Exploring The Effect of Fertilizer in The Asexual Propagation of Red Onion Cuttings Using Water as a Growing Medium

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Abstract

The increase of deforestation and the decline of soil fertility rates around the world have reduced the availability of red onions, a staple in various diets and cultures globally. Our motivation for this study is to find an alternative growing medium that does not require agricultural land and nutrient-rich soil which may combat these concerns at a household level. Our study aims to explore water as an alternative growing medium and to understand the effect of adding Miracle-Gro fertilizer to water in the asexual propagation of red onion cuttings. In our experiment, red onion cuttings were suspended in tap water with and without fertilizer and observed for sprout growth over a period of three weeks. We performed a one-way ANOVA test and obtained a p-value of 0.03 using a significance level of 0.05. We found that tap water with 50% of the recommended amount of fertilizer was the most effective growing medium and therefore, it may act as an alternative growing medium to soil. Additionally, this alternative growing medium may allow individuals to decrease food waste by using their food scraps to propagate red onions at home.

Introduction

Red onions (*Allium cepa*) are a commonly used culinary food item, however, the global demand for vegetables including onions cannot be met by the current availability (Mason-D'Croz et al., 2019). Additionally, soil fertility rates are declining around the world due to deforestation and clearance of vegetation and these low fertility rates are a big hindrance to improved agricultural production (Ayoub, 1999). Further, the demand for food sources such as onions is increasing and resources including land are becoming increasingly exploited in an attempt to meet these demands (Lehman et al., 2015). This is a concern because land degradation affects growing mediums including soil, which are critical to plant growth to obtain nutrients (Lehman et al., 2015). To sustain future demand for agricultural production, alternative growing mediums are required. In this experiment, we will be evaluating the effectiveness of tap water and tap water with Miracle-Gro Water Soluble All Purpose Plant Food fertilizer as alternative growing mediums for red onion propagation. Based on previous findings, adding fertilizer to the growing medium is beneficial for plant growth because it provides them with essential nutrients for optimal growth and replenishes nutrients that are utilized by plants in their growing medium (Baligar, Fageria, & He, 2001). For this reason, we hypothesized that tap water with 100% of the recommended fertilizer will have the most growth and will be the most effective growing medium. Research to determine the effectiveness of tap water and tap water with added fertilizer as a growing medium can serve as an effective at-home growing method which may help individuals cope with limited availability and potential food insecurity by allowing them to grow their own produce from food scraps. Using food scraps to widely grow more food has the potential to decrease food waste worldwide which can ultimately increase global vegetable availability (Mason-D'Croz et al., 2019). This approach can also be implemented in regions that frequently experience harsh weather wherein the weather does not allow for open-field agriculture (Al Salmi, et al., 2020).

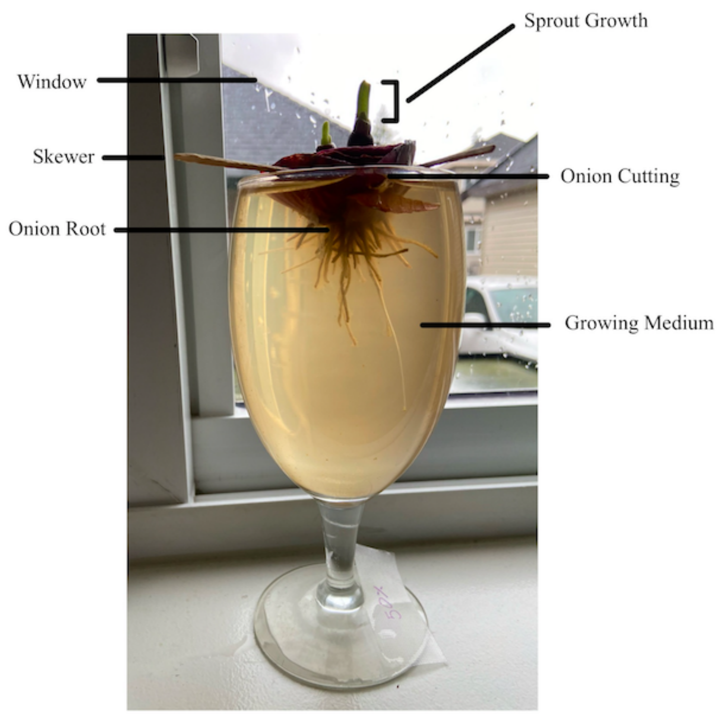
Methods and Materials

In this experiment, we had a six-glass setup and tested three different growing mediums, tap water (n=2), tap water with 50% of the recommended fertilizer amount (n=2), and tap water with 100% of the recommended fertilizer amount (n=2). The fertilizer tested in this experiment was Miracle-Gro Water Soluble All Purpose Plant Food.

