Effect

of different light intensities on the growth in length of *Hyparrhenia rufa.*

Biology

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INTRODUCTION

Plants, algae, and some bacteria use the process of photosynthesis to convert solar energy into chemical energy. Water and carbon dioxide (CO2) are chemically changed into food (sugars) and oxygen during the process. The pigment chlorophyll, which gives plants their green hue, is frequently used in the chemical reaction. Our planet's atmosphere is abundant in oxygen because of photosynthesis. Both oxygenic and anoxygenic photosynthesis are possible. Both of them adhere to very similar principles, however the former is more prevalent and can be found in plants, algae, and cyanobacteria.

Light energy is used in oxygenic photosynthesis to convert water (H2O) absorbed by plant roots into CO2 and generate carbohydrates. In this process, the water is "oxidized," or loses electrons, while the CO2 is "reduced," or gains electrons. Carbohydrates are generated along with oxygen.

The carbon dioxide that breathing organisms produce when they burn oxygen during respiration is transformed back into oxygen by plants, algae, and photosynthetic bacteria as a result of this process, which maintains a balance on Earth. Despite the fact that both types of photosynthesis are intricate, multistep processes, the entire procedure can be neatly condensed into a chemical equation.

The oxygenic photosynthesis equation is:

$6CO_2 + 12H_2O + \text{Light Energy} \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$

Here, light energy is used to mix 12 molecules of water (H2O) with six molecules of carbon dioxide (CO2). A single glucose molecule (C6H12O6) and six molecules each of oxygen and water are produced as a result. Due to the fact that chlorophyll pigments reflect the color green, green plants are more capable of performing photosynthesis, as shown in the figure below.

 

Figures: Showing the plants that can have the reaction above.

Photosynthesis occurs in chloroplasts, a type of plastid (an organelle with double membrane) that contains chlorophyll and is primarily found in plant leaves.

In that they have their own genome, or collection of genes, stored within circular DNA, chloroplasts are analogous to mitochondria, the energy centers of cells. These genes produce proteins that are necessary for both photosynthesis and the organelle.

Thylakoids, which have a plate-like form, are found inside chloroplasts and are in charge of collecting light photons for photosynthesis. Thylakoids are arranged in columns called grana, which are piled on top of one another. The stroma, a liquid containing ions, molecules, and enzymes where sugar production takes occur, is located between the grana.

Light energy must ultimately be transmitted to a pigment-protein complex so that it can be transformed into chemical energy in the form of electrons. Chlorophyll pigments in plants deliver light energy to them. As a chlorophyll pigment releases an electron, it can then go on to an appropriate recipient, converting the energy into chemical energy.

Reaction centers are the pigments and proteins that transform light energy into chemical energy and start the process of electron transfer.

An electron is released from a pigment molecule like chlorophyll when a photon of light strikes the reaction center.

An electron transport chain, a collection of connected protein complexes, is how the liberated electron escapes. Adenosine triphosphate, a source of chemical energy for cells, and NADPH are both necessary for the subsequent stage of photosynthesis in the Calvin cycle, and they are produced as the energy goes along the chain.

By stealing one electron from water, the "electron hole" in the original chlorophyll pigment is filled. By breaking apart the water molecules, oxygen is released into the atmosphere. The following diagram displays the Calvin Cycle's gains and outputs. In the presence of sunshine, light-dependent processes take place in the thylakoid membrane of the chloroplasts. These processes transform the solar energy into chemical energy. The photosynthesis process is carried out by the photosystem, which receives energy from the sun through the chlorophyll in plants.

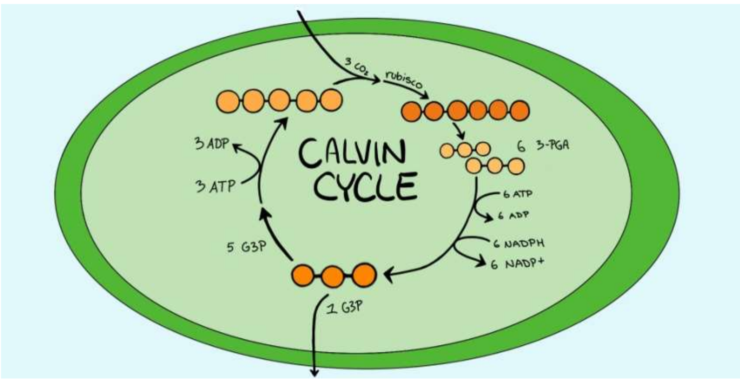

Figure: Showing the calvin cycle stages as it is explained in the text.

