Testing effects of a biochar blend on container-grown Albion strawberries

Senior Project

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By

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Abstract

Biochar as a soil amendment seems, in a majority of studies, to affect the physical and chemical properties of container substrates (Elad et al. 2012). These properties include bulk density, total porosity, container capacity, nutrient availability, pH, electrical conductivity and cation exchange capacity (Huang and Gu 2019). Biochar has also been shown to affect soil microbiota (Huang and Gu 2019). Several studies have also conveyed the ability of biochar to trigger defense-related genes in plants, which aid the plants in disease suppression (Elad et al. 2012). Because of the potential benefits of biochar in agriculture and nurseries, this study was aimed at analyzing any effects of a biochar blend on the growth and flowering of container-grown strawberries. This study was divided into two separate experiments, both using everbearing bare root Albion strawberries (Fragaria x ananassa "Albion"). The first experiment tested the effects of varying percentages of a biochar blend on container-grown Albion strawberries in greenhouse conditions. The second experiment also tested the effects of the biochar blend on container-grown Albion strawberry plants-but in field conditions. Results so far imply that the plants treated with lower percentages of biochar had more vegetative growth, but less flowering overall. This could be because of excess moisture, an overload of nutrients, and/or pathogens from the biochar blend suppressing plant growth.

Introduction

"Biochar is a type of charcoal or activated carbon that is especially good at supporting plant growth" (Vermont Organics 2020). In fertile soils, biochar does not have a profound effect (Jay et al. 2015). However, in poorer soils, it can act positively as an amendment (De Tender et al. 2016). Research has shown that a single, short-term application of biochar may not be sufficient for tangible effects on soils (Jay et al. 2015). However, research has also shown that low percentages of biochar are required to create an effect on a soil (Jay et al. 2015). 77.3% of studies reviewed by Huang and Gu (2019) suggested that certain percentages of biochar had positive effects on plant growth. Half of those studies further suggested that certain percentages of biochar actually reduce plant growth (Huang and Gu 2019). The effect of the biochar depends on how it is created and in what percentage it is applied to crops. The production and feedstocks incorportated into biochar affect it's physical and chemical properties, and therefore, it's ability to affect the soil's physical and chemical properties (Huang and Gu 2019).

In the first experiment, 30 Albion strawberry plants were grown in round containers in a small greenhouse that waters overhead daily. The second experiment tested the effects of the biochar blend on 24 Albion strawberry plants- but in long, rectangular containers situated in a standing rack.

The initial purpose of this study was to test the effects of a biochar blend on the establishment of containter-grown, everbearing, bare-root Albion strawberries (Fragaria x ananassa "Albion"). Establishment was measured by survivorship of plants after the bare-root strawberry plants were transplanted into container pots. The establishment period was 4 days after planting. However, all strawberry plants survived the 4 day establishment period, so my mentor and I decided to extend our studies further by measuring the effects of the biochar blend on plant growth and flowering.

According to StrawberryPlants.org (2020), Albion strawberries are among the recommended strawberry varieties for North Carolina. According to Burpee Seeds and Plants (2020), the Albion strawberry is a new variety from California that produces firm, especially sweet fruits. The variety resists Verticillium wilt, Phytophthora crown rot, and resists anthracnose crown rot. "US Plant Patent #16,228" (Burpee Seeds and Plants 2020).

Methods

Treatments were 0% biochar blend, 0% biochar blend + 30% sand, 5% biochar blend, 10% biochar blend, 20% biochar blend, and 30% biochar blend for both the outdoor and indoor experiments. The 30% sand was used in 9 of the controls (4 from the outdoor experiment and 5 from the greenhouse experiment) because strawberries normally prefer sandy soils. The biochar blend that was used consisted of invasive buckthorn for feedstock, kiln-kired biochar, and organic fertilizer (coffee skins). Vermont Organics claimed that the coffee skins were included in the blend "to charge the biochar with nutrients and add bio-available carbon to the soil" (2020). Vermont Organics claimed that the fertilizer used in this blend is coffee skins (2020). Specifically, the biochar blend consisted of 75% coffee skins and 25% biochar, by weight (Vermont Organics 2020).

