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Investigation of Photosynthetic Properties In Spinach and Geranium: Pigments, Starch Production, and Light Wavelength Absorbance

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Investigation of Photosynthetic Properties In Spinach and Geranium: Pigments, Starch Production, and Light Wavelength Absorbance

by Alison Lederer

(Biology 1151)

ABSTRACT

An investigation into photosynthetic production based on the absorbtion spectra of pigments present in spinach leaves, the presence of multiple pigments in spinach leaves, and the apparent relation between light and the production of starch in *Geranium* leaves was performed. The data illustrates the dependence of starch production on the availability of light in *Geranium*. It was found that spinach photosynthetic pigment absorbed light optimally between wavelengths of 400 nm and 450 nm and also at 650 nm. It was also found that this green phototroph absorbed light minimally at wavelengths of near 550 nm. Chromatographic separation of the molecules of pigment showed the presence of two different pigments in spinach leaves. Further investigation is needed to validate assumptions drawn using the experiments performed.

INTRODUCTION

The importance of studying the process of photosynthesis is that "a major product of photosynthesis is carbohydrate" (Edwards and Walker, 2003) which is a major source of metabolic energy in plants and animals. In plants, the starch is made and stored in a short period of time called the light period (Zeeman et. al., 2002). These storage starch granules have multiple stacking structures that are created by internal amylopectin organization (Zeeman et. al., 2002) which are later used to fuel the plant during non-daylight hours. The process by which this is done, or photosynthesis, is defined as "the process in which light energy is used to drive the conversion of inorganic matter (carbon dioxide, sulfate, inorganic phosphate, nitrate) into organic matter" (Edwards & Walker, 2003). Light energy can be found in different wavelengths from non-visible to visible light. Light appears as waves due to the magnetic and electrical properties which rise and fall together at right-angles to each other (Edwards & Walker, 2003). The following study investigates three different ideas in regards to the photosynthesis of plants: the relation between light and starch production, the number and absorption wavelength preferences of the pigments involved in photosynthesis, and some possible assumptions that can be drawn from the correlation of the data gathered.

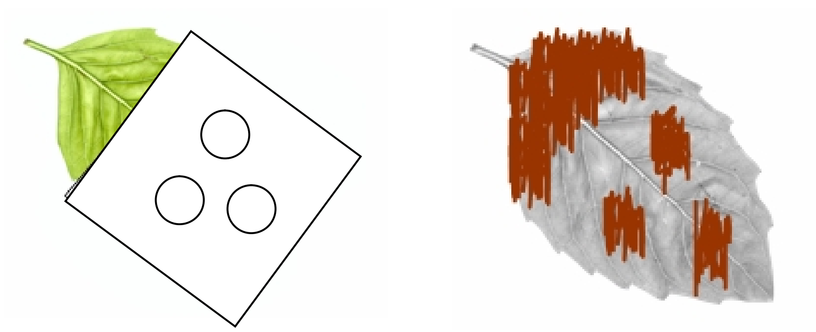
METHODS

Pigment samples were extracted from spinach leaves by grinding and filtering the spinach leaves taken and then suspending the pigments in acetone. A sample was placed in a Spectronic 20D spectrometer and the absorbance measured from 400 nm to 650 nm in 50 nm increments. In addition, the pigment extract was chromatographically separated by applying the spinach extract to filter paper and soaking the pigmented paper in chromatography solution enclosed in a test tube to examine the color and number of pigments (Petersen and Anderson, 2005). Another experiment was performed in which a leaf on a *Geranium* plant was partially covered and the plant placed in the dark overnight. At the end of the dark treatment the plant was introduced to high intensity light for several hours prior to the experiment (Petersen & Anderson, 2005). This same sample was then placed in boiling water bath to extract the water-soluble pigment, which was then followed by a bath of hot alcohol until a creamy white color appeared. Finally, the sample was removed from the alcohol bath, it was bathed a final time in potassium iodide (I_2KI) for 5 minutes and then rinsed with tap water (Petersen & Anderson, 2005).

RESULTS

As may be seen in the model of the *Geranium* experiment in Figure 1.1, the starch was present in the same locations where the high intensity light was able to reach the *Geranium* leaf. In general, the only areas where there was starch present in the test sample were where the leaf had been exposed. Starch was not present in the locations that the leaf used for testing had not received light since prior to the experiment.