Each glass setup had an onion root suspended into the growing medium and was placed by a well-lit window (Figure 1).

Figure 1

Experiment Setup



Note. Picture of the experiment setup. Onion cutting is placed root side down into a glass full of growing medium (either tap water or tap water with added fertilizer) and held in place using three skewers. The glass setup is placed on a bright and well-light window sill.

To obtain onion root ends, we cut the red onion 1 cm from the end of the root. All glasses were filled to the brim with growing medium and each onion cutting was suspended, root side down, in each glass to ensure that the root of the onion was in contact with the growing medium at all times. The onion was held in place using 3 skewers pierced through the sides of the onion so that the skewers held the onion in place using the edge of the glass.

Two glasses (labelled 1A and 1B) were filled with tap water. Two glasses (labelled as 2A and 2B) contained 50% of the recommended fertilizer with 7.9×10^{-4} g/mL of fertilizer in tap water. Two glasses (labelled as 3A and 3B) contained 100% of the recommended fertilizer, which was 1.6×10^{-3} g/mL of fertilizer in tap water. Over time, water evaporated from the glasses and to ensure that roots were always in contact with the growing medium at all times, glasses were topped up with either tap water or growing medium with the appropriate concentrations of fertilizer in their respective glasses.

Every seven days, the growing mediums were replaced with a fresh solvent (tap water and fertilizer or only tap water) that was the same as the previous solvent to provide fresh, oxygenated water to the onion cuttings. This was done to prevent the growth of unwanted bacteria and fungus and to replenish nutrients in the water as the nutrients in water get used up by plant roots over time (Baligar, Fageria, & He, 2001). The six cups were placed side-by-side along the same window sill and their positions were switched every day for three weeks to ensure each glass received an equal distribution of sunlight. Over time, sprouts erupted from the onion tops and we measured these sprouts to collect our data. Growth of the sprouts (upwards from the onion cutting) was measured once a week over the course of three weeks, with a ruler. If multiple sprouts formed in the same onion cutting, an average of all the sprouts was taken because each onion cutting had varying amounts of sprouts growing from them. To increase sample size, a replicate experiment was conducted in another experimenter’s home.

We performed a one-way ANOVA test in Excel using sprout lengths from all three groups. A sqrt(y) transformation was performed on the sprout growth data to create a normal distribution as required by the one-way ANOVA. A sqrt(y) transformation was done instead of the log(y) transformation as our data set contained a few onions that had no growth present. We conducted a one-way ANOVA test using a significance level of 0.05, as done in previous studies which conducted similar experiments (Baligar, Fageria, & He, 2001).

Results

The root ends grown in tap water (group 1) had a mean growth of sprouts of 0.6 mm with n=4, the roots ends grown in tap water with 50% of the recommended fertilizer amount (group 2) had a mean growth of sprouts of 6.3 mm with n=4 and the root ends grown in 100% of the recommended fertilizer amount (group 3) had a mean growth of sprouts of 2.3 mm with n=3 (Table 1).

Table 1

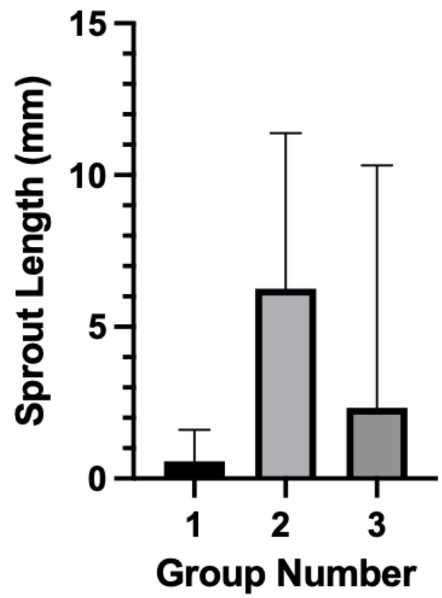
Sample Sizes of Onion Cuttings in Different Growing Mediums

Group No.	1	2	3
Growing Medium	Tap Water	50% fertilizer and tap water	100% fertilizer and tap water
Sample Size (n)	4	4	3

Group 3 had a smaller sample size (n) compared to other groups due to one onion cutting being spoiled by mold so it was discarded and not used in our analysis. Using a one-way ANOVA test and a significance level of 0.05 we obtained a p-value of 0.03. This indicates that the mean of sprout growth in the three groups of growing mediums is statistically different and there is a significant difference amongst the three growing mediums (Figure 2).

