<u>The Effects of Different Water Amounts on Green Onion (*Allium fistulosum* L.) Growth</u>

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Abstract

Green onions (*Allium fistulosum* L.) are widely cultivated crops known for their culinary and medical importance. In an effort to test the preferred growth conditions for green onions,. over the course of 15 days, 1, 2, and 3 tablespoons (tbsp) of water were given daily to three groups of three green onion replicates, and the overall heights of the green onions were measured in centimetres (cm) using a ruler. Freshly cut stalks were planted in 4-inch pots with built-in drainage holes at the bottom and filled with indoor potting soil, with about 1 cm protruding above the soil surface. According to the One-Way ANOVA test, there is no significant difference between the overall growth of the green onions based on the volume of water given to them. Thus, there is no difference in overall growth between the green onion plants based on varying water treatment levels.

Introduction

Green onions (*Allium fistulosum* L.) are widely used ingredients in many dishes, and are recognized as therapeutic herbs (Gao et al., 2021); *Allium* genus vegetables are known for their treatment of diseases including the reduction of risk of cardiovascular diseases and cancer (Xiao, 2004). The plant's broad usage in both the culinary and medical fields suggests the importance of understanding the plant's optimal growth conditions for increased production and thus consumption.

While there have been studies investigating the effects of environmental variables including LED light treatment (Gao et al., 2021) and soil composition such as metal contents (Kim, 1995) on the growth of green onions, none so far have studied the effects of water amount. The onset of climate change has introduced many challenges for agriculture – notably, the increasing scarcity of water resources (Im et al., 2008). Thus, studying common crop growth (such as green onion) in various water conditions would be beneficial in developing better agricultural practices under climate change induced environmental stresses.

Generally, for plants, water deficits result in decreased carbon accumulation, leading to decreased tissue expansions and less plant growth (Tardieu et al., 2011). For instance, plant vegetative growth was found to be reduced with decreased water availability for the herb, *Satureja hortensis* L. (Baher et al., 2002), supporting the understanding of reduced plant growth with water deficits. Furthermore, water is an essential resource for plants and is responsible for numerous processes that are required for their growth, including photosynthesis and nutrient absorption (Im et al., 2008). Based on these past studies and observations, it is reasonable to predict that green onion, being a species of plant, would exhibit similar growth responses in that greater growth would be observed with higher water availability. We hypothesized that if the total growth of green onions are positively correlated with the amount of water they are given, then green onions that have been given more water will experience greater amounts of growth, as measured by their height, compared to those given less water. As such, we predict that the total growth of green onions in Treatment 3 will be the greatest followed by Treatment 2 and then Treatment 1.

Methods

The green onions used were sourced from Safeway, 2733 W Broadway on February 28, 2022. Stalks were cut near the bottom to leave 5 cm of stem above the root. Freshly cut stalks were immediately planted in 4-inch pots (Fig. 1) with built-in drainage holes at the bottom and filled with indoor potting soil (mySoil organic potting mix), with about 1 cm extending above the soil surface. Three stalks were planted equilaterally in each pot, and were placed indoors (to minimize environmental variance) in a well-lit area by a window. The ambient temperature was held at a constant of approximately 20 °C throughout the experiment.

Over the course of 15 days, the plants were watered once daily in the evening. We added a unique amount of tap water, ensuring that it was equally distributed over the pot surface: we added 1 tablespoon (tbsp) of water per day for Pot 1, 2 tbsp of water per day for another Pot 2, and 3 tbsp of water per day for the Pot 3. We recorded the heights of the plants daily by holding the longest stalk of the plant vertically and measuring from the original cut to the top of the stalk. We took pictures every five days.

For each plant group, we measured the growth exhibited by each of the three replicates in centimetres using a ruler and averaged the values to obtain the mean total height growth. We collected data about the growth using Microsoft Excel and plotted the mean total growth in centimetres on a bar graph for the three groups, along with their respective standard deviation values. We performed a One-Way ANOVA test using the online calculator, Astatsa, to detect any significant differences between group means.

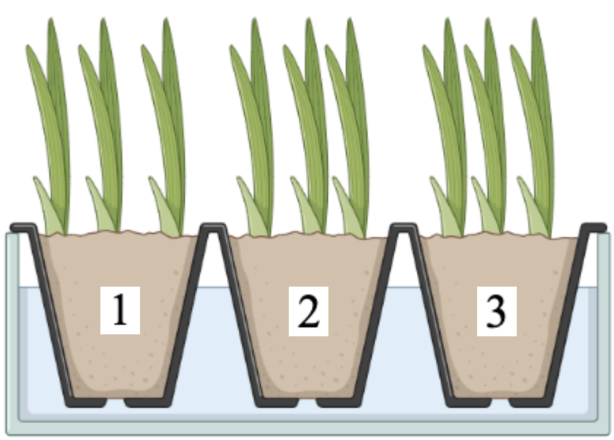

Figure 1. Experimental Set-up.

