Phototropism: Battle for Light

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Abstract:

In our experiment, we want to observe how the plants grow when they are being covered, uncovered, and have a hole so we can research the tilt of the growth of the lima beans. To accomplish this, we will first prepare the cartons by using the permanent marker, label the sides of the milk cartons with the numbers 1–5, and prepare the cartons according to the amount of light exposure the plant will have in each. Afterward, we will observe the plant's growth and tilt and record its progress three times. The plant in carton 1 grew towards an angle of 85° up by day 9 as expected since it was exposed to perfect sunlight. The plant in carton 2 started to grow at an angle of 89° up by day 9 and started wilting exhibiting yellowish color and a weak stem. The plant in carton 3 grew towards an angle of around 67° tilting towards the side with light exposure by day 9 and showed some signs of wilting. The plant in carton 4 grew towards an angle of 59° by day 9, similar to the plant in carton 3, which also shows signs of wilting. The plant in carton 5 grew to an angle of 59° towards the side with light exposure by day 9 and showed minimal to no signs of wilting. In the one trial performed, all plant growth patterns shown in carton plants 1 through 5 showed predicted outcomes.

Introduction/Problem/Purpose:

In our project, we are trying to figure out how the growth habits of plants will change based on the direction and exposure of light. The following will provide more background information on our project. We want to see how the plants grow when they are covered, uncovered, and have a hole so we can research the tilt on the growth of the melon seeds. Will the tilt be affected by the increase in the amount of sunlight despite it coming from the same side of the carton? But how will the amount of the sun affect the tilt/degree of a plant when sunlight is brighter on one side than the other? For example, if you had a tree in your front yard and it's a fairly big tree and you put a flowerpot under the tree close to the trunk. The plant will over a couple of days start to shift towards the sun and bend as much as it can just to get more sunlight to grow and reach its energy. Compared to when you put the flower where it gets complete sunlight it will not shift or bend at all it will grow straight up. By enacting our experiment, we will be able to help gardeners maximize sun exposure since it will show the growth habits concerning the light and how much sun each plant will need to maximize their variation in plant growth.

Background:

Did you know that one of the most important discoveries about phototropism, or the ability of plants to grow towards the direction of a light source, in plants, was made by Charles Darwin? Through his experiment, *The Power of Movement of Plants,* in 1880, Darwin together with his son discovered that there was a substance at the coleoptile, or tip of the seedling, where the light is perceived from, that moved to the rest of it. However, when the tip was cut off or covered, it lost the phototropic response or the directional response that allows plants to grow towards or away from a source of light. Later on, Fritz Went discovered in the 1920s that this substance

was auxin. This plant growth hormone causes the elongation of cells at the coleoptile, which causes tropism, or the movement of plants, in response to environmental stimuli.

Method/Process/Approach:

Hypothesis: By growing the plants in different light exposure environments (covered /uncovered), a significant change will be observed in how the plants tilt regarding the amount and side of light exposure.

Variables:

- ➔ Independent Variable: The independent variable for this project is the state of the carton for each seed which will allow light to enter into its interior as each carton will have a different amount of holes.
- ➔ Dependent Variable: The dependent variable is the tilt towards which each seed will grow.
- ➔ Control Variable: The control variables are the amount of water, type of soil, placement to a source of light (sun), and type of seed.

Materials:

- 5 spoons of soil per carton
- 5 cartons for the seedlings
- 5 seeds
- Ruler
- Permanent Marker
- Clear Tape
- Grow Lamp
- Graph Paper
- Lab Notebook
- Hole Puncher

Procedure:

Preparing the Cartons
Using the permanent marker, label the sides of the milk cartons with the numbers 1–5.
For carton # 1, cut off the top of the carton with the scissors.
The plants in this carton will grow in normal lighting.
For carton # 2, do not make any holes.
The plants in this carton should germinate and start to grow but will be kept in total darkness.
For the following cartons, use the hole punch to make holes in one side of each carton, about 6 cm from the bottom. You must open the top of the milk carton to make the holes.
Carton #3: One hole
Carton #4: Two holes; should be near each other, but not overlapping
Carton #5: Four holes; should be near each other, in a cluster
Planting the Seeds

