Interaction and Effects of Phenolic Acids on Early Stage Plant Growth

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Abstract

The study conducted was based around abiotic plant stresses. Various phenolic acids were mixed with water, forming ‘stress solutions’ which were used as the plant’s main water source. The beginning hypothesis was that exerting this stress onto the plants would inhibit growth more than using deionized water would, due to plants having a possibility of already containing or producing phenolic acids—oversaturation of the phenolic acids would thus hypothetically cause negative outcomes. Materials and methods are then discussed, including how the plants used (cucumber seeds) were prepared and then measured on a continuous basis. There were two controls present as well as five variables. Midway through the experiment as well as at the end, the plants true leaves and roots were measured in centimeters to assess growth and compare controls to variables. Results revealed that the beginning hypothesis did not hold completely true, as some of the plants treated with phenolic acids grew larger or as large as the controls. Lastly, discussion was based around the experiment’s results as well as how this experiment could be conducted differently in the future.

Introduction

Stress is defined as pressure or tension exerted on a material object. In this instance, the stress is in the form of multiple chemical solutions and the material object is a plant. Plant stress is essentially a cause and effect relationship. When an object comes into stress and/or stressful situations (cause), there are many potential outcomes (effect). Plant stress responses specifically are divided into two categories: biotic and abiotic. Biotic stress resulting from living organisms, or abiotic stress resulting from nonliving things. This study is based around abiotic plant stresses. Plant stresses include varying levels of stress intensity. “Depending on the intensity and duration of stress, such changes can be reversible or irreversible, leading in extreme cases to the plant’s death” (Weidner). The specific stresses tested were from phenolic acids mixed with water to form “stress solutions” that the plant would use as its main water source.

The chemical solutions added in included phenolic acids such as: Gibberellic Acid (GA), Salicylic Acid (SA), and Auxins (IAA). GA and SA are notable for their influence in the growth of stems and roots, while IAA is notable for its influence in only stem growth. According to Prashant Kaushik’s article “*Breeding Vegetables with Increased Content in Bioactive Phenolic Acids*”, “Phenolic acids are secondary metabolites characterized by the presence of an aromatic ring with an organic carboxylic acid functionality”. Secondary metabolites are not primarily needed in the growth and function of organisms, but impair the organism when they happen to be absent, or greatly assist the organism when present.

Researching plant stress resulting from phenolic acids is important for multiple reasons. One of the reasons being that phenolic acids are being seen much more often in breeding plants. Phenolic acids have become a prominent factor in the breeding of plants, however when used too heavily, they can lead to negative outcomes. “In consequence, increasing phenolic acids content in vegetables may have an impact in other traits of interest, like tolerance to biotic and abiotic stress, browning, or flavor that should be considered in breeding new vegetable crops varieties” (Kaushik et. al). Not only are phenolic acids widely important for the breeding and sustaining of plants, but they also have an impact on human health.

It was hypothesized that exerting stress onto the plants themselves would inhibit growth more so than allowing the plants to grow naturally. This is because plants themselves may contain or produce phenolic acids, so when they are added manually / purposefully, it can lead to an oversaturation and cause a negative impact.

Materials / Methods

For the research experiment, the different phenolic acids were broken up among groups. Each group obtained seven jars that were used for each solution. Five of these jars contained the acid + water solution and two of the jars remained as controls. Each jar was filled to nearly the top with 110mL of solution. One of the controls remained at full strength and one of the controls was 1/32 strength, while the five variable jars were at 1/32 strengths. The solutions were made by being weighed out using a volumetric flask, then stirred and heated until they were brought to a boil, and ultimately stored in a cabinet due to photodegradation.

Following the solutions being prepared, the plants themselves had to be prepared. The plants used were cucumber seeds. The plants were grown within vermiculite, soil without nutrients, as to not tamper with the purpose of the experiment. Within a glass tray, a small amount of vermiculite was added, followed by the seeds and water. The glass trays were kept in a 30-degree Celsius environment for two days and covered in aluminum foil as to keep out unwanted light, and allow for germination to begin. After those two days, the plants were uncovered and placed in light to grow for five days. The seedlings were transplanted into the previously made nutrient solution jars after their five days of growth. Before the jars were put away to allow the plants to grow, there were holes poked in the plastic lid to allow the roots to breathe. The plants were then placed directly under light for a period of two weeks to grow and develop.

Throughout the two weeks, the plants were continuously monitored and well kept. Students continuously came in every few days to fill up their solution jars, and maintain saturation in the plants. Around halfway through the experiment, and at the end, the plants true leaves and roots were measured (in cm), to assess any growth that may have taken place. At the end of the two weeks, the plants were taken out of the nutrient solutions, dried, and the roots and shoots were separated and the dry-weight was taken for every plant.

Results

There was little to no qualitative data shown throughout the experiment. Qualitative data was looked for, but not quite as abundant as predicted. Qualitative data was only found in the purpose of if, there was change between the pre-treatment and post-treatment, and that result is yes.

Quantitative data was the abundance of what resulted from the experiment. This data included number of leaves, leaf area, dry weight (both root and shoot), and root length. The number of leaves for each plant varied from three to five, but was really only abled to be measured in the post treatment phase. Dry weights were nearly the same, as they were only able to be measured following the completion of the growth cycle as the plants were killed to do so.

Change is root length was the most abundant difference between all plants. Figure 1 shows the average root-length change between the pre-treatments and post-treatments for all used phenolic acids and both controls. It’s shown that there was no significant difference between the phenolic acids themselves and the controls, but there was significant difference between the pre-treatment and post-treatment for nearly every plant.

Figure 1. Average Change in Root Length from Pre to Post Treatment for all Solutions. This graph shows the average change in root length from the pre-treatment to the post-treatment for all solutions. The treatments compared to the controls show no significant difference in varying strengths and phenolic acids.

Discussion

The plants throughout the experiment were measured for both qualitative and quantitative data. Although it was looked for, there was little to no qualitative data throughout the entire experiment. There however was an abundance of quantitative data. This data includes leaf area, number of leaves, and root length. One of the most apparent changes in the plant between pre-treatment and post-treatment as well as between each solution was root change. Overall, each plant’s average root change increased by a good amount from the beginning to end, thus showing almost no difference between the phenolic acids and the controls.

It was hypothesized at the beginning of the research that exerting stress onto the plants themselves would inhibit growth more so than allowing the plants to grow naturally. It was found that the hypothesis was not entirely true, as some of the treated plants grew to be larger than the controls. The stresses themselves also did not inhibit growth, as expected. According to Sylwia Swigonska’s article “Influence of abiotic stress during soybean germination followed by recovery on the phenolic compounds of radicles and their antioxidant capacity”, it is believed that interactions of plants with their environment comprise biosynthesis of various secondary metabolites. These secondary metabolites, or Phenolic Acids, are actually meant to help the plants as opposed to harm them.

In the future, one of the most notable changes to make would be testing more than one plant type. Nearly all the articles that were read and researched had comparisons of multiple plants and how they interacted with similar stresses, as opposed to the same plants with different stresses. Another test for the future could include how these phenolic acids contained within plants affect the consumer.

Literature Cited

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