This blend was designed to prevent the need to mix biochar with a fertilizer prior to adding it to soil. The remaining percentages of substrate in the containers consisted of Miracle Grow® potting soil. There were 5 containers of each of the 6 treatments for the greenhouse experiment, so 30 containers total. There were 4 of each of the 6 treatments for the outdoor experiment, so 24 total plants. The containers for the outdoor experiment were rectangular, while the greenhouse containers were round pots.

The rectangular pots for the outdoor experiment were situated on a standing rack that was angled so that all plants had access to sunlight and water (shown below). A randomized block design was used when placing treatment pots in a grid in the greenhouse and on the standing rack for the outdoor experiment. We decided to use rectangular pots because we believed this would mimic the open ground that strawberries normally have access to on crop field. However, this still allowed us to see the effects of biochar in container-grown strawberries, as the strawberries were still in containers. Strawberries usually spread out in crop fields by way of stolons, or runners, so these rectangular pots in theory should have allowed for more stolon development. The 30 containers in the greenhouse were all level with each other on a table underneath watering heads. Rain gauges were used to measure the average amounts of water the plants received. Water was measured weekly (and divided into daily averages) for the greenhouse experiment. For the outdoor experiment, water was only measured after rain fell. The greenhouse regularly waters the plants inside with an average of 4mm of water a day. After the plants' initial transplanting into their respective containers, the plants were not watered by us.

Height and number of flowers was measured the second and third week after planting to test the effects of the biochar blend. On the 4th, 5th, and 6th weeks, we measured plant width (mm) and leaf width (mm), as well as plant height (mm) and number of flowers. In order to make measurements of height, leaf width, and plant width, a standard clear ruler was used (300mm) The plants never reached a height that exceeded the ruler (300mm), but some of the plants exceeded the 300mm ruler in width. When this was the case, the aforementioned plants were recorded as having a width of "300+." Leaf width was measured by finding the largest leaf on each plant and measuring across. Plant width was recorded by measuring the widest diameter of each plant. Flowers were cut off of each plant as they were counted each week. Data was entered into Excel spreadsheets for the generation of graphs (shown below) to better grasp the data and draw any possible trends or conclusions.

Results

A 30% biochar blend plant from the outdoor experiment died in week 4. A 20% biochar blend and a 0% +30% sand plant died from the greenhouse experiment in week 6.

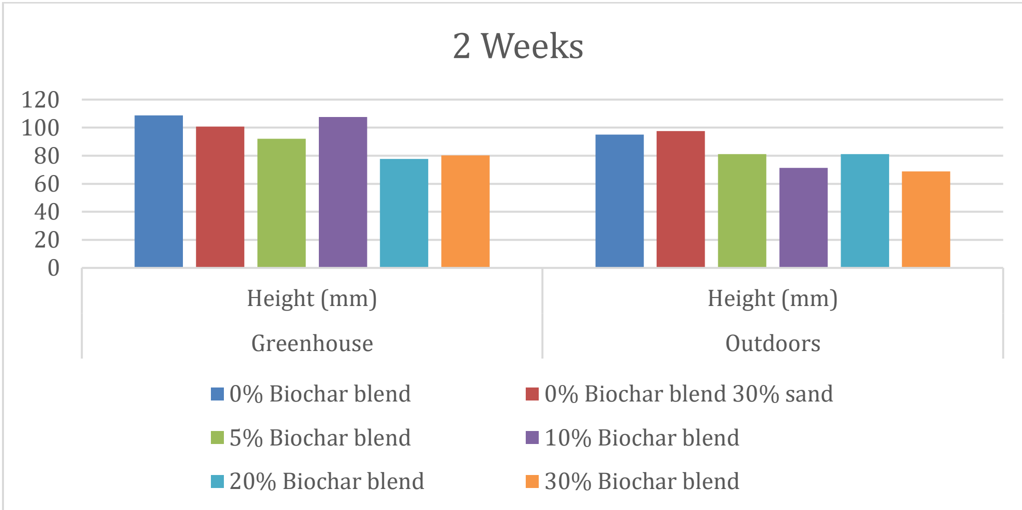
<u>Outdoors:</u>
Visually, the controls look to be more successful than those treated with more biochar blend.