The Calvin cycle is the three-step process that generates sugars for the plant, and is named after Melvin Calvin, the Nobel Prize-winning scientist who discovered it decades ago. The Calvin cycle uses the ATP and NADPH produced in chlorophyll to generate carbohydrates. It takes plate in the plant stroma, the inner space in chloroplasts.

In the first step of this cycle, called carbon fixation, an enzyme called RuBP carboxylase/oxygenase, also known as rubiso, helps incorporate CO_2 into an organic molecule called 3-phosphoglyceric acid (3-PGA). In the process, it breaks off a phosphate group on six ATP molecules to convert them to ADP, releasing energy in the process.

In the second step, 3-PGA is reduced, meaning it takes electrons from six NADPH molecules and produces two glyceraldehyde 3-phosphate (G3P) molecules.

One of these G3P molecules leaves the Calvin cycle to do other things like cellular respiration in the plant's cell. The remaining G3P molecules go into the third step, which is regenerating rubisco. In between these steps, the plant produces glucose, or sugar.

Three CO_2 molecules are needed to produce six G3P molecules, and it takes six turns around the Calvin cycle to make one molecule of carbohydrate.

Steps of Photosynthesis

The endosymbiotic hypothesis states that the origin of chloroplasts is comparable to that of mitochondria since photosynthesis occurs in eukaryotes in chloroplasts, an organelle that shares genetic similarities with cyanobacteria.

In instance, chloroplasts arose from heterotrophic eukaryotes that took up photosynthetic cyanobacteria. Endosymbiosis rendered the bacteria incapable of existing on their own, converting the host eukaryotes from heterotrophs to autotrophs. The figure below illustrates the chloroplast's structural makeup.

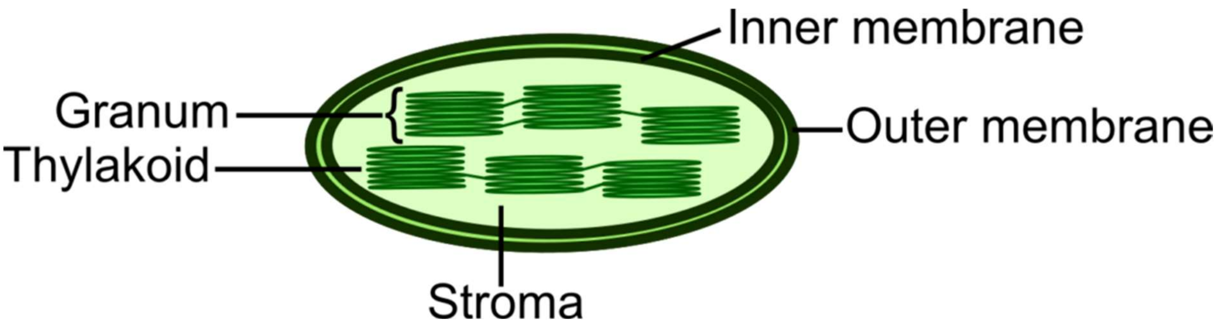

Figure: Showing the structural features of chloroplast.

The electromagnetic waves that the sun emits have a range of wavelengths that are inversely proportional to its energy level. Light quanta, also known as photons, are used to measure the lowest unit of energy carried by light. The majority of autotrophs use visible light, which has wavelengths between 350 and 800 nanometers, for photosynthesis.

In algae, cyanobacteria, and plants, chlorophylls act as the main pigments that absorb light and collect photons. Four pyrroles make up their porphyrin ring, which coordinates with a magnesium ion (Mg2+) in the middle. The combined light-absorbing action of all photosynthetic pigments will enable organisms to maximize the capture of photons since all photosynthetic pigments absorb light at various wavelengths.

Chlorophylls can be dissolved in lipids and incorporated in the thylakoid membrane thanks to the ring's lengthy hydrocarbon side chain with one double carbon-carbon bond.