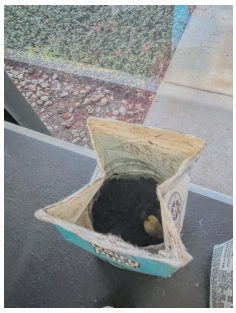
Put about 3 centimeters (cm) of moist potting soil into each carton. Keep the amount of soil equal in each carton.
Record the time and date that the seeds were planted in your lab notebook.
Make Your Observations
Record the time and date that the plants were exposed to light in your lab notebook.
Place the cartons in a well-lit room, but out of direct sunlight. Record the time and date in your lab notebook.
Expose the plants to light during the day. Keep them in darkness at night.
Record how long the plants receive light from the holes in the carton.
Use the protractor to measure the angle of the stems. Record observations of the plants from all five cartons in your lab notebook.
Return the cartons to their original states (covered or uncovered), place them in the light again, and allow them to grow for another day.
Repeat steps 6–7 until you feel you have enough data.
For each day you collected data on the angles of the plants, and graph the angle of the stems vs. the amount of light (the number of holes) to which the plants were exposed.
Graph the data for each plant individually.

Finding and Results:

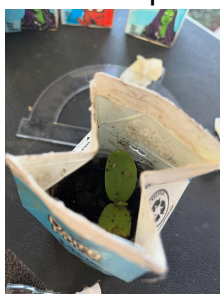
Pictures:


Number one is open, number two is completely closed, and three, four, and five have holes.

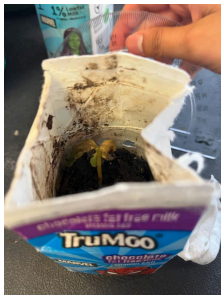

Whole top cut off, will grow with normal light



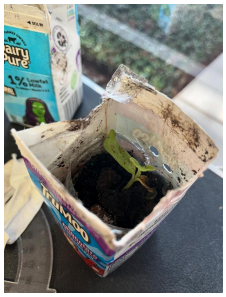
No holes, will grow in complete darkness



One hole in side, light will enter solemnly from that hole



Two holes on same side, light will enter solemnly from those holes



Four holes in a cluster on same side, light will enter solemnly from those holes

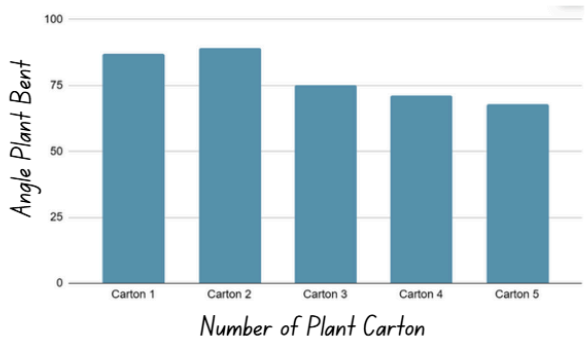
Data Tables:

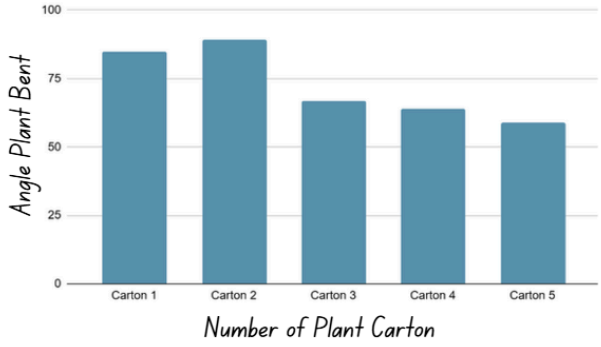
# of Carton	Angle tilt
Carton 1	87°
Carton 2	89°
Carton 3	75°
Carton 4	71°
Carton 5	68°

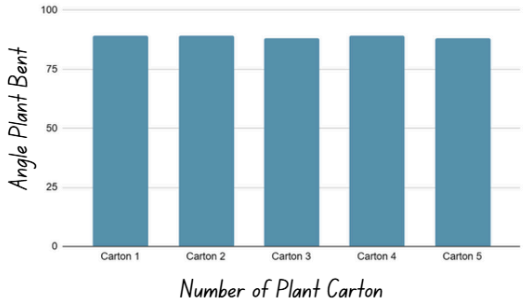
# of Carton	Angle tilt
Carton 1	85°
Carton 2	89°
Carton 3	67°
Carton 4	64°
Carton 5	59°