0% Biochar blend →

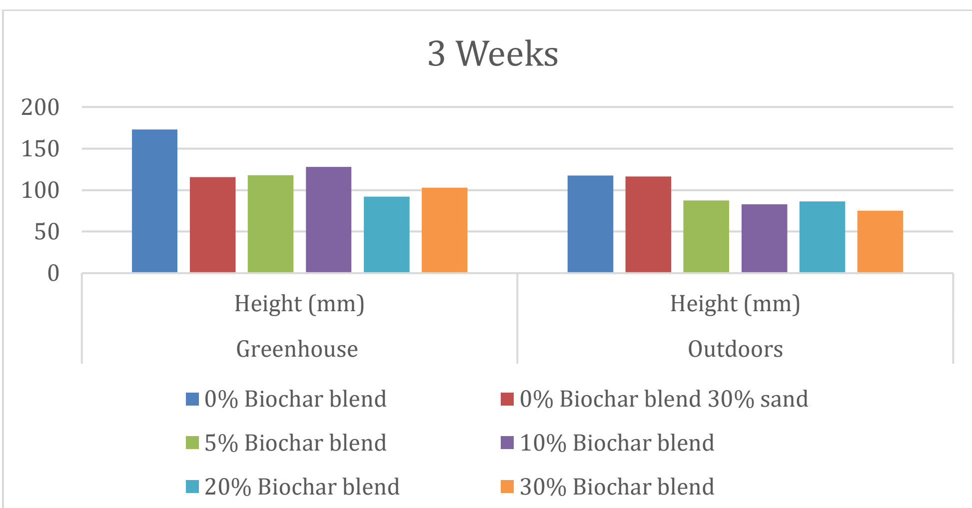
30% Biochar blend →

<u>Greenhouse:</u>

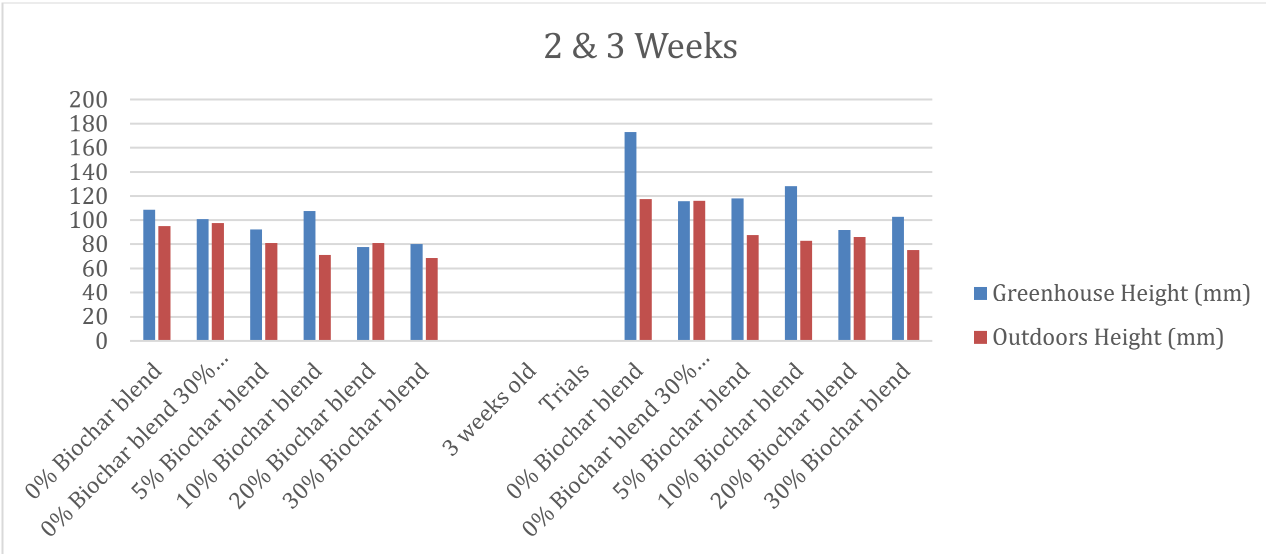
Visually, the controls look to be more successful than those plants treated with higher biochar blends. However, this data could not just be analyzed visually, so I created some graphs below to get a more accurate analyzation.



