# Examining the Effects of Drought and Floods on St. Augustine and Bermuda Grass

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## Abstract

How do extreme weather events like droughts and floods affect grass species? In the context of climate change, these extreme weather events are becoming more common and more intense. This is important because species that can survive under these stresses now may not be able to survive in the future. Grass species provide many benefits to humans like cleaning the air and reducing the effects of climate change by $CO_2$ uptake, reducing erosion from stormwater runoff, soil integrity, and many more. This experiment was devised to study the effects of these stressors on two of the most common grass species in America, Bermuda, and St. Augustine. Through many mechanisms, we hypothesized that grass samples treated with no-water and explicitly overwatered would show a significant decrease in photosynthetic rate and other health metrics. These measurements were taken using a PASCO $CO_2$ probe, and other indications of health were gained from photographic records and a visual root rot inspection. After the 11-day experiment, clear health declines were seen and quantified in both grass species treated with no-water, and samples treated with overwater and healthy watering both showed significant growth throughout the test period. In addition, the root rot inspection showed early signs of root rot in the overwatered Bermuda samples but not in the Augustine samples.

## Introduction

Climate change has been an increasingly prevalent issue in modern-day society as Trenberth (2005) has found; climate change is increasing the likelihood of droughts in the summer and floods in early spring. Furthermore, it has been stated by Stott (2016) that human-induced climate change has led to an increase in the intensity and frequency of daily temperature extremes and daily precipitation extremes. Grasses are one resolution to combat this prevalent issue. Yoro & Daramola (2020) have found that grasses clean air and reduce the effects of climate change through their carbon dioxide capture via photosynthesis. Furthermore, grasses provide further benefits such as the reduction of erosion from stormwater runoff as suggested by Duan (2022) and human recreation.

When plants experience a drought, Anosheh et al. (2016) mentioned how stomata closure is the first response in a plant with stomata closure resulting in a decrease in photosynthetic rate; Chaves et al. (2001) suggested that this occurs due to a decline in water potential which in turn lowers water-use efficiency and leads to a decrease in photosynthesis (Hamanish 2012).

On the contrary, when plants experience floods, this results in too much water in the soil, preventing the roots from intaking oxygen. As a result, the roots are unable to perform aerobic respiration, which results in root rot. This is especially true when terrestrial plants are under complete submergence in water as Mommer and Visser (2005) have suggested that this imposes stress on plants due to a lack of oxygen and rapidly results in a loss of biomass. In return, Yordanova and Popova (2001) found that long-term exposure of [barley] plants due to soil flooding led to a noticeable decrease in photosynthesis. Similar results are seen in Quercus alba seedlings as well (Gravatt and Kriby 1998).

Overall, under both extreme weather events, droughts and floods result in a decrease in photosynthetic rate of plants which leads to a decline in their health and can have potentially detrimental effects on the plants. Thus, understanding the effects of droughts and overwatering on two common types of grass: Bermuda and Saint Augustine grass can inform us on which species are resistant to which high-stress environment, allowing for better urban planning.

Due to the detrimental effects of both droughts and overwatering on plants, we expected there to be a decrease in photosynthetic rate of both flood conditions and drought conditions as measured by a decrease in the rate of carbon dioxide consumption due to photosynthesis. For control conditions, we expect consistent and constant photosynthetic rates during the period of our experiment.

## Methods

Two grass species were used in this experiment; *Cynodon dactylon* (Bermuda), and *Stenotaphrum secundatum* (Augustine) from Houston Grass and Houston Garden Center respectively. Each sample was divided into 9, 12x20 cm plots. These plots were placed atop potting soil and watered twice daily for two days before the experiment started to ensure plant health. After this pre-experiment assessment, plots were transported to the UH greenhouse.

Three repeat plots per species were used in each of the three treatments which consisted of no watering, healthy watering, and overwatering. These treatments were meant to simulate drought conditions, control conditions, and flood conditions, respectively. Each plot was given its own container to ensure independence. The no-water treatment received no-water, the healthy water treatment received two to three seconds of water from a watering pot daily, and the overwater treatment was fully saturated with water and replaced daily.

Three methods were used to assess plant health. Visual indications through pictures, $CO_2$ measurements, and a visual root rot inspection. To measure $CO_2$, two Pasco $CO_2$ probes were used simultaneously. The two probes were placed inside an airtight clear container with the plot to be measured and the final-initial $CO_2$ concentration change was recorded. These measurements were taken on day 1 (pre-treatment), day 3, day 5, day 8, and day 11, with pictures being taken every day except weekends due to the lack of greenhouse access. The root rot inspection was conducted on day 11 after $CO_2$ measurements were taken.