Mechanisms of Photosynthesis

Based on the amount of light needed, photosynthesis mechanisms can be separated into two stages. The two high-energy molecules ATP and NADPH link the two phases of photosynthesis. When hexose sugar is created in the second stage, both ATP and NADPH are used. Hexose sugars are the basic ingredients used to create complex carbohydrates. The Calvin

Cycle and the light-dependent response in the cytoplasm and thylakoid membrane are depicted in the image below.

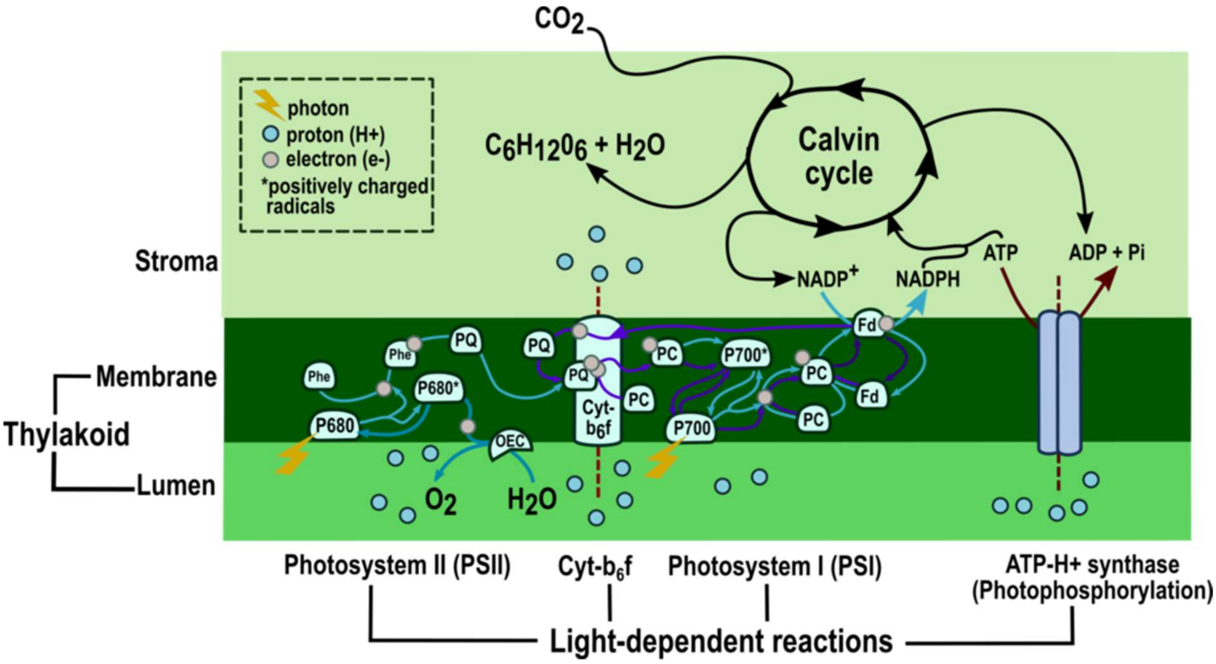

Figure: Showing the reactions of the photosynthesis

1.Light Dependent Reactions

Light is required for the photosynthetic activities that depend on it, as suggested by the name. In eukaryotes, the light-dependent processes take place in the thylakoid membrane. Chlorophylls, auxiliary pigments, and proteins connected to chlorophyll function as photoreceptors to initially catch photons of light. Functional groupings of photoreceptors consist of a light-harvesting (LHC), a core antenna complex, and a photosynthetic reaction center. Auxiliary pigments and proteins bound to chlorophyll make up the central antenna and LHC complexes. They act as photon collectors for the photosynthetic reaction center, capturing photons from different light wavelengths. The caught photon is delivered one at a time until it reaches the core of the photosynthetic reaction.

Chlorophyll a serves as the main photoreceptor in photosystem I (PSI), the first reaction center for photosynthetic reactions. With a maximum wavelength of 700 nanometers, light can stimulate it. Chlorophyll a and b are used by the second reaction center, photosystem II (PSII), to absorb photon energy. Up to light with a wavelength of 680 nanometers, PSII can absorb photons.

Photoinduced charge separation occurs as a result of photon harvesting. A photoreceptor electron is excited to a higher energy level, resulting in the formation of a negatively charged radical. The photoreceptor is left positively charged because of the spontaneous electron transfer that results from the excited state's instability to a neighboring acceptor molecule. Finally, electrons from water or another electron transfer chain are used to refuel the photoreceptors.

