The Study of Water's Effect on Potassium in the Soil and Rhododendron Plants

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Abstract

Potassium is an element that is significant to the development of soil and plants, enabling plants to receive nutrients and regulating their water content. Potassium ensures that the process of photosynthesis will occur, and plant growth occurs only when potassium is accessible. However, the E.S.S.R.E 2018 Biota Survey revealed a near total absence of potassium in the soils in the 4 E.S.S.R.E Microclimate. We hypothesized that this was because of the significant and prolonged lack of rain prior to the data collection, and that adding water to the soil will increase the levels of potassium in the plants by making potassium still in the soil more accessible , thereby, decreasing the potassium levels in the soil. The hypothesis was tested by identifying 5 locations with a monoculture of Rhododendron, and each location's water content was manipulated. Location 1 received no water, location 2 received 0.5 liters, location 3 received 1 liter, location 4 received 1.5 liters, and location 5 received 2 liters. Soil and plant samples were then collected, extracted, and tested for potassium levels to test the relationship between water and amount of potassium in plants and their surrounding soil. Our hypothesis was partially supported by the data collected.

Introduction

Potassium is essential to the health of plants. It is critical to the regulation of moisture within the plant through the opening and closing of the stomata (Soil Quality, 2018), and this regulation provides the plants with the ability to cope better with stresses such as extreme temperatures, pests, and droughts (Groiler 2011).

Several factors affect the amount of potassium absorbed by plant life, including temperature, wetting and drying cycles, soil types, aeration, moisture, and pH levels. However, moisture levels in the soil have the greatest impact on potassium availability, and following a drought, as the topsoil dries, potassium becomes the least available to plants (Schmitt and Rehm, 2011). This results in potassium deficiency when water begins to leave plant cells and the organism becomes flabby, causing a plant to be sensitive to drought, frost, and high levels of salt content (Parnes, 2013).

Potassium regularly serves as the only nutrient that remains in plant fluids, due to its function as an osmoregulator, and it is actively employed in the synthesis of proteins and starches (Parnes, 2013). In order for plants to obtain this critical nutrient effectively, it needs to be present in large quantities. But in soil, potassium is not a main constituent (Groiler, 2011), and the behavior of potassium in the soil is caused by physical tendencies such as organic residue decomposure (Schmitt and Rehm, 2011). Soils mainly preserve potassium levels by trapping potassium ions in small crevices in clay particles and the exchange of other cations through clay and humus particles. Once the potassium is trapped within the soil, plants can then absorb it, and it is available for plants to use to regulate the amount of accessible water that can be absorbed; thus allowing the plant to be able to photosynthesize through the use of water in the creation of its food. Without potassium, photosynthesis could not occur, resulting in the eventual death of the plant.

Given potassium's significance for plant health, we were puzzled when the 2018 E.S.S.R.E. Biota Survey (ESSRE 2018) revealed almost a complete absence of potassium in the soils in all 4 microclimates. However, the first weeks of July 2018 were the driest on record in the region (NOAA, 2018). Therefore, our group speculated that due to the lack of rainfall in the past weeks, there has been almost no water for the plants in the 4 microclimates to absorb, requiring the plant life there to drain the soil of potassium in order to attempt to regulate their internal water levels, resulting in a potassium deficit in the soils studied during the survey. We hypothesized that the addition of water to the soil would overall increase the potassium levels, enabling such potassium to transfer from the soil to the plant life.

Methods

5 locations were chosen in E.S.S.R.E. Microclimate 3 (N39.35797;W076.63836) to ensure a monoculture of *Rhododendron ferrugineum*. Location 1 was 5.3 meters east of the stream in quadrant 2 of Microclimate 3. Location 2 was 6.8m north of location 1 and 10.1 m from stream. Location 3 was 8.1m south of location 2 and 3.1m from the stream. Location 4 was 12.7m north of location 3 and 13.6m from the stream. Location 5 was 7.8m north of location 4 and 2m from the stream. 3 soil cores of 15cm deep by 2.5cm in diameter were extracted at each location and 2 leaves of rhododendron at each location were collected July 18, 2018 to serve as a positive control. Then immediately after 0 liters of water from the stream was poured onto