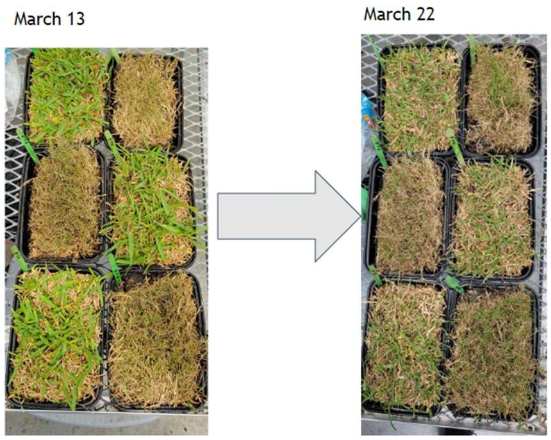
To quantify health changes seen in photographic records, greenness was used as a metric for health. ChatGPT was utilized to write a piece of code to do this. The code worked by using MATLAB's image processing functions to extract the green channel of two images (initial day and final day), by subtracting the red and blue channels. It then computes the average pixel value of the green channel using the mean function, which provides a measure of the overall greenness of the images.

## Results

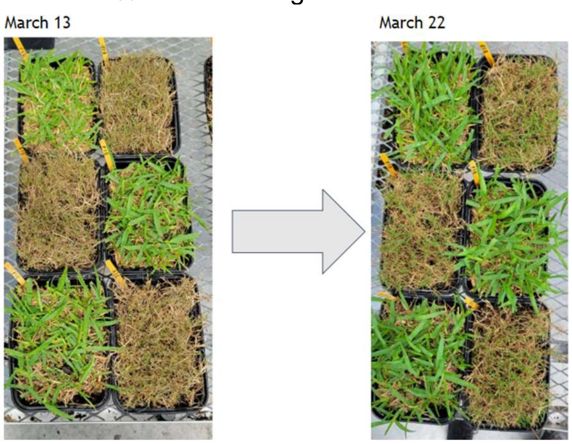
Quantitatively, no significant results in the $CO_2$ data were seen. For the no-water treatment group, Saint Augustine grass showed an increased carbon dioxide consumption, whereas Bermuda grass showed an increased carbon dioxide rate. For the healthy water treatment, both Bermuda grass and Saint Augustine grass showed an increase in carbon dioxide rate. Lastly, for the overwater treatment, Saint Augustine and Bermuda grass showed an increase in carbon dioxide rate, similar to that of the healthy water treatment. From the photographic record (Picture), the overwater treatment saw a 14.5% increase in greenness (Picture 3), the healthy treatment saw a 28.4% increase (Picture 2), and the no-water treatment saw a 35% decrease (Picture 1) from day 1 to day 11.

Qualitatively, the no-water treatment throughout the experiment showed a significant decline in health, as defined based on the color and growth of the plant, showing signs of browning for both Saint Augustine and Bermuda grass. The treatments for the healthy water and overwatering, however, showed an increased sign of growth, as indicated by the increase in a pigmented green throughout the blades of the grass in addition to visible grass height growth, especially in the Saint Augustine grass.

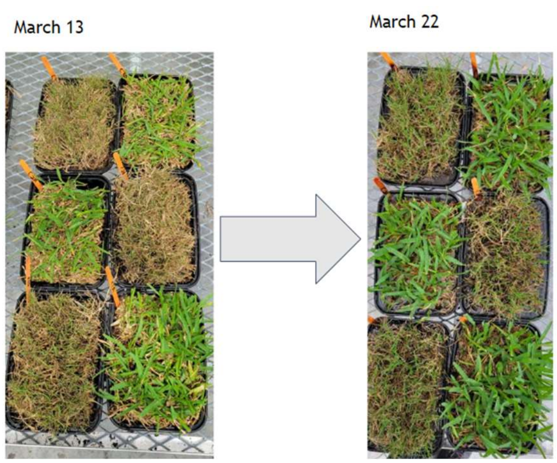
In a root examination of the plants, no signs of root rot were seen in the healthy water treatment for both Saint Augustine and Bermuda grass. For the overwatering treatment, no signs of root rot and decay were seen in the Saint Augustine grass, but the Bermuda grass had early signs of root rot and decay, as indicated by a discoloration (purple) stem and a discoloration (blackening) of roots.




Picture 1. No-Water treatment of Bermuda and Saint Augustine Grass before and after experimental time period. 35% decrease in greenness.