Our setup included having three pots of three equidistant green onion plants for each treatment. Pots were labelled based on the number of tablespoons of water given to each plant. All three plants were kept in the same location over 15 days. This accounts for overcoming any abiotic factors that could interfere with results. The soil amounts were kept similar between the three pots.

Results

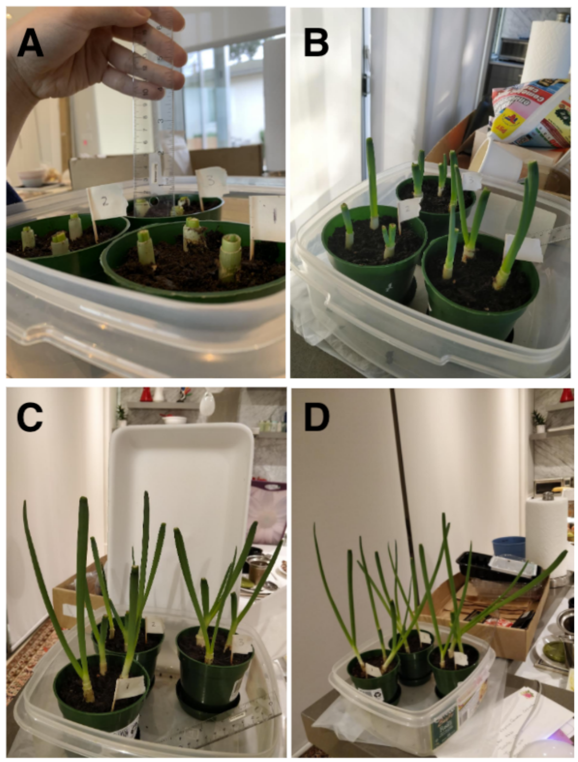

Figure 2. Photos from the Experiment.

Image A (top left) displays green onion growth on day 1. Image B (top right) displays green onion growth on day 5. Image C (bottom left) displays green onion growth on day 10. Image D (bottom right) displays green onion growth on day 15.

We observed that on day 1 (Fig. 2A), all the trials had begun to sprout and form tubular structures. The base of the stem had a whitish shell or covering with the inside of the stalk having a yellow colour. All the trials seem to be of a similar thickness and height. On day 5 (Fig. 2B), the base of the green onions appeared as a lighter shade of green with the stalk gradually becoming a darker shade of green towards the tips. As in day 1, the inside of the stalk had a yellow colour. On day 10 (Fig. 2C), the base of the stalk developed a whitish colour and the tips for all the green onions had darkened in their shade of green. Finally, on day 15 (Fig. 2D), the two stalks of each plant were unequal. The smaller stalks had blunt ends that were wider than the longer stalks with fine tips. The distance between the stalks grew wider and the stalks with blunt ends were a darker green colour compared to the stalks with fine ends. The white base from which the stalks separated had increased in length. One green onion in Treatments 1 and 2 were noticeably shorter than the others in their pot.

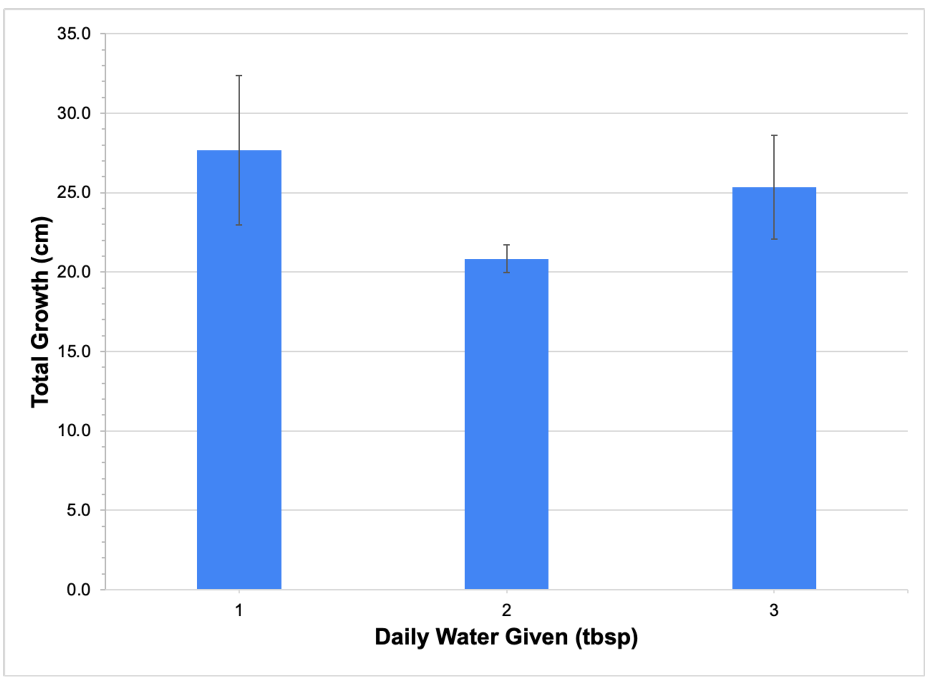

Figure 3. Total Growth of Green Onions in Different Water Conditions Over 15 Days.
Each bar represents the mean total growth of each water treatment level (n = 9) over the same time period (t = 15 days). The error bars represent the 95% confidence interval with $p > 0.05$. Temperature, sunlight, and other abiotic factors were kept consistent throughout the different conditions.

