Observing the Influences of Carbon dioxide, Light, and Chlorophyll in *Sansiveieria trifasciata* and *Pelargonium hortorum* on Photosynthetic Rate, Starch Content, and Rate of Flow

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ABSTRACT

The goal of these experiments was to test the influences of chlorophyll, light, and carbon dioxide on the process called photosynthesis. The first experiment involved testing light intensity as a factor of distance on the rate of photosynthesis of leaf disks. The results showed that the shorter the distance the light source is to the leaf disks the greater the rate of photosynthesis. The second experiment involved testing the starch content found in leaves exposed to different light conditions using I$_2$KI. The results showed that the leaves kept in the light for 24- hours had higher levels of starch than the leaves kept in the dark for 24-hours. The last experiment preformed involved measuring the rate of flow of different pigments found in plant extract using pigment chromatography. The results showed that the pigments that traveled the furthest from the solute spot had a higher rate of flow. In conclusion, light and chlorophyll are key essentials to productivity of plants and without them plants could not provide us with oxygenated air.

INTRODUCTION

Plants get energy from sunlight through a process called photosynthesis. Photosynthesis is a chemical process that turns carbon dioxide into carbohydrates, simple sugars, and generates oxygen as a byproduct (Gannon, M. R.). A number of factors influence the photosynthesis process in plants. Chlorophyll is a light-absorbing pigment found in plants, it plays a key role in converting light energy into food for plants. When no light is present plants cannot preform photosynthesis, therefore plants need other means of food to survive (Smith, R. L.). Some plants convert light energy and store it as reserves in the form of transitory starch, for which plants to use during the nighttime
hours. Transitory starch is confined to leaves and many plants can often survive without this starch but most have the ability to retain them (Weise & Sharkey, 2011). Also, “The relationship between the availability of light and the rate of photosynthesis varies among plants. For example, plants growing in shaded environments tend to have lower light compensation point, a lower light saturation point, and a lower maximum rate of photosynthesis than plants growing in high-light environments”(Smith, R.L., 101). At the end of the day, plants need sunlight to thrive and other species rely on plants as a source of food and to create breathable air for the world.

The purpose of part 1, Rate of Photosynthesis Experiment, was to measure the photosynthetic rate of leaf disks under light sources raised to different heights. The following hypothesis was tested: The greater the light intensity is on the leaf disks of *Sansiveieria trifasciata*, the greater the rate of photosynthesis. The null hypothesis for this experiment is that there will be no difference in leaf disks response to the different heights of the light sources. The experiment began with placing 5 leaf disks in a petri dish filled with sodium bicarbonate and then placing the dish under a lamp set at a certain height. The disks were then timed for how long it took them to float to the top of the petri dish. These times were then used to calculate the rate of photosynthesis.

The purpose of part 2, Products of Photosynthesis Experiment, was to observe the starch content in leaves exposed to different light conditions. The following hypothesis was tested: The leaves kept in light will have greater starch content than leaves kept in the dark. The null hypothesis for this experiment is that light has no effect on the starch content in leaves. This experiment started out with taking three leaves exposed to different light conditions, 24-hour light, partly covered, and 24-hour
darkness; and essential denaturing the leaves by boiling them in water then ethanol. The leaves were then stained with iodine to view the amount of starch found in them under that light condition.

The purpose of part 3, Photosynthetic Pigment Chromatography Experiment, was to measure the rate of flow of different pigments found in plant extract using pigment chromatography. The following hypothesis was tested: The pigments that travel the furthest from the solute spot will have a greater rate of flow. The null hypothesis for this experiment that the distance the pigments travel have no effect on their rate of flow. This experiment started with applying a small plant extract to one end of a chromatography strip and then placing the strip in a chamber containing a chromatography solution. The pigments separated and the distance each pigment travelled from the solute spot was measured. This value along with the distance of the solvent line was used to then calculate the rate of flow.

MATERIALS AND METHODS

Part 1: Rate of Photosynthesis Experiment; involved taking a cork borer and cutting out 5 disks from a leaf of a Snake plant while avoiding the large leaf veins. The 5 disks were then placed in a test tube filled with .016 M sodium bicarbonate. An aspirator was then used to evacuate all the air out of the tube until the solution bubbled. Removing the hose from the faucet broke the seal from the vacuum causing the sodium bicarbonate to be forced into intercellular spaces of the leaf disks. This caused the leaf disks to sink to the bottom of vile. The disks were then washed off in a petri dish with new sodium bicarbonate. Next, the petri dish was then placed under a lamp set at a height of 5 cm. Then using a stopwatch, each disk was timed for how long it took them to float to the top
of the petri dish. This process was repeated four more times for lamp heights set at 10 cm, 20 cm, 40 cm, and 80 cm. The times were recorded in table and rate of photosynthesis was calculated. Rate of photosynthesis is equal to 1 divided by the mean time in seconds all multiplied by a 1000. The rates of photosynthesis were then graph in a line graph. Also, a line graph containing the means was created. The independent variable in this experiment was the light intensity as a factor of distance and the dependent variable was the rate of photosynthesis.