location 1; 0.5L of water from the stream was poured onto location 2; 1L of water from the stream was poured onto location 3; 1.5L of water from the stream was poured onto location 4; and 2L of water from the stream was poured onto location 5. On July 19, July 20, and July 23, 2018, 3 soil cores of 15cm deep by 2.5cm in diameter were extracted at each location and 2 leaves of rhododendron at each location were collected each day, and on July 19 and 20 the watering procedure was repeated. All samples of soil and leaves were tested for potassium level (ppm) using a LaMotte Test Kit Model STH-14.

Results

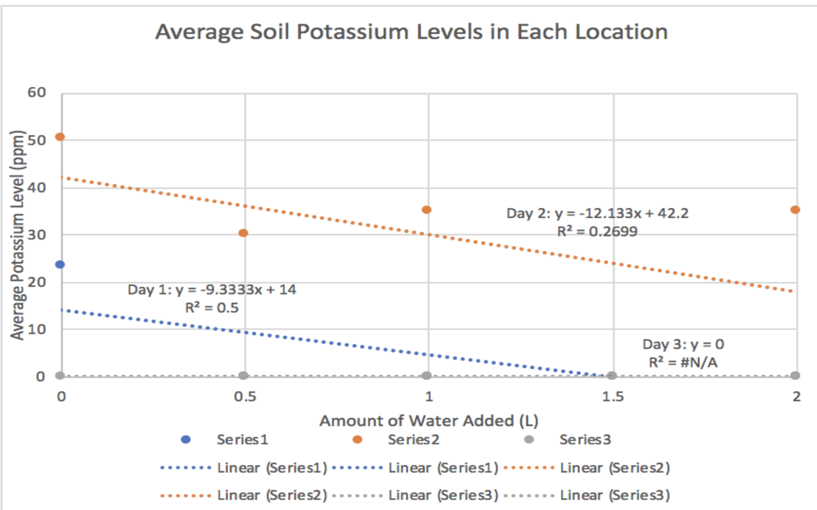

Figure 1 This scatter plot shows the relationship between the amount of water added and the average amount of potassium levels in the soil per each location.

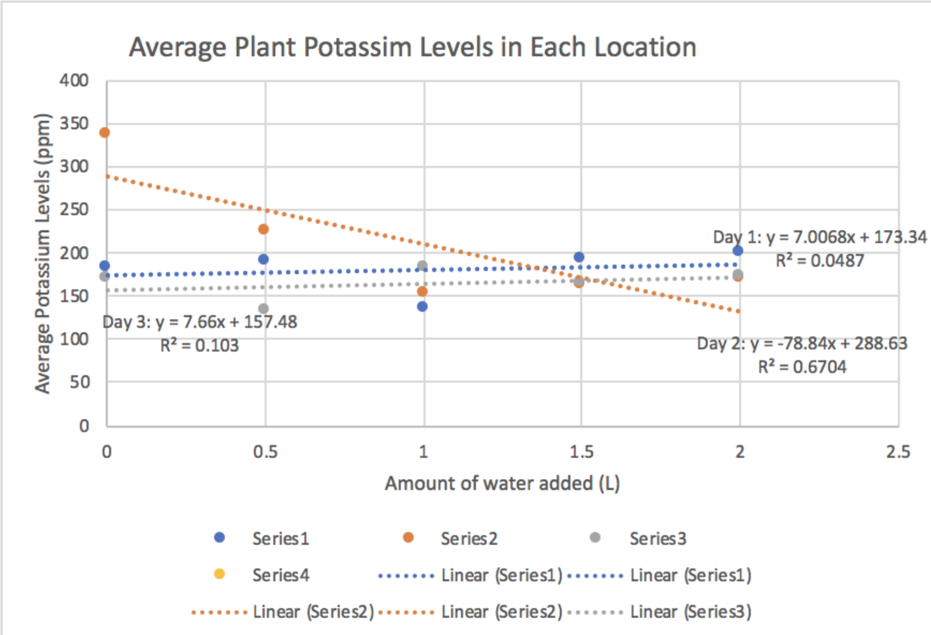

Figure 2 This scatter plot shows the relationship between the potassium levels found in the plant and the amount of water added to the Rhododendrons.