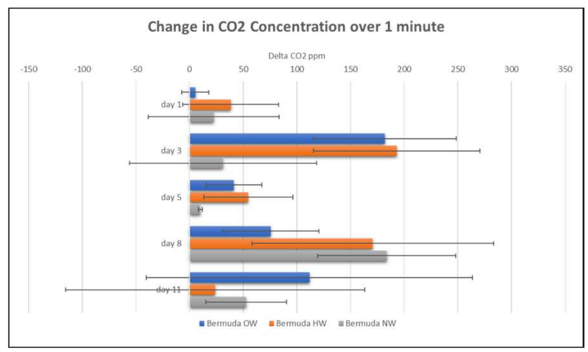



Picture 2. Healthy Water Treatment of Bermuda and Saint Augustine Grass before and after experimental time period. 28.4% increase in greenness.

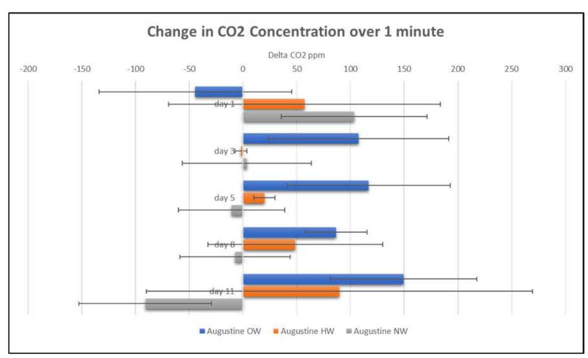



Picture 3. Overwater treatment of Bermuda and Saint August before and after experimental time period

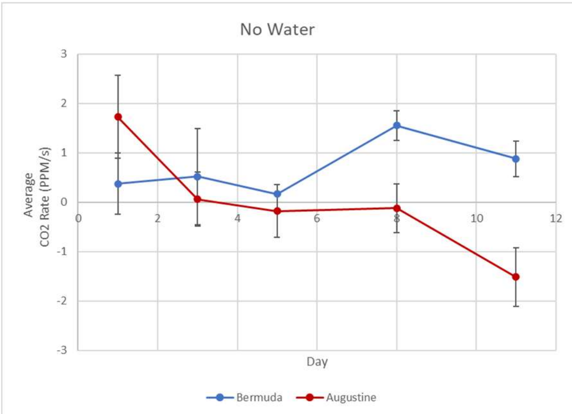
Picture 4. Root rot analysis of Saint Augustine grass (top) and Bermuda grass (bottom). Healthy water treatments are on the left and overwatering treatments are on the right.



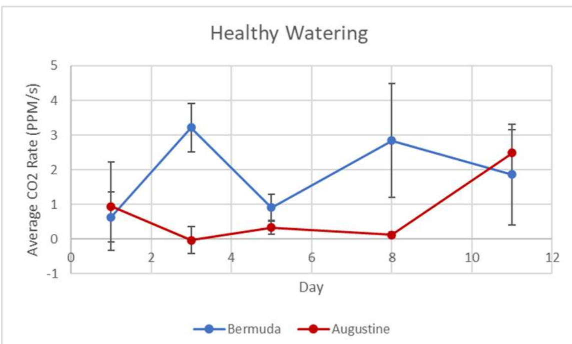

Graph 1. Change of carbon dioxide concentration of Bermuda grass over one minute on days 1, 3, 5, 8, and 11 of treatment.



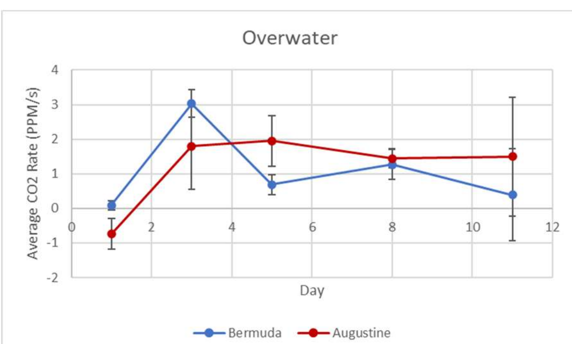

Graph 2. Change of carbon dioxide concentration of Saint Augustine grass over one minute on days 1, 3, 5, 8, and 11 of treatment.




Graph 3. Line graph of the no-water treatment group of both Bermuda and Saint Augustine graph on days 1, 3, 5, 8, and 11 of treatment.




Graph 4. Line graph of the healthy water treatment group of both Bermuda and Saint Augustine graph on days 1, 3, 5, 8, and 11 of treatment.




Graph 5. Line graph of the overwater treatment group of both Bermuda and Saint Augustine graph on days 1, 3, 5, 8, and 11 of treatment.