Part 2: Products of Photosynthesis Experiment; involved selecting a leaf from each of geranium plants that were exposed to different light conditions. The first plant grew in a bright light for 24 hours, the second plant grew in bright light with a part of the leaf covered, and the third leaf grew in complete darkness for 24 hours. The leaves were then placed in boiling water for 15 to 20 seconds to break down the cell membranes to allow for the release of any water-soluble anthocyanins that might have been present. While wearing goggles, each leaf was placed in a beaker containing 75-100 mL of boiling 90% ethanol to extract the chlorophyll in each leaf. After the extracted was removed, the leaves were rinsed for a few seconds and were placed immediately in a petri dish containing 25 mL of I₂KI. The leaves were left in the petri dish for two minutes until the leaves changed to a bluish or purplish color. The leaves were then rinsed off with cold water and compared with one another. The observations and comparisons were recorded. The independent variable in this experiment was the amount of light that the leaves are exposed to and the dependent variable was the amount of starch content in the leaves.

Part 3: Photosynthetic Pigment Chromatography Experiment; involved performing two runs using Paper Chromatography strips and the setup in Figure 1. A dot
was made with a pencil 1.5 cm from the bottom of the chromatography strip to indicate where the plant extract was going to be applied. Using a capillary tube, a small amount of plant extract was placed on the pencil dot on the chromatography paper. The smaller the dot of the extract was, the better the results were. After the first dot dried, the dotting process was repeated 10 to 12 more times on the same spot until the spot turned a dark green. While the paper strip dried, the chamber was prepared by adding about 25 drops of chromatography developing solution. Once the strip was dry, it was hung in the test tube or chamber as shown in the figure. The strip did not touch the walls of the test tube and the spot on the strip was above the solvent line in the chamber. Next, the chamber was placed in the rack so not to disturb the solvent that was migrating up the strip and separating the pigments. The strip was removed from the chamber when the solvent was about 1 cm from the top of strip. Then the solvent ending point was marked with a pencil line. The pigments were then locate on the strip and outlined with a pencil. Carotenes are orange, lutenin are gray, chlorophyll A is blue/green, and chlorophyll B is yellow/green. The distance of the pigments and the solvent line were then measured from the solute spot. The distances were recorded and then were used to calculate the rate of flow (Rf) for each pigment. Rf is equal to the distance a pigment travels divided by the distance of the solvent travels. Lastly, Rf values were recorded and each pigment was determined using the values. The independent variable in this experiment was the pigments in the plant extract and the dependent variable was the rate of flow of the pigments.
RESULTS

The results for part 1 of this experiment show that the greater the light intensity is the less time it takes for the leaf disks to float (Graph 1). Also, the further away the leaf disks were from a light source the slower the rate of photosynthesis is (Graph 2). Next, the results for part 2 of this experiment show the leaf kept in 24-hour brightness turned completely bluish, the leaf kept in bright light with a part of it covered turned partially bluish, and the leaf kept in complete 24-hour darkness hardly turned bluish in color from I₂KI (Figure 2). Lastly, the results for part 3 of this experiment show that pigments that traveled the furthest from the solute spot had a higher rate of flow (Table 1).
Graph 1: The mean times for each disk float trial

The Mean Time (s) that the Disks took to Float as a Function of the Light Intensity as a Factor of Distance

This graph shows the average times it took each of leaf disks to float when exposed to light sources set at different heights. The greater the light intensity the faster the disks floated.

Graph 2: The rate of photosynthesis for each trial

The Rate of Photosynthesis as a Function of the Light Intensity as a Factor of Distance

This graph shows the rate of photosynthesis for each trial and how longer the distance the light source is from the disks the slower the rate of photosynthesis.
Figure 2: Leaves exposed to different light conditions and their starch content

This figure shows how leaves kept in the dark use up their stored starches to survive because they cannot perform photosynthesis.

Table 1: The Rf values for each pigment

<table>
<thead>
<tr>
<th>Substance</th>
<th>Rf</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyll B</td>
<td>.13</td>
<td>Yellow-green</td>
</tr>
<tr>
<td>Chlorophyll A</td>
<td>.35</td>
<td>Blue-green</td>
</tr>
<tr>
<td>Lutin</td>
<td>.46</td>
<td>Gray</td>
</tr>
<tr>
<td>Carotenes</td>
<td>.59</td>
<td>Yellow-orange</td>
</tr>
</tbody>
</table>

This table shows the rate of flow (Rf) and colors for each of the substances that migrated through chromatography strips. The greater the distance the substance traveled the greater the rate of flow (Gannon, M. R.).

