Exploring the Effects of Salt and Banana Peels on Green Onion Growth

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Abstract

Farming is everyone's business, not only because it supplies our food but because it is the root of so many industries and a large portion of Canada's trade and commerce. Our experiment aims to explore the growth rate of produce in both fertilized and salinated environments. Over a 15-day experimental period, we monitored the biomass of green onions grown in a fertilized environment using bananas and a high-salt environment, with regular water as a control. We hypothesize that if salt impairs plant development, then green onion bulbs grown in a high-salinity environment will have a lower biomass than onions exposed to no treatment. Additionally, we hypothesize that if banana peels are an effective fertilizer, then green onion bulbs grown in a fertilized environment will have a greater biomass than onions exposed to no treatment. An analysis of variance test (ANOVA) with Tukey's post hoc test was used to identify a statistically significant result. Our results suggest that there is a significant difference between the growth of green onions exposed to salt and the control group. However, we fail to reject the null hypothesis that there is no difference between green onion growth in the control group and when exposed to banana peel fertilizer. As such, we can conclude that the salt impaired growth and extend the evidence proving salt is a factor of concern when looking to increase crop yield.

Introduction

Farming is not only essential to put food on the table, but is the base of many industries and trade in Canada. The economic welfare of the country is reliant on the gross domestic product (GDP) generated by the agriculture industry; in 2016, the industry made up 6.7% of Canada's total GDP (Government of Canada, 2017). Further, the Government of Canada also reported the agriculture industry employed 2.3 million people in 2016 (Government of Canada, 2017). The agriculture sector, and therefore millions of Canadian jobs, relies on both commercial and organic fertilizers to replenish the soil of essential nutrients after each harvest (Government of Canada, 2015). As

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such, fertilizers increase the yield of crops and allow for maximum efficiency of growth (Fertilizer Canada, 2020).

Soil salinization is a significant issue for agriculture in the Canadian Prairies (Government of Canada, 2020). The lack of moisture, increased concentration of mineral salts in groundwater, and high annual evaporation rates in these provinces account for the increased accumulation of soluble salts in the landscape (Government of Canada, 2020). The salinity level of the soil poses an issue because certain crops will not grow in even moderately salinated soil, and no crop will grow appropriately in soil with high saline (Government of Canada, 2020). This growth inhibition is due to oxidative and ionic stress pathways, which limit the capacity of plant roots to take up water. This reduction in water uptake aids in the accumulation of salts in plant cells to toxic levels (Parvais et al., 2013).

Banana peels were selected as a potential fertilizing agent for its ease of acquisition and nutrient breakdown (Hussein et al., 2019). Bananas are rich in potassium, phosphorus, and calcium; each of these minerals are crucial for the successful growth of plants. Potassium is essential in promoting plant turgor, aiding in pest resistance, and the regulation of a number of enzymes (Hussein et al., 2019). Phosphorus is necessary for the regulation of enzymatic activity in plants, in addition to key metabolic pathways (Schachtman et al., 1998). Calcium serves as both a structural component of the cell wall and membrane structure, as well as a signalling molecule for several physiological processes such as root growth (Thor, 2019).

Our goal is to explore the growth rate of produce in both fertilized and salinated environments. To achieve this, we will evaluate the biomass of green onions grown in both a fertilized environment and a high-salt environment, with regular water as a control. The banana is intended to act as an organic fertilizer to contribute nutrients to the onions. We hypothesize that if salt impairs plant development, then green onion bulbs grown in a high-salinity environment will have a lower biomass than onions exposed to no treatment. Additionally, we hypothesize that if banana peels are an effective fertilizer, then green onion bulbs grown in a fertilized environment will have a greater biomass than onions exposed to no treatment.