Figure 1.1



As can be seen in Figure 1.2, there appears to be a maximal absorption of light wavelengths by the spinach extract until 450 nm. From 450 nm to 500 nm the level of absorbance by the spinach extract decreases sharply from maximal absorbtion to 1.26. A less drastic decrease was found between 500 nm and 550 nm. At 550 nm the absorbtion of wavelengths by the sample extract reached the lowest point recorded and began to increase again from 550 nm to 600 nm. The final sharp increase from 600 nm to 650 nm shows the absorbance to be higher on either end of the 550 nm wavelength.

Figure 1.2

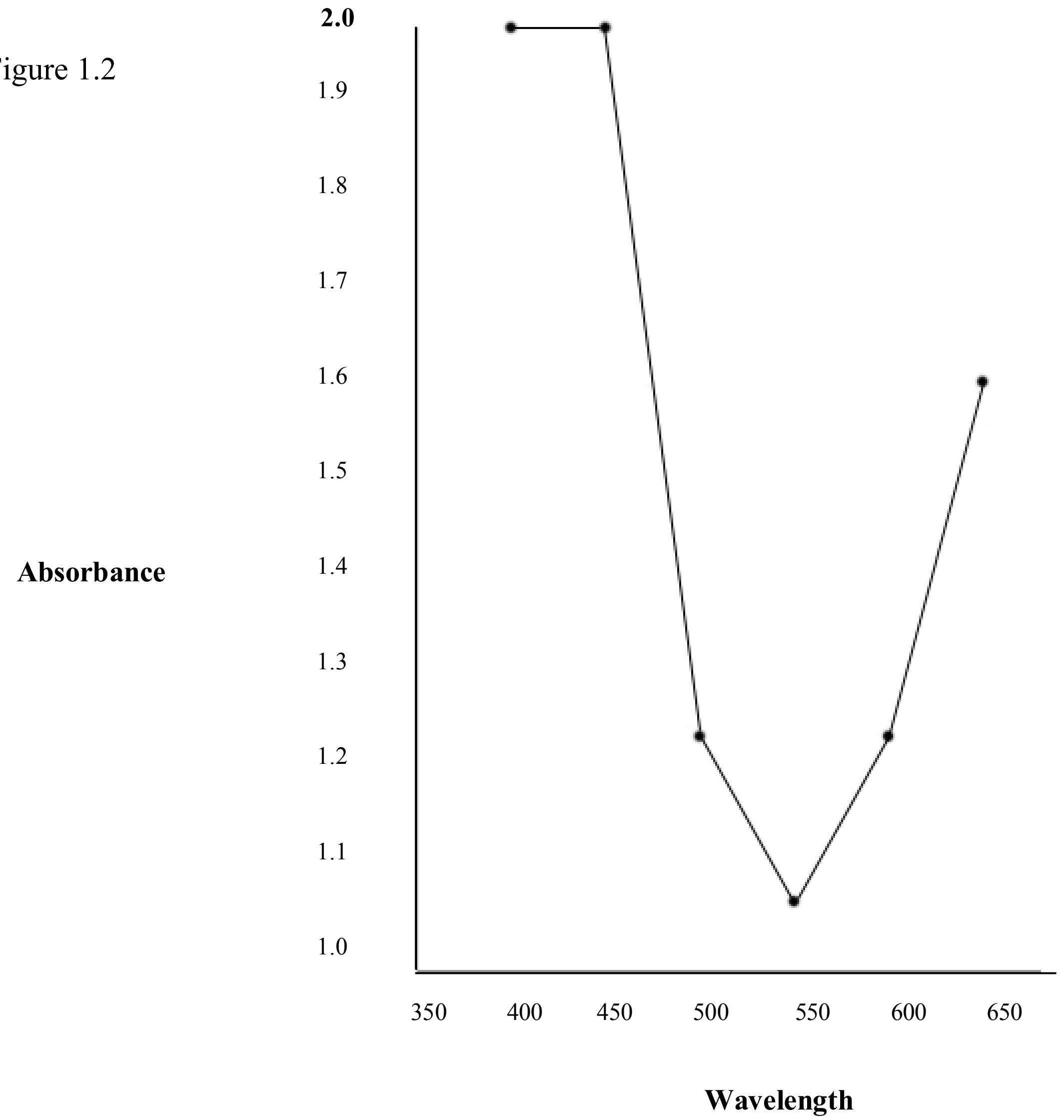
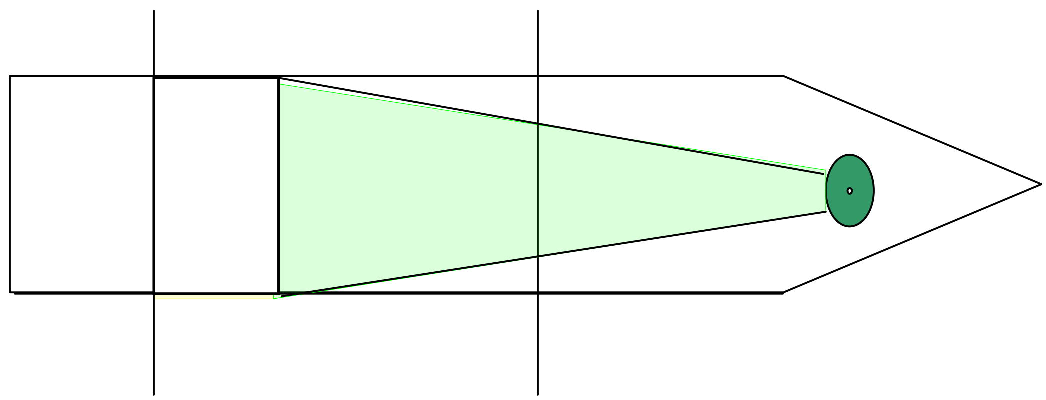