DISCUSSION

The results for part 1 show that the greater the distance the light source is from the leaf disks the longer it takes for the disk to perform photosynthesis and float to the top. The sodium bicarbonate solution caused the leaf disks to sink, and when the disks were placed under the light the photosynthetic process began. Under
the lamps, the disks began converting Carbon dioxide into a food source. Oxygen was released as a by-product, which caused the disks to float. There is a negative correlation between distance and rate of photosynthesis. Also, there is a positive correlation between distance and time. The results of the experiment support the hypothesis that the greater the light intensity is on the leaf disks, the greater the rate of photosynthesis. The overall general idea of this experiment is to show that plants need light to survive and preform photosynthesis. Without sunlight, plants could not convert Carbon dioxide and air humans breathe would no longer be oxygen-enriched. The results were conclusive to the prediction; however, errors could have occurred. For example, human error could have occurred with the timing the disks. Some modifications could be made to the experiment to produce better results. For example, the experiment could involve more light sources at different heights or more light sources raised to the same heights to produce more accurate results. Additional experiments could be done to further test this hypothesis. Different color light sources could be tested to see how they affect the rate of photosynthesis. Also, the results of this experiment raise some important questions that pertain to other issues. What would happen to plant life if and when the sun burns out? And if that happened, what would happen to the organisms that depend on plant life? In conclusion, other organisms rely on plants for food and for oxygen-filled air. Without sunlight, plants could not perform photosynthesis and provide those necessities for organisms.

The results for part 2 of the photosynthesis experiment show that the leaf kept in the 24-hour brightness had higher starch content than the leaf partially
covered and the leaf kept in complete 24-hour darkness. The leaf that was kept in the light turned blue from the I$_2$KI. It did not need to use the stored starch the leaf reserved for food, because it was able to perform photosynthesis. On other hand, the leaf kept in complete darkness had to use its stored starch to survive, because it was not able to perform photosynthesis. The results of the experiment support the hypothesis that leaves kept in light will have greater starch content than leaves kept in the dark. The general idea that can be drawn from this experiment is that without sunlight plants use up stored nutrients such as starch to survive. This is how plants survive at night, by using the stored food that they had made during the day from photosynthesis. The results were conclusive to the prediction; however, there are some possible sources of error. For example, maybe not all the chlorophyll was extracted for the leaves when they were boiled in the ethanol. This could have damaged the staining processes of starch content in the leaves. Next, some modifications could be made to the experiment to produce better results. For example, test more than just one leaf from each light condition to provide more accurate results. In addition, additional experiments can be performed to further test this hypothesis. Possibly test different plant leaves for their amount of starch content under different light conditions. Also, maybe test different light conditions on leaves such as exposing leaves to an hour of light then an hour of dark and alternate back and forth for a 24-hour period. Lastly, the results of this experiment raise some important questions that pertain to other issues. What other types of nutrients are found in plants? Are these nutrients beneficial to other organisms? In conclusion, without performing photosynthesis during the day plants could not produce the food that they use to survive during the night.
Finally the results for part 3 of this photosynthesis experiment show that carotenes have an Rf value of .59, lutin have an Rf value of .46, chlorophyll A have an Rf value of .35, and chlorophyll B have an Rf value of .13. The pigment that traveled the furthest from the solute spot was carotene, which means it had the highest rate of flow, .59, compared to the rest of the pigments. The results of the experiment support the hypothesis that the pigments that travel the furthest from the solute spot will have a greater rate of flow. Next, some general inferences cannot really be made from these results. The results really only apply to plants. However, the technique of allowing a substance to migrate across field is applied to more than just plant extract. For example, using a process called electrophoresis separates genes. An electric current is applied and genes separate as they travel along a gel field. An error that could have occurred is not allowing the solvent to travel up the strip far enough before measure the distance. This could have caused the Rf values to be inaccurate when calculated. Also, the chromatograph strip could have touched the side of the chamber, which could have thrown off the calculation. The results are reliable because more than one trial was done, and the trials revealed same conclusion. In addition, some modifications could have been made to the experiment to produce more accurate results. For example, maybe eliminating the chamber and a clothesline technique to have the strips just dangle in the solvent. By eliminating the chamber, the error of the strips touch the sides is eliminated. Additional experiments can be done to further test this hypothesis. For example, test using a line of plant extract instead of a spot of plant extract. Pigments would be more easily seen when separated if the solute is spread in a line. The results of this experiment raise some important questions that pertain to other topics. What role do chlorophyll pigments play in photosynthesis? How does different quantities
chlorophyll effect photosynthesis? In conclusion, chlorophyll captures sun’s light energy that the plants use to produce food. Chlorophyll is the most important pigment in photosynthesis.