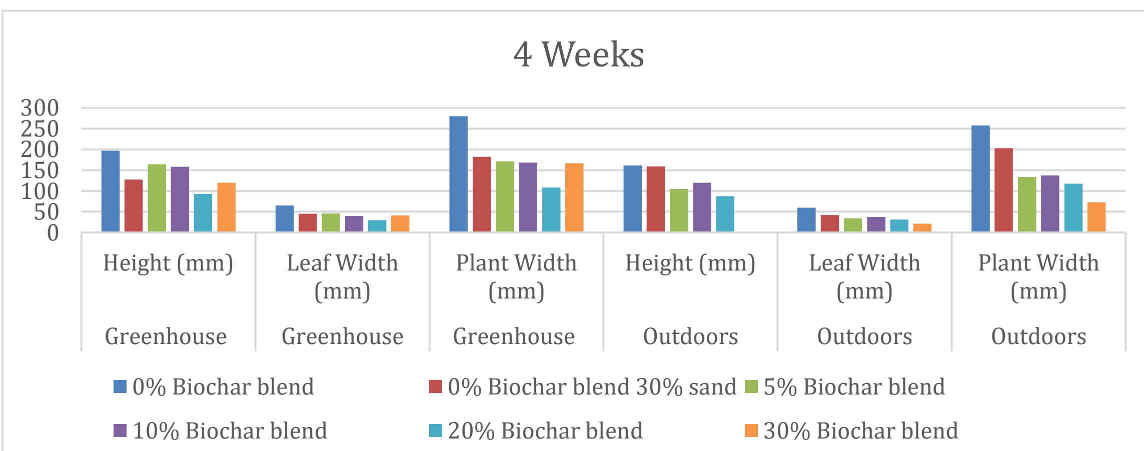
These graphs show the compiled average heights (in mm) of the greenhouse and outdoor trials 2 weeks after transplanting. This data shows that for the greenhouse Albion plants, the 0% biochar blend, 10% biochar blend, and 0% biochar blend + 30% sand were the tallest. These three treatments were followed by the 5% biochar blend, 30% biochar blend, and 20% biochar blend. In the outdoor experiment, the 0% biochar blend + 30% sand, 0%, 5%, and 20% were the tallest. These were followed by 10% and 30%.



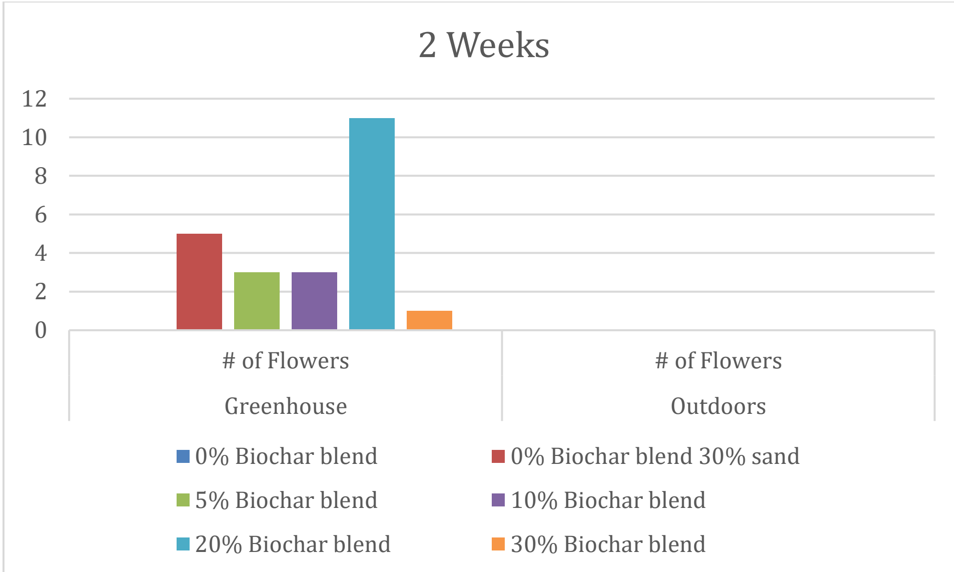
In the greenhouse on the third week, the 0%, 10%, and 5% biochar blends were the tallest. These treatments were followed in succession by 0% +30% sand, 30%, and 20% biochar blend. Outdoors, the tallest plants were from the 0%, 0% +30% sand, and 5% biochar blends. The next tallest were the 20%, 10%, and 30% treatments.



