilizer.com/articles/potassium-in-plants

10. E.S.S.R.E. Biota Survey: http://essre.rpcs.org/ESSRE%20Survey%20Data/Total%20Site%20Data%20Fixed.html

11. Fromm, Jörg. "Tree Physiology." *OXFORD Academic*, 2 May 2010, academic.oup.com/treephys/article/30/9/1140/1637967/Wood-formation-of-trees-in-relation-to-potassium. Accessed 27 July 2017.

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