Methods

Experimental design

To prepare the banana peel-based fertilizer, we added 30g, 50g, and 70g of banana peels to three bowls with 150 mL of tap water each. The bowls were left for 24 hours to allow the nutrients to leach into the water. The control treatment was prepared by filling three cups with 150 mL of tap water. The fertilizer treatment group was assembled by pouring the prepared fertilizers into three cups. The growth inhibitor treatment was prepared by adding 20g, 40g, and 80g of table salt to three cups with 150 mL of tap water, and stirring until the salt was fully dissolved. This process is summarized in Figure 1.

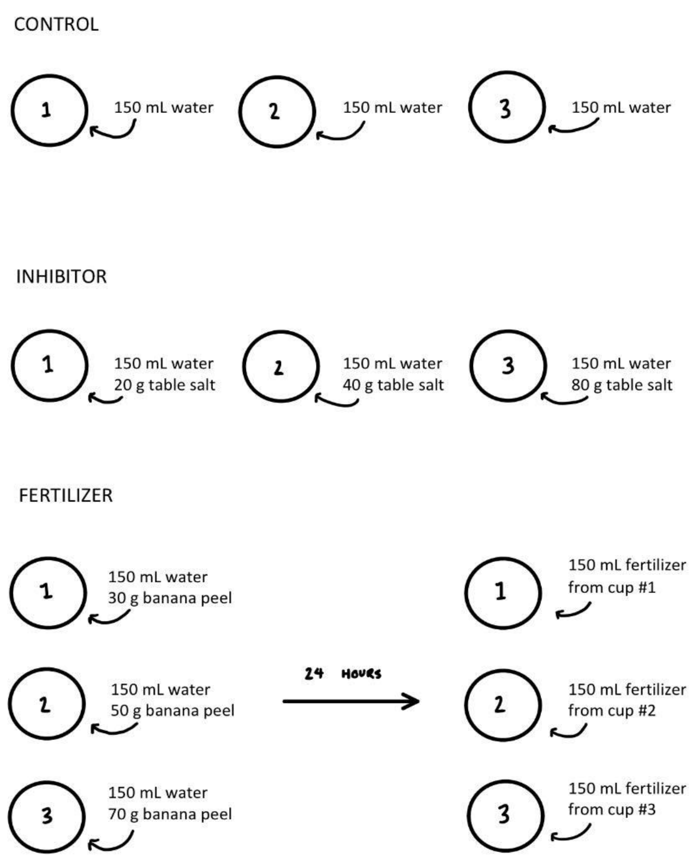

Figure 1. Schematic of the preparation process for each treatment used.

The initial weight of each green onion bulb was taken prior to the commencement of the experiment. Two green onion stalks were placed into each trial, and were supported using string to ensure the top was not submerged. The onions were placed in the same room, and were exposed to identical environmental conditions.

Observations were taken twice a day at approximately 10am PST and 10pm PST, with a particular focus on the colour and length of the onions in each group. Qualitative observations were also noted, and included the temperature of the room and the weather that day. The weight of each onion was recorded every three days for a total of 15 days, and the difference between the initial and final weights were recorded.

Statistical Analysis

Statistical analysis was conducted using Stata 16 software. First, a one-way ANOVA test was used to determine if there was a statistically significant difference between the treatment groups. The null hypothesis that the true mean value of onion growth in treatments 1, 2, and 3 were equal was tested against the alternative hypothesis that the true mean values of onion growth in treatments 1,2, and 3 were not all equal.

As the result was found to be significant at $\alpha = 0.05$, we used Tukey's test for our post-hoc analysis to determine which groups exhibited statistically significant differences, once again at $\alpha = 0.05$. We tested the null hypothesis that the true mean value of onion growth in both treatments were equal against the alternative hypothesis that the true mean values of onion growth in both treatments were not equal.

Results

The green onions appeared slightly wider and in some cases taller as the experiment progressed. They also changed from a light green and white colour to a darker green. Some wilting of the external layer of the bulb was observed in all treatments, but was especially prevalent in the growth inhibitor treatment group.