2. The Calvin Cycle

At the second stage of photosynthesis, several Calvin cycle reactions require NADPH and ATP from the light-dependent activities. The Calvin cycle is the reductive pentose phosphate route, depending on the nature of the reaction and the reactant (pentose). The cycle's processes happen in the stroma without the involvement of direct light. This is how dark answers acquired their name. Ribulose-1,5-bisphosphate (RuBP), a five-carbon sugar molecule, is fixed and incorporated with ambient CO2. The inclusion yields two 3-phosphoglycerate molecules. RuBP absorbs CO2 in a very exergonic way, which may indicate that the action is almost irreversible. The process is catalyzed by the ribulose-1,5-bisphosphate carboxylase/oxygenase enzyme (RubisCO).

RubisCO is the sole enzyme that can fix CO2 from the atmosphere. RubisCO is the sole enzyme that can fix CO2 from the atmosphere. It is also among the most significant and common enzymes in plants. The two molecules of 3-phosphoglycerate created by the absorption of CO2 are transformed into the three-carbon glyceraldehyde-3-phosphate (G3P) and its isomer, dihydroxyacetone phosphate, through a series of reductive reactions (DHAP). These mechanisms make use of the ATP and NADPH generated during the light reactions. At this point, one-sixth of the G3P and DHAP molecules condense to form the six-carbon phosphate sugar molecule fructose-1,6-bisphosphate (FbisP). Afterwards, FbisP is either converted to glucose or irreversibly hydrolyzed to fructose-6-phosphate, which is subsequently employed as a reactant in the production of starch and cellulose. The majority of G3P and DHAP are used in the regeneration of RuBP. Three pentose phosphate molecules are produced in the last stage by a series of enzyme reactions involving two DHAP and three G3P molecules. Each pentose phosphate has a phosphate group and five carbon molecules. ATP phosphorylates the three pentose phosphates to create RuBP, which is subsequently utilized in the following Calvin cycle. The reactions of the Calvin cycle can be summed up as follows.

The following formula yields,

$6CO_2 + 12NADPH + 12H^+ + 18ATP + 12H_2O$ —-> $C_6H_{12}On + 12NADP^+ + 18ADP + 18P_i$

The summary suggests that two NADPH molecules and three ATP molecules are used in the fixation of one CO2 molecule.

How Does Level of Light Effect the Rate of Photosynthesis

It's likely referring to light intensity, which can be measured, when it talks about different light energies. The amount of energy that strikes a certain area over time is often how light intensity is characterized. So, in the case of a plant, more "photons," or light packets, are striking the leaves at a higher light intensity. The rate of photosynthesis will increase as you go from low light intensity to high light intensity because there is more light available to trigger the react ions of photosynthesis. The pace of photosynthesis will be constrained by other variables once the light intensity is high enough, so it won't continue to increase. The quantity of chlorophyll molecules that are absorbing light might be a limiting factor. The rate of photosynthesis would rapidly decrease at very high light intensities when the light began to harm the plant.

Relationship Between Photosynthesis and Plant Growth

During photosynthesis, carbon dioxide, a gas, is combined with water and solar energy, and converted to carbohydrates. Formation of carbohydrates is a chemical way to store the sun's energy as "food." Carbohydrates produced from photosynthesis provide energy for all plant growth and maintenance.

Research Question: How does different light intensities (0J, 50J, 100J, 150J, 200J) affect the growth in length of *Hyparrhenia rufa* (long grass) in two weeks time period?

Aim of the Study

Aim of this experiment is to investigate that how does different light intensities effect the rate of photosynthesis depending on the plant growth. Plant growth and photosynthesis are directly proporitonal with each other, so we can have an idea that less growed plant had less photosynthesis. I have chosen this topic of study because, I wanted to investigate the environmental factors on productivity and how they adapt to the order.

Hypothesis

In this experiment, twenty five identical plants will be kept under 0J, 50J, 100J, 150J, 200J light intensities, and data will be collected after 2 weeks. Out of twenty five plants; which the most light taken (200 J) plant will be longest and the plant that haven't taken light (0 J) will be shortest. I think like that because more light means more photosynthesis to a plant.