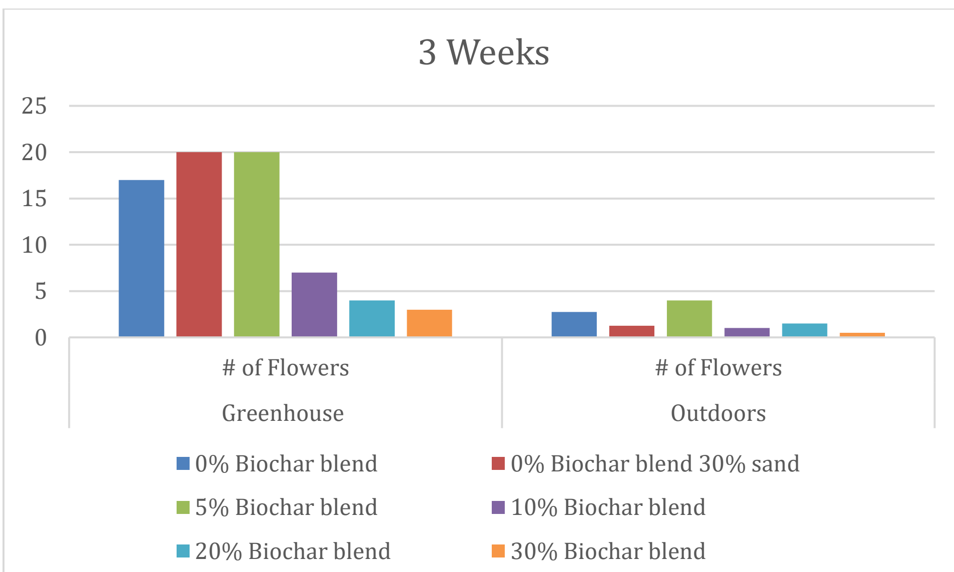
This graph show a side-by-side view of the height data from the 2nd and 3rd weeks. The greenhouse heights on average are shown to be higher than the heights of the outdoor experiment in both weeks 2 and 3. The 20% biochar blend treatment was the only treatment where the outdoor height exceed the greenhouse height (in the 2nd week). In the third week, the 30% biochar blend was the only treatment where the outdoor height exceeded the greenhouse height.



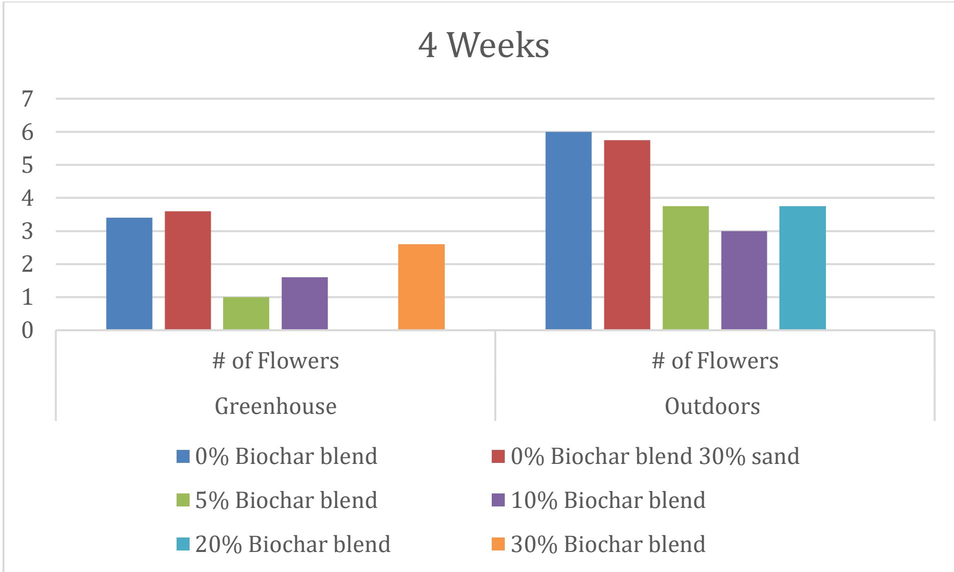
On the 4th week, we began measuring leaf width and plant width as well as plant height and number of flowers. In both the outdoor and greenhouse experiments, the 0% biochar treatment plants had the greatest average heights, leaf widths, and plant widths. The second highest averages were from treatment 0% biochar blend + 30% sand, with the exception of the greenhouse heights. The second highest greenhouse plant height was the 5% blend. The trend for the lowest measurements belongs to the 20% and 30% biochar blend treatments.