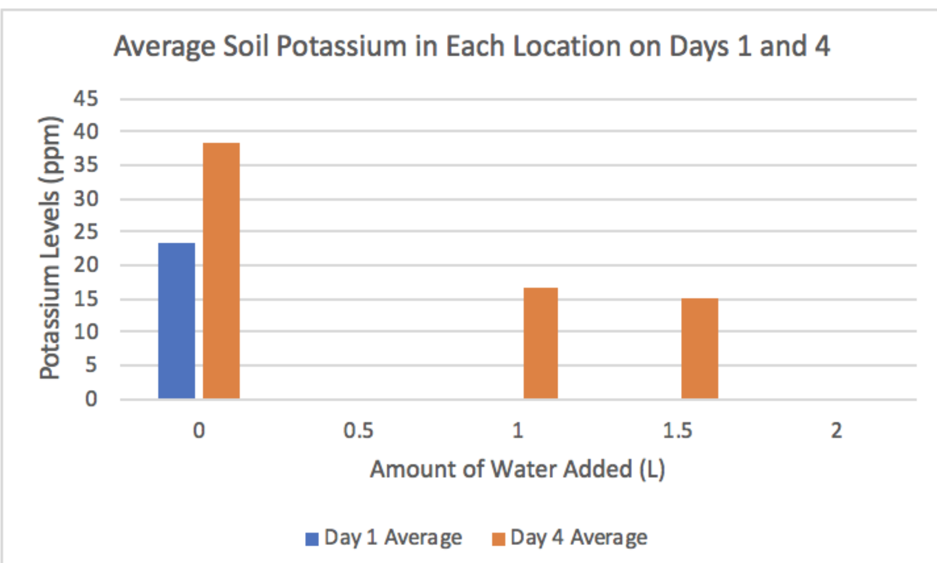

Figure 3: This bar graph shows the the average potassium levels at each location within the soil on day 1 (positive control) and day 4 (final experimental data).

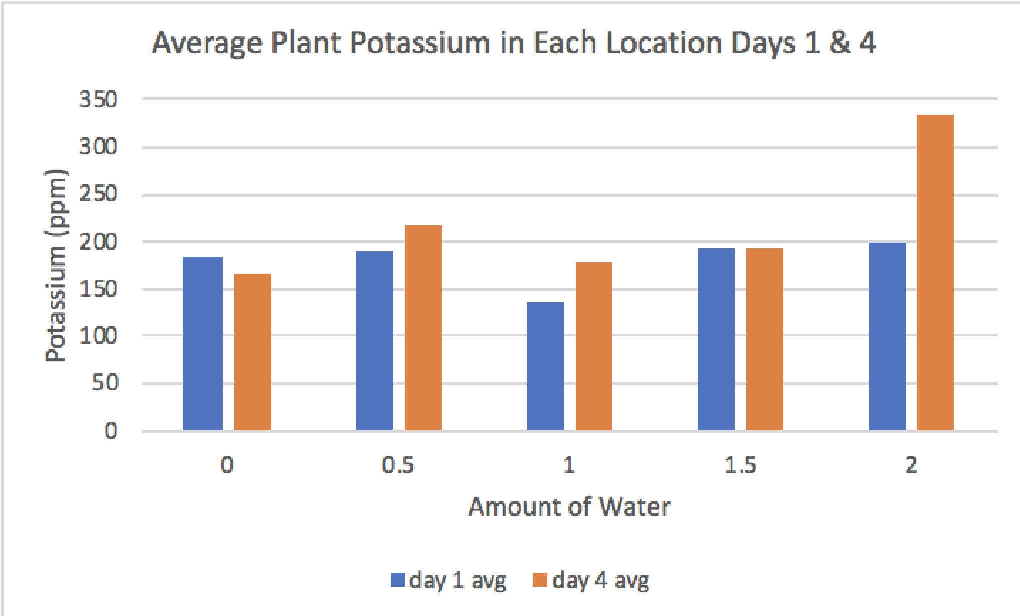

Figure 4: This bar graph compares the average potassium levels in the plants on day 1 (positive control) and day 4 (final experimental data).