METHODOLOGY

Data was collected from twenty five identical plants which is *Hyparrhenia rufa*, the long grass, about their growth in length according to taken light intensity. Room temperature will be 25 ± 0.1 C^{o} and the amount of water given to plants for each day will be 20 ± 0.1 ml, so the difference can be only from the taken light intensity. Then, the data was compared to discuss the growth in length of the plants to the different intensity of light taken.

Independent Variable

The independent variable in this experiment is the intensity of light (0J, 50J, 100J, 150J, 200J) taken by the plants. Twenty five plants having the same length 10± 0.1 cm, will be put under the places having the light intensities 0J, 50J, 100J, 150J, 200J for a specific time period (for 2 weeks). After the time period, change in the plant growth will be discussed in the conclusion section.

Dependent Variable

The dependent variable is the growth in length of *Hyparrhenia rufa*, depending on the rate of photosynthesis which is the process by which green plants and some other photosynthetic organisms use sunlight to synthesize nutrients from carbon dioxide and water in the 2 weeks time period. In this experiment, the rate of photosynthesis will be depending on the different intensities of light.

Controlled Variables

Plant type will the *Hyparrhenia rufa*, because it makes photosynthesis in a fast way when they are growing. Another controlled variable in this experiment is the temperature. As temperature increases the number of collisions increases, therefore the rate of photosynthesis increases.

However, at high temperatures, enzymes are denatured and this will decrease the rate of photosynthesis. In this experiment, the room temperature will be equal and 25 ± 0.1 C^{o}.

Water amount will be kept the same for all trails. 20 ± 0.1 ml of water will be given to each plant for once in a day. Soil type will be zonal soil.

Materials

1. Twenty five equal vases of the plant *Hyparrhenia rufa* having the size 20±cm^3 volume.
2. One ruler (30 ±0.01 cm)
3. Four identical light bulbls having the light intensities 50J, 100J, 150J, 200J.
4. One marker.
5. Water (20 ± 0.1 ml will be given for every twenty five plant for 2 weeks time.)
6. A beaker (50± 0.1 cm^3)

Procedure

1. Take 5 vases.
2. Label them as group 1 with a marker.
3. Put the plants of group 1 under the light having the intensity of 100J.
4. Take five another vases and label them group 2.
5. Put the plants of group 2 under the light having the intensity of 150J.

6. Take five another vases and label them group 3.

7. Put the plants of group 3 under the light having the intensity of 200J.

8. Take five another vases and label them group 4.

9. Put the plants of group 4 under the light having the intensity of 250J.

10. Take five another pots and label them group 5.

11. Put the plants of group 5 under the light having the intensity of 300J.

12. Before starting to the experiment, make sure that every grass in each trails must have 10± 0.1 cm long. If not, cut them to be equal.

13. Give 20 ± 0.1 ml of water to every 25 pot for every each day with a beaker.

14. After 2 weeks, measure them separately and calculate the lengths of each group.

Justification

I have chosen the plant *Hyparrhenia rufa* because their population is so much in the environment and it can be find everywhere. *Hyparrhenia rufa* is a photosynthetic plant and it takes less time grow from other types of plants in the environment. In this experiment, there will be twenty five identical pots will be used and datas from the length changes will be used. Data will be collected from the plants after two weeks. The water amount will be 20 ± 0.1 ml beacuse it is proportional to the size of the vase of the plant. Growth in length will give the answer to my research question beacause the photosynthesis is not the case of obtaining only sugar and oxygen, it is also helpful for accumulation of biomass. In the experiment, I will be chosing the most long grass in every each vase, then I measure five grass in each trial and take the average of them.

Risk Assesment and Ethical Considerations

At the end of my experiment, I have planted the grasses in my garden and look after them. None of the plants were dead during the experiment. There is no risk asessment in my experiment.