In the 2nd week after transplantation, the outdoor experiment plants produced no flowers at all. The greenhouse experiment plants did though. Among the greenhouse trials, the 0% biochar (control) did not have any flowers. The 20% biochar blend treatment had the highest amount of flowers- significantly more than the other treatments. This is interesting because the 20% treatment plants (according to previous graphs) are shown to be lower in height on average than the rest of the treatments.



At 3 weeks, the outdoor trials had grown flowers, with the 5% treatment containing the most flowers on average. Of the greenhouse trials, the 5% and 0% + 30% sand had the highest numbers of flowers. The 0% biochar blend had the 3rd highest amount of flowers on the greenhouse trials, and the 2nd highest number of flowers in the outdoor trials. The 30%, 20%, and 10% treatments in both greenhouse and outdoor experiments had the lowest number of flowers.



At 4 weeks, the outdoor experiment was producing more flowers in every treatment category except for the 30% biochar blend. There were no flowers in the 30% blend at all in the outdoor experiment at week 4. There were no flowers at all in the 20% blend for the greenhouse experiment. The 0% and 0% +30% sand were the highest flower producers in both experiments in week 4.

Discussion & Conclusions

As noted above in the results section, three plants have died since we began this experiment, and the cause is unknown to us. In the case of the 20% biochar blend plant that died in the greenhouse, the rest of the 20% biochar blend plants look weak as well. Perhaps all five of those plants are undergoing the same stressors. The dead 30% plant from the outdoor experiment could have died from excess moisture in the soil, which can lead to pathogens, fungi, and mold. Green mold was recorded in every 30% biochar blend container in the greenhouse.

We noticed that although the rain gauges showed that both sides of the table in the greenhouse were watered approximately the same amount each day, the containers with the higher biochar blend percentages felt more moist than the lower percentage pots. Because of this, we believe that the biochar retains moisture well. This could be the reason that fungus was growing in the pots with higher biochar blend percentages in the first two weeks of planting.

According to Burpee Seeds and Plants (2020), Albion strawberry plants are usually planted 18-24 inches apart in rows in crop fields for best results, but the outdoors experiment that was performed was meant to mimic field conditions as closely as possible whil still planting in containers. However, the overall vegetative growth performance of the greenhouse plants was better than the outdoor plants. This is probably because of the daily access to water, versus the outdoor plants depending on occasional rainfall. The greenhouse strawberries had faster vegetative growth and they flowered sooner, but the data also seems to show that the outdoor plants' flower numbers are steadily increasing while the greenhouse plants' flower numbers are decreasing every week.

Because of Huang and Gu's research (2019), and advice from Dr. Bryan Sales in the UNC Pembroke Biology Department, we decided it would be beneficial to send samples of the biochar blend to a soils lab at NC State for analyzing. We would like to know the pH and nutrient content. According to Huang and Gu (2019), the production and feedstocks of biochar affect it's chemical and physical properties, and this is why my mentor and I would like to know the specifics of our biochar blend. In conclusion, more information is needed on the properties of this specific blend of biochar before we can make any more assumptions. More repetitions are also needed, of course, to determine if the slight trends we are seeing are constant.

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