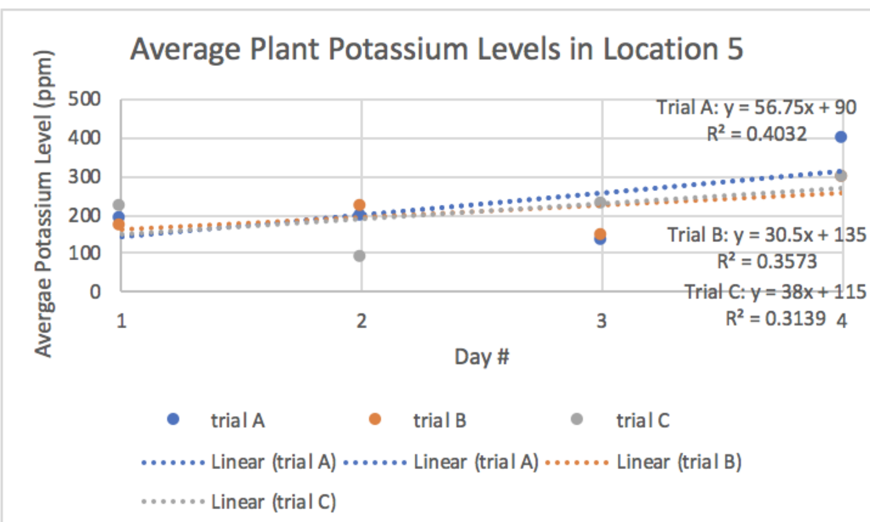

Figure 5 This scatter plot shows the exact amount of potassium found in all 3 of the plant samples taken each day from location 5, which was receiving 2 liters per day.

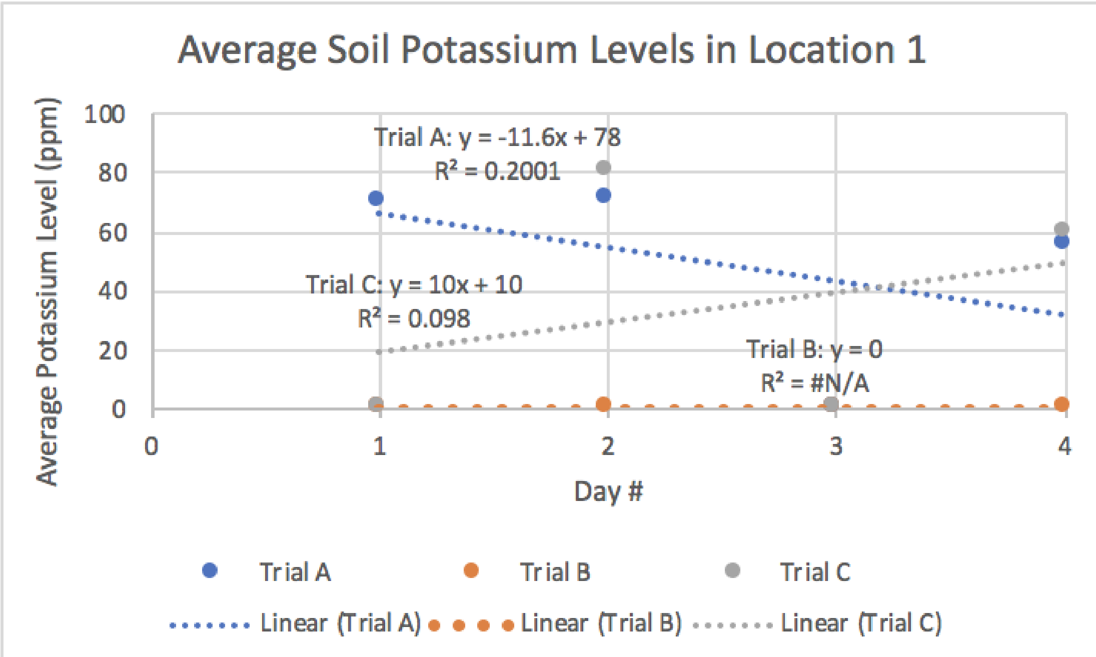

Figure 6: This scatter plot shows the exact amount of potassium found in all 3 of the soil samples taken each day from location 1, the location without any water added.