Figure 2. Experimental setup on the first day of the experiment (left) and the final day of the experiment (right).

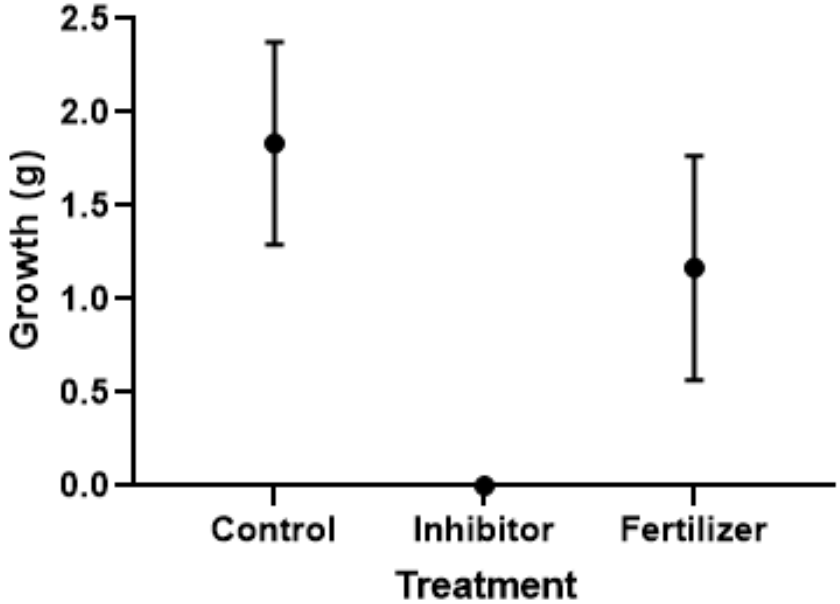

Figure 3. The mean growth (μ) of each treatment is represented by a circle. Error bars represent the standard error of the mean (SEM). The sample size is 6 for each group. (Control: $\mu = 1.833$, $SEM = 0.543$, Inhibitor: $\mu = 0$, $SEM = 0$, Fertilizer: $\mu = 1.17$, $SEM = 0.601$)

As seen in Figure 3, the most growth was observed in the control group, followed by the fertilizer, while the inhibitor treatment showed no growth. We observed significant variation in the growth rates of both the control and the fertilizer groups, while the inhibitor treatment displayed no variation, as all plants exhibited no growth. There were 6 observations in each group, and the range of our observations in both our control and fertilizer group were from 0 cm to 4 cm. Running a one-way ANOVA test, our results yielded a p-value of 0.0421, which is statistically significant at the 95% confidence level. Therefore we rejected our null hypothesis, and proceeded to our post-hoc analysis.

Treatment Groups	p-value	95% Confidence Interval
Control vs. Fertilizer	0.583	[-2.384,1.050]
Control vs. Inhibitor	0.036	[-3.554,-0.116]
Fertilizer vs. Inhibitor	0.215	[-2.884,0.550]

Figure 4. Results of the post-hoc analysis using Tukey's Test.

Our post-hoc analysis revealed that the only statistically significant difference in growth was observed between the control group and the inhibitor group.

Discussion

Our analysis suggests there is a significant difference between the growth experienced by green onions grown in a high-salt environment and those grown in plain water. There was no significant difference between the results of the fertilizer treatment and the control treatment. As a result, we fail to reject the null hypothesis that there is no difference between green onion growth in the control group and when exposed to banana peel fertilizer. We conclude that there is a statistically significant difference in growth between the control and growth inhibitor treatments, but not between the control and fertilizer treatment groups.

The onion growth observed in a high-salinity environment was inhibited by two major salt-mediated stress pathways - these are osmotic stress and ionic stress. Osmotic stress occurs as a result of high salt concentrations in either the soil or water, and ionic stress results from the cytotoxicity induced by high salt concentrations within plant cells (Yang & Guo, 2018). These stresses occur since high salt concentrations limit the capacity of roots to take up water, and this reduction in water uptake aids in the accumulation of salts in plant cells to toxic levels (Parvais et al., 2013).