RESULTS, ANALYSIS and CONCLUSION

Raw Data Table

Light intensity (±0.1 J)	Trials	Initial Length of Hyparrhenia rufa (± 0.1 cm)	Final Length of Hyparrhenia rufa (± 0.1 cm)	Volume of Water (± 0.1 ml)
0	1	10	10.2	20
	2	10	10.2	
	3	10	10.4	
	4	10	10.3	
	5	10	10.2	
50	1	10	11.5	20
	2	10	11.6	
	3	10	11.7	
	4	10	11.4	
	5	10	11.4	
100	1	10	12	20
	2	10	13	
	3	10	11.7	
	4	10	13	
	5	10	11.9	
150	1	10	12	20
	2	10	13	
	3	10	11.5	
	4	10	12.1	
	5	10	13	
200	1	10	15	20
	2	10	16	
	3	10	14	
	4	10	114	
	5	10	15.1	

Table: Showing the initial and final lengths of each plant according to their taken energy.

Sample Calculations

Formula of Average

$$\text{Average} = \frac{\text{Total sum of all numbers}}{\text{Number of item in the set}}$$

One example for trial 1,

$$\text{Average} = \frac{0.2+0.2+0.4+0.3+0.2}{5} = 0.275$$

Standard Deviation

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}.$$

Where
x_i is an individual value
μ is the mean/expected value
N is the total number of values

One example for trial 1,

$\mu = (0.2+0.2+0.4+0.3+0.2) / 5 = 0.275$

$\sigma = \sqrt{}[(1 – 0.275)^2 + (2 – 0.275)^2 + ... + (5 – 0.275)^2)]/5$

$\sigma = \sqrt{}(0.5256+ + 2.97+ 7.42+13.8+22.32)/5= 2.48$

Processed Data Table

Light intensity (±0.1 J)	Trials	Change in Length of Hyparrhenia rufa (± 0.1 cm)	Mean Change in Length of Hyparrhenia rufa (± 0.1 cm)	Standard Deviaton İn Length of Hyparrhenia rufa (± 0.1 cm)
0	1	0.2	0.275	2.48
	2	0.2		
	3	0.4		
	4	0.3		
	5	0.2		
50	1	1.5	1.52	13.68
	2	1.6		
	3	1.7		
	4	1.4		
	5	1.4		
100	1	2	2.32	20.90
	2	3		
	3	1.7		
	4	3		
	5	1. 9		
150	1	2	2.32	20.90
	2	3		
	3	1.5		
	4	2.1		
	5	3		
200	1	5	5.42	45.05
	2	6		
	3	4		
	4	4		
	5	5.1		

Table: Showing the elongation amount of the each plant according to their taken energy.

If we have to calculate the change of the lengths in the plants, we should substract the initial length from the final length. The relevant data is written on the processed data table.

Discussion

Plants can do photosynthesis and it is important either for the environment and for the future generations of a plant. So, I wanted to do a research about how does different light intensities effect the growth of a plant.

Every plant engages in photosynthesis, which is advantageous to both the plant and the environment. Because we cannot survive without oxygen and because oxygen is one of the byproducts of a photosynthetic reaction, we are also dependent on photosynthesis. Using either solar or artificial light energy, the primary purpose of photosynthesis is to change water and carbon dioxide into oxygen and glucose sugar. Without photosynthesis, there wouldn't be enough oxygen for us to live, and the atmosphere's carbon dioxide levels would be greater. The plants will undergo more photosynthetic processes and have access to more nutrients in places with higher sunshine intensities.

In the light of these information, the basis of this research was to understand higher light intensity means more photosynthesis effecting the growth change of the plant *Hyparrhenia rufa*.

The results can be obviously seen that higher light intensity means more photosynthetic reaction and more in growth. From the 0 J energy that the plants take from the sun had the lowest growth but the plants which take 200 J of light intensity had the greatest growth in all.

Evaluation

Strengths

I have used artifical lights to be very sure about how do the plants in each trail take how muh joule of light. This is a strength because I could know how much intensity of light comes to the plant. If I would do the experiment with natural sunlight, I wouldn't know the difference in light intensity.

Limitations

If the season was spring or summer, I would be setting my experiment out of the house so the datas would be more realiable because the occassions would be more stable.

Conclusion

In my experiment, I have investigated that how does different light intensities affect plant growth. I have controlled all the other variables instead of light intensities. The experiment had last in two weeks time period. At the end of my experiment, I have seen that more energy means more photosynthetic reaction and photoynthesis cause growth for the plant. The datas supported for my hypothesis that the group of plant which exposed to the light intensity of 200 J. If a plant have plenty of water and available temperature near it's surrounding, plant will tend to be grow more as the reactants of the photosynthesis give permission.

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