Figure 1.3 is a model of the approximate separation of different pigments from the spinach extract. As the particle separate the larger green colored molecules of pigment stay close to the bottom of the chromatograph and the smaller yellow colored molecules of pigment move to the top.

Figure 1.3



DISCUSSION

The data gathered in the experiments suggests three distinct ideas. First, that the *Geranium* was only able to create starch where there was a direct light source available. Second, that the spinach extract had a maximal absorbance between 400 nm and 450 nm as well as the beginning of a peak absorbance at 650 nm. Third, that there were multiple pigments isolated chromatographically from the spinach extract. The whole concept of photosynthesis is not complete without all three ideas and even using logical assumptions from the three experiments that were performed further experimentation would be needed to truly understand the theorem behind photosynthesis.

The starch production experiment was significant as an illustration of the fact that plants require light to produce starch. *Geranium* plants then are dependent on the light available in their environment to create the carbohydrates that make-up their metabolic source of energy. This data is consistent with our understanding of the overall process of photosynthesis in which light is converted into the biologically useful forms of energy ATP and NADPH. These products are then utilized, with carbon dioxide from the environment, to produce glucose and ultimately starch (Campbell & Reece, 2005). We could assume from these findings that more plants will be dependent on light for production of starch. Other factors of starch production were not explored and would require further investigation.

The pigment extraction and absorbance spectrum experiment illustrated that the pigments present in the experiment absorbed light optimally at ranges of 400 nm to 450 nm and also at 650 nm. Using the starch production experiment as a basis for assumption, it could be said that the plant would potentially create the maximum amount of starch in light wavelengths of 400 nm to 450 nm and also at 650 nm. Additionally, the difference in plant species may be found to show differentiation of starch production optimization that may vary, with different plants preferring different wavelengths.

Further investigation would again be necessary to ascertain the validity of this assumption using plants from the same species and preferably from the same genetic ancestry or parent plant. The pigment extraction chromatography experiment showed different pigments in the spinach leaf.

One possibility for the presence of different pigments may be that one pigment reacts to one of the wavelengths found in the absorbance experiment and the other pigment reacts to the remaining wavelengths. The use of the pigments separately was not explored in the experiment and warrants further study. To conclude, the findings of the study indicate that it is likely that the multiple pigments found in the extract absorbed maximally in 400 nm to 450 nm and 650 nm, and the energy from these wavelengths leads to the production of starch.

Literature Cited

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