In addition to the impact of salt on plant growth, both drought and waterlogged conditions negatively impact plant growth. Long-term osmotic and ionic stress can induce a secondary stress response known as oxidative stress, in which a type of free radical known as a reactive oxygen species (ROS) can inhibit the normal function of biochemical and physiological processes in plant cells (Parvaiz, 2016). Oxidative stress will, for example, influence the nutrient uptake pathway and the cell signalling pathways that are responsible for the synthesis of important biomolecules (Parvaiz et al., 2013). Notably, oxidative stress will reduce the synthesis of free radical scavenging enzymes which play an important role in ROS detoxification. Salt-mediated plant stress will also alter metabolic processes, induce cell membrane disorganization, and genotoxicity of plant cells (Parvaiz et al., 2013).

Our findings leave little evidence that the potassium, phosphorus, and calcium extracted from the banana peels increased the growth rate of our onions. It is possible that these were not limiting nutrients to green onion, and as a result had no effect. Alternatively, the means of nutrient extraction may have been insufficient to impact the growth of the onions. There is evidence in published literature that the application of nanofertilizers impacts germination percentages in agricultural settings (Hussein et al., 2019). However, this may be mediated by other amino acids that may not be relevant to the growth of onions. Physical and chemical characterization of the fertilizer constituents would allow us to further elucidate the efficacy of the nutrient extraction performed during this experiment.

Several factors may have impacted the reliability of our results. Most notably, we were unable to control for variations in weather and ambient temperature conditions. This was mitigated by performing the experiment in one location, but daily variation in weather conditions were not considered in the course of our research. Additionally, both the small sample size and variation in the starting size of the onion may have reduced the validity of our statistical findings. Finally, our precision was limited to intervals of one gram. Obtaining a more accurate scale would increase the precision of our data and allow us to better describe the efficacy of fertilizers and the impact of growth inhibitors.

Future research into the impact of growth inhibitors and fertilizers on the growth of plants could aim to utilize a variety of growth mediums that have agricultural relevance. Additionally, diversifying the crops being investigated will allow for the wider application of these experimental findings across a greater variety of plants.

Conclusion

Our results suggest that there is a significant difference between the growth of green onions exposed to salt and the control group. However, we fail to reject the null hypothesis that there is no difference between green onion growth in the control group and when exposed to banana peel fertilizer. Therefore, we conclude that the onions exposed to salt likely experienced osmotic and ionic stress, which mediated the oxidative stress response and inhibition of growth. No evidence suggests the potassium, phosphorus, and calcium extracted from banana peels increased onion growth rate. It is possible that these were not limiting nutrients to the green onions, and as a result had no effect, however a larger sample size would be required to increase certainty in this conclusion.

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Appendix

Treatment	Change in Weight (g)					
Control Group	0	1	2	2	2	4
Inhibitor	0	0	0	0	0	0
Fertilizer	0	0	1	1	1	4

Appendix 1. Sample of raw data from our experiment.

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	10.3333333	2	5.16666667	3.94	0.0421
Within groups	19.6666667	15	1.31111111		
Total	30	17	1.76470588		

Appendix 2. ANOVA table from our analysis conducted using Stata 16.

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. pwmean var2, over(var1) mcompare(tukey) effects

Pairwise comparisons of means with equal variances

over         : var1
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	Number of Comparisons
var1	3

var2	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
var1						
2 vs 1	-.6666667	.6610878	-1.01	0.583	-2.383822	1.050489
3 vs 1	-1.833333	.6610878	-2.77	0.036	-3.550489	-.1161776
3 vs 2	-1.166667	.6610878	-1.76	0.215	-2.883822	.5504891

Appendix 3. Tukey's test for post-hoc analysis conducted using Stata 16.