Figure 2

Mean Sprout Length (mm) in Different Growing Mediums (group number)



Note. *Mean lengths (mm) of sprouts on onion cuttings.* n_{total}*= 11. Group 1: water with 0% recommended fertilizer,* n_1 *= 4. Group 2: water with 50% recommended fertilizer,* n_2*= 4. Group 3: water with 100% recommended fertilizer,* n_3*= 3. p= 0.03 using a one-way ANOVA. Error bars represent 95% confidence intervals.*

Discussion

The purpose of this experiment was to determine the effectiveness of tap water and tap water with added fertilizer as growing mediums for red onion cuttings. Previous studies have been conducted to test the effect of fertilizer on plant growth (Baligar, Fageria, & He, 2001), but no studies have been conducted to determine the effectiveness of added fertilizer to tap water as a growing medium for red onions. We initially hypothesized that the onion cuttings placed in growing mediums with 100% of the recommended fertilizer amount would have the most growth (in mm) of the sprout from the onion cutting. However, we found that onion cuttings grown in 50% of the recommended fertilizer amount had the most growth. We performed a one-way ANOVA test in Excel using a significance level of 0.05 and the resulting p-value was 0.03. Therefore, a statistically significant difference does in fact exist between the three different growing mediums. Based on this analysis and our data, the most effective growing medium for onion propagation was group 2, the growing medium with 50% of the recommended fertilizer concentration because it exhibited the most sprout growth (in mm). Since similar experiments have not been conducted, we are unable to confirm our findings with existing literature.

One sample from group 3 (3B), was excluded from the data set due to the presence of mold, which we believe may have been caused by the presence of too much fertilizer. Additionally, when topping up the glasses, some of the growing medium splashed onto the top of the onion cutting which could have encouraged the formation of mold since it thrives in damp and wet conditions and requires water to grow (Ceylan, et al., 2013).

Other sources of error include instrument uncertainty and human error during measurement. The kitchen scales used to weigh out the fertilizer were only accurate to one significant figure which meant we were unable to determine how much fertilizer was accurately added into each glass and whether the concentrations of fertilizer remained constant as the experiment progressed. Additionally, it was difficult to accurately measure the length of the sprouts using a ruler. This was especially an issue when there were multiple sprouts emerging from each onion cutting. Furthermore, since this experiment was conducted in two different locations, there was variability in environments between the setups and different instruments with varying precision were used. These variations in environments may have affected the sprout growth caused by variations in sunlight, temperature and humidity. Additionally, the amount of fertilizer added to the growing medium may have varied between experiments due to variations in the kitchen scales used. Since our experiment only tested the effectiveness of Miracle-Gro Water Soluble All Purpose Plant Food, future experiments can test if other fertilizers yield the same results. Future studies may also test our findings with a larger sample size and over a longer period of time to confirm our results with more certainty. It may also be worthwhile to test the effects that other readily available fertilizers, such as coffee grounds, have on onion cuttings as compared to the fertilizer that was used in our experiment.

Conclusion

We found that the mean lengths of the sprouts grown in three different growing mediums were statistically different. From our analysis, we conclude that tap water with 50% of the recommended fertilizer amount is the most effective growing medium to encourage sprout growth and propagate red onions. With declining soil fertility rates and deforestation rates on the rise, finding alternative growing mediums are crucial. Further, to combat the problem of food waste, our experimental setup can be used to propagate onions from food scraps at home (indoors or outdoors) as a cost-friendly growing method.

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Appendix A

The packs of fertilizer used are 12g and meant to be diluted in 2 gallons of water (7570mL)

Group 1: Control
0 g fertilizer

Group 2: Small amount of fertilizer (50% of what is listed on the package)
6g/7570mL =0.0007926 g/mL * 265mL = 0.21 g fertilizer in 265mL of water.

Group 3: Intended amount of fertilizer as listed on the package
12g/7570mL =0.0015852 g/mL * 265mL = 0.42 g fertilizer in 265mL of water.