<u>Table 1: Site 3 Average Potassium Levels of Rhododendron and Soil in Each Location</u>
Key: Location 1= 0L, Location 2= 0.5L, Location 3= 1.0L,
Location 4= 1.5L, Location 5= 2.0lL

	Location 1		Location 2		Location 3		Location 4		Location 5	
	soil	plant	soil	plant	soil	plant	soil	plant	Soi l	plant
Day 1	23.3333	183.333	0	190	0	136.7	0	191.7	0	200
Day 2	50.3333	336.666	30	225	0	35	153.3333	164	35	170
Day 3	0	170	0	133.3	0	183.3	0	166.6	0	172.5
Day 4	38.3	166.6	0	218.3	16.6	176.6	15	193.3	0	333.3

Table 2: Site 3 Potassium P-values of Rhododendron

Data Collection Day #	Samples Compared	P-values of Potassium Samples	
		Soil K	Plant K
Day 1	0;0.5	0.423	0.387
Day 1	0.5;1	0	0.041
Day 1	1;1.5	0	0.247
Day 1	1.5;2	0	0.946
Day 2	0;0.5	0.541	0.103
Day 2	0.5;1	0.831	0.193
Day 2	1;1.5	0.145	0.576
Day 2	1.5;2	0.184	0.898
Day 3	0;0.5	0	0.725
Day 3	0.5;1	0	0.665
Day 3	1;1.5	0	0.805
Day 3	1.5;2	0	0.867
Day 4	0;0.5	0.814	0.648
Day 4	0.5;1	0.423	0.698
Day 4	1;1.5	0.944	0.609
Day 4	1.5;2	0.423	0.038

*2-Sample T-Tests were performed to find p-values comparing the locations per site 3 in a chronological order to determine whether adding water throughout the duration of the experiment served significance.

Discussion

As Figure 1 shows, the levels of potassium in the soil steadily decreased on days 1 and 3 as additional water was added (r^2 =0.5; r^2=0.27 respectively), and as Figure 2 indicates, the levels of potassium in the plants steadily increased on days 1 and 3 as additional water was added (r^2 =0.0487; r^2=0.103 respectively). Collectively, then, the data trends for days 1 and 3 affirm our hypothesis that the additional water would make it easier for the plant to extract more accessible potassium from the soil.

When examining the total average potassium in the plants and soil between the positive control and the final day of the experiment (see figures 3 and 4), the only locations to show a statistical significant change in potassium levels in either the plants or the soil were found in location 1 (0L of water; $p = 0.647$) and location 5 (2L of water; $p= 0.039$). For potassium in the plants, as figure 4 shows, location 5 has the greatest change in potassium levels from day 1 to day 4, indicating that once at least 2L of water was added to soil, plants could access the potassium better; however for completely dry soil, as figure 3 indicates, only the massive rainfall between day 3 and day 4 (NOAA, 2018) during the experiment was able to make the potassium in the soil more accessible.

When data from these two locations are then examined over the course of the entire experiment, the expected increase in potassium levels in the plants is observed (see figure 5) and the expected random fluctuations of potassium levels in the soil is observed (see Figure 6). Therefore, figure 5 and figure 6 also affirm our hypothesis.

But, as figures 1 and 2 show, the day 2 data for the experiment challenges our hypothesis. In the plants, the potassium levels decreased on day 2 ($r^2 = 0.6704$) and in the soil, the potassium levels did not change at all on day 2 ($r^2 = 0.2699$). Therefore, the day 2 data suggests that our hypothesis is incorrect. Hence, a final judgement on the validity of our hypothesis is not yet possible. There is only circumstantial evidence in support of our hypothesis; in all probability due to the limited amount of time of 4 days to conduct the experiment. For future research, the experiment would need to be conducted for a longer time to account for changes in weather.

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