We plotted the average growth of each treatment, the standard deviation, and the 95% confidence interval (Fig. 3). In terms of total growth, Treatment 1 had the highest followed by Treatment 3 and then Treatment 2. Average total green onion growth was calculated with the AVERAGE function. Standard deviation was shown using ST.DEV function and confidence interval was done with alpha = 0.05 and the CONFIDENCE function. Using the ANOVA calculator to record significance in the means of total growth, it was found that the p-value was above 0.05 (Table 1), meaning that a post-hoc test was not needed.

Table 1. ANOVA Results Table

Final results produced from the ANOVA calculator, Astatsa (Vasavada, 2016), showing the sum of squares, degrees of freedom, mean square, F statistic, and p-value (p = 0.0743).

One-way ANOVA of your k=3 independent treatments:

source	sum of squares SS	degrees of freedom ν	mean square MS	F statistic	p-value
treatment	72.3889	2	36.1944	4.1365	0.0743
error	52.5000	6	8.7500		
total	124.8889	8			

Discussion

After analyzing the One-Way ANOVA, there is no significant difference between the overall growth of green onions, as measured by their height, based on the volume of water given to them ($p > 0.05$). As such, we fail to reject the null hypothesis that there is no difference in overall growth between the green onion plants based on varying water treatment levels and thereby fail to support our alternative hypothesis.

The similar growth between treatments may be attributed to the drought-tolerant properties of green onions (Padula et al., 2022). Plants employ a wide range of mechanisms to reduce water loss such as closing stomata or increasing root growth (Gilbert & Medina, 2016). However, a couple studies performed on closely related onion species recorded decreases in growth and dry weight. Two studies performed on *Allium cepa* L. found that decreases in irrigation water levels led to lower biomass dry weight and bulb yield (Kumar et al., 2007; Abbey & Joyce, 2008). These results were obtained over the course of two years and 10 weeks, respectively. Since our experiment was carried out over the course of 15 days, the water-stressed conditions may not have been employed long enough to challenge the drought-tolerance of the green onions. This may explain why the green onion plants in Treatments 1 and 3 were similar in total growth despite the difference in the amount of water given to them.

A lack of high reactive oxygen species production in the plants as a result of the water treatment levels being too high when considering the sizes of the pots we used may also be a reason for this similarity. Reactive oxygen species are produced in regions such as chloroplasts and have many roles within plant cells such as the initiation of senescence and the signalling for defence against pathogens (Kar, 2011). However, in response to water stress, abnormally high levels of reactive oxygen species are produced and can potentially result in the degradation of many significant molecules including those necessary for photosynthesis such as chlorophyll, thus destroying the chloroplast (Kar, 2011). A study performed on *A. fistulosum* L. found that drought conditions promoted decreases in the leaf chlorophyll content (Liu et al., 2021). Chlorophyll is an important contributor to photosynthesis and decreases in this component significantly reduces the net photosynthesis rate, which further reduces plant growth (Liu et al, 2021). As such, the water levels of each of our treatments may not have been low enough to see the damaging effects of reactive oxygen species at high concentrations.

While most extraneous abiotic factors were kept as constant as possible by growing the green onions in the same location, there is some uncertainty regarding the exact amount of water given to each plant in each treatment. Water for each treatment was given to the entire pot rather than to each plant and was measured using a tablespoon. As such, some individuals may have received more water than others due to differences in root length. Although water was given within the same general area for each pot, we cannot control how the water flows through the soil and reaches the roots of the green onion plants. It is this distribution of water within the pots that likely explains the differences in total growth between green onion plants of the same treatment. The difference in total growth between plants of the same treatment may also be attributed to the fact that three green onion plants were grown in a single pot for each treatment, leading to possible undesirable competition between individuals.

Potential future studies may include modifications to the current experiment such as increasing the experiment duration to increase the likelihood that the green onion plants reach a growth limitation despite their drought tolerance or decreasing the amount of water given to each treatment to potentially increase reactive oxygen species production. The usage of a greater sample size may also result in more conclusive results due to less variation. In addition, we predict that measurements done on the rate of growth rather than the total growth of green onions may yield different results.

Conclusion

In an effort to study the effects of varying watering conditions on green onions, three groups of green onions were grown for 15 days. Each group was watered a unique amount per day (1, 2 or 3 tbsp/day). Our findings show that there is no significant difference in total growth between our different treatment groups. Considering that green onions are such a fundamental food source in many cultures and are grown in many dry regions, future studies may include a wider range of water levels and observing other commonly grown crops in agriculture to maximize their yield with respect to the number of resources employed.

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