# of Carton	Angle tilt
Carton 1	89°
Carton 2	89°
Carton 3	88°
Carton 4	89°
Carton 5	89°

Graphs:







Analysis:

With our phototropism project, the plants were analyzed with growth and measurements to project how light would affect the angle that they were growing in to see how the growth is affected by the amount of light exposure. The plant in carton 1 grew towards an angle of 85° almost perfectly straight up by day 9 as expected since it was exposed to perfect sunlight. On day 4, the seedling sprouted at an 89° tilt, and by day 6, the seedling was at an 87° tilt. The plant in carton 2 started to grow at an angle of 89° the nearest to perfectly straight up by day 9 and started wilting exhibiting yellowish color and a weak stem. On day 4, the seedling sprouted at 89° tilt, by day 6, the seedling stayed at around 89° tilt, and by day 8, the seedling still stayed at about 89° tilt. The plant in carton 3 grew towards an angle of around 67° tilting towards the side with light exposure by day 9 and showed some signs of wilting. On day 4, the seedling sprouted at 88° tilt, and by day 6, the seedling was at a 75° tilt. The plant in carton 4 grew towards an angle of 59° by day 9, similar to the plant in carton 3, which also shows signs of wilting. On day 4, the seedling sprouted at 89° tilt, and by day 6, the seedling was at a 71° tilt.

The plant in carton 5 grew to an angle of 59° towards the side with light exposure by day 9 and showed very minimal to no signs of wilting. On day 4, the seedling sprouted at 89° tilt, and by day 6, the seedling was at a 68° tilt.

Conclusion:

As the research has demonstrated, the plants grew towards where there was more light. In the one trial performed, all patterns of plant growth shown in carton plants 1 through 5 showed predicted outcomes. Carton plant 1 showed the most growth and second, almost perfectly straight tilt, while carton plant 2 showed an 89° tilt and exhibited some abnormal features, and carton plants 3 to 5 all grew towards the side where they were exposed to light and had a similar tilt degree. The difference in tilt in cartons plants 3 to 5 was due to the amount of light received. As carton plant 5 receives more sunlight since it had 4 holes it had a greater tilt, then carton plant 4 followed with 2 holes, and finally carton plant 3 with one hole. The wilting that took place in plants 2 to 5 was due to a phenomenon known as etiolation which is a condition that plants exhibit abnormal growth due to lack of light exposure, which is why carton plant 2 displayed the most etiolation behavior out of all the plants as it was grown in complete darkness.

Applications and Further Research:

One of the major challenges gardeners face is uneven light distribution in gardens. Light is essential for photosynthesis to occur and for the plant's overall health. By furthering our research about our project and experimenting with different amounts of light each plant in the cartons receives to a bigger scale by using different types of plants and multiple trials to determine how much amount of light exposure and tilt each plant needs and supports to stay healthy, gardeners will be able to make better use of the amount of light each plant needs thus minimize the problem of uneven light distributions, especially when there are obstructions, such as fences, building, or other structures that may block light, and seasonal changes, as the amount and angle of natural light change.

References:

1. Fisher, I. (2023, June 8). Gardening challenges. Sandia Seed Company. https://www.sandiaseed.com/blogs/news/gardening-challenges - 2. Liscum, E., Askinosie, S. K., Leuchtman, D. L., Morrow, J., Willenburg, K. T., & Coats, D. R. (2014, January). Phototropism: Growing towards an understanding of plant movement. The Plant cell. https://pmc.ncbi.nlm.nih.gov/articles/PMC3963583/ - 3. Pedmale, U. V., Celaya, R. B., & Liscum, E. (2010). Phototropism: Mechanism and outcomes. The arabidopsis book. https://pmc.ncbi.nlm.nih.gov/articles/PMC3244944/ - 4. Science Buddies Staff. (2022, March 3). Plants on the Move! Experiments with Phototropism. Retrieved from https://www.sciencebuddies.org/science-fair-projects/project-ideas/PlantBio_p041/plant-biology/plants-movementphototropism