## Discussion

No noticeable significant trend was seen in the time progression line graph of both Bermuda and Saint Augustine grass. Though all three graphs indicate a trend in photosynthetic rate with their respective treatments, the healthy watering treatment, representing our control, showed that there is a variation in photosynthetic rate. As a result, it is not plausible to claim that a trend was significant throughout our experiment as the control treatment should have shown no change, or a linear change (due to growth) in photosynthetic rate.

One inference for our data to suggest variability in our data is that microorganism aerates the soil, which produces carbon dioxide gas as they go through cellular respiration, giving a reason for variability in photosynthetic rate between all of the treatment groups. Though further experimentation is needed to support this analysis.

Furthermore, a physiological examination of the plant health, as determined by the vigor and color of the plant, suggested that there was a significant decrease in plant health when comparing the no-water treatment group to that of the healthy watering and overwatering treatment groups. This is backed up by the quantitative results from the greenness test, which showed a large decrease in greenness compared to healthy and over watering which showed a large increase. This suggests that in this case, drought conditions played a much larger role in decreasing plant health compared to flood conditions.

When examining the roots of the over watering and healthy watering treatments, early indications of root rot can be examined within the bermuda grass of the overwatering treatment group. The healthy watering treatment group, however, had no indications of root rot.

## Limitations and Future Implications

Money was a limitation on the experiment as it limited the study to a limited supply of species to perform the experiment with. With more money, more variations of species can be experimented on and more samples of data can be collected. Furthermore, the greenhouse that was utilized to host the experiments was inaccessible during the weekends, resulting in two days of the week with little observance and performance. Access to the greenhouse on the weekends would allow for more consistent scheduling of data collection. The study was limited to only grasses and not floral plants, so experiments with a variety of plants would allow for a more comprehensive understanding of the effects of droughts and floods on plants. Experimentation of microorganisms in the soil that could perhaps influence carbon dioxide readings were not measured, so further experimentation is needed to determine the impact microorganisms have on carbon dioxide production. Lastly, the carbon dioxide probes utilized for the study showed inconsistent results, so different methodologies to determine photosynthetic rate should be documented.

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**Literature Cited**

Chaves, M. M., Pereira, J. S., Maroco, J., Rodrigues, L. M, Ricardo, P. P. C., Osorio, L. M., Carvalho, I., Faria, T., and Pinheiro, C. 2002. How Plants Cope with Water Stress in the Field? Photosynthesis and Growth, *Annals of Botany*, 89: 907–916, https://doi.org/10.1093/aob/mcf105

Duan, J. Liu, Y. , Wang, L. , Yang, L. , Jie and Tang, Chong-Jun and Zheng, H. 2022. Importance of grass stolons in mitigating runoff and sediment yield under simulated rainstorms. CATENA: Soil Science-Hydrology - Geomorphology 213: 3-7 https://www.sciencedirect.com/science/article/pii/S0341816222001187?via%3Dihub

Gravatt, D. and Kirby, C.1998. Patterns of photosynthesis and starch allocation in seedlings of four bottomland hardwood tree species subjected to flooding, *Tree Physiology* 18: 411–417 https://doi.org/10.1093/treephys/18.6.411

Mommer L., Visser, E. 2005. Underwater Photosynthesis in Flooded Terrestrial Plants: A Matter of Leaf Plasticity, *Annals of Botany*, 96: 581–589 https://doi.org/10.1093/aob/mci212

Pirasteh-Anosheh, H. , Saed-Moucheshi, A., Pakniyat, H. and Pessarakli, M. 2016. Stomatal responses to drought stress. In Water Stress and Crop Plants, P. Ahmad (Ed.). https://doi.org/10.1002/9781119054450.ch3

Stott, P. 2016. How climate change effects extreme weather events. Science: Climate Change 352: 1517-1518 https://www.science.org/doi/epdf/10.1126/science.aaf7271

Trenberth, K. 2008. The Impact of Climate Change and Variability on Heavy Precipitation, Floods, and Droughts. Encyclopedia of Hydrological Sciences 5: 5-11 http://climate.envsci.rutgers.edu/physclim2010/Trenberth2008.pdf

Yordanova, R. 2001. Photosynthetic Response of Barley Plants to Soil Flooding. Photosynthetica 39: 515–520 https://doi.org/10.1023/A:1015643710177

Yoro, K. and Daramola, M. 2020. $CO_2$ emission sources, greenhouse gases, and the global warming effect. Advances in Carbon Capture 1: 3-27 https://www.researchgate.net/publication/343508726_CO2_emission_sources_greenhouse_gases_and_the_global_warming_effect