Effects of pH Conditions That Simulate Acid Precipitation on the Growth of *Brassica Rapa*

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Introduction

Acid precipitation is defined as rain, snow or fog with a pH less than 5.6 and results mainly from the presence in the air of sulfur oxides and nitrogen oxides. These oxides are generated primarily from the burning of fossil fuels in factories and vehicles and become acid precipitation when they react with water vapor in the air to form sulfuric and nitric acids, which fall to the earth in rain and snow. The effects of acid precipitation in lakes have been measured and some evidence exists that it has contributed to the decline of American and European forests. Long-term effects on plants and soils have not been determined. (Campbell et. al. 2006).

The objective of this study was to simulate acid precipitation conditions and determine if plant growth would be negatively affected. We simulated the effects of altering the pH of the soil in which *Brassica rapa* plants were growing. We posed the question: would the plants subjected to solutions with pH in the acid range grow at a slower rate than plants at the preferred neutral pH? Would a difference be seen between the two acid solutions, one more acidic than the other? In addition, would plants subjected to solutions with pH in the acid range show other signs of stress such as yellowing of leaves, dropping leaves, loss of blossoms, or withering?

The pH of the soil determines the extent nutrients in the soil will be available to the plant. Nutrients like nitrogen, phosphorus and potassium are less available in soils with low pH. (Kluepfel and Lippert, 1999.) Acid rain lowers the pH in soil and can have an effect on plant growth for plants that prefer neutral or alkaline conditions.

Precipitation can affect pH by leaching away nutrients as well as by changing the pH if acidic. (Campbell et. al. 2006).

Several experiments have been conducted to determine the effects of soil pH as well as simulate the effects of acid rain and the cumulative effects of fertilizers used on crops. A study conducted in Georgia showed that growth of amaranth was adversely affected by soils in the acid pH range and that a pH of 6.4 resulted in high yields. (Singh and Whitehead, 1993).

Brassica Rapa, a fast growing plant useful for student lab experiments, grows well with a pH around 6.6. (Duke, 2003). As of 2000 the most acidic acid precipitation in the United States had a pH of about 4.3. (EPA, 2008). Solutions of lime juice at pH's of 2 and 4 were used to alter the pH of the soil to determine if an effect would be observed. Eight cubes containing moisturized soil were planted with *Brassica Rapa* seeds and placed under white lights. Two cubes were labeled as controls and received no treatment. Cubes one to three were treated with pH solution 2, while cubes four to six were treated with pH solution 4. Solutions were added weekly, while data was collected on length of each plant, as well as observing other signs of stress.

Methods and Materials

In preparing our Fast Plant, *Brassica rapa,* experiment, we filled a rectangular container with distilled water. A hole was cut into the container's cover so that a large water mat could draw water from the reservoir to the diamond wicks. The wicks conducted water from water mat to the soil in the styrofoam grid. We then filled the girds' eight quads with soil, added one fertilizer pellet near the bottom of each cell and put in two seeds per cell above the fertilizer with a soil buffer to reduce burns to the *Brassica rapa* seeds. We then topped off the cells with soil.

After one week, we weeded out one plant from cells that had two plants growing and transplanted plants to cells that had nothing growing, leaving us with one plant in each of our 32 cells. We labeled our eight quads and made two of them control quads that received no treatment. On one side of our grid, we added one drop of pH2 concentration to each cell in the first quad, 2 drops to each cell in the 2nd quad and 3 drops to each cell in the 3rd quad. The closest quad to the control was given the least amount of drops. On the other side of the grid, we did the same thing except with pH4. Drops were applied every week before lab in the same way stated above. The grids were rotated so that the same side was not introduced to the light all the time. We measured each plant's height every week to determine how plants grow in acidic areas. We observed the plants for other signs of deterioration such as yellowing, withering, loss of leaves. The plants were left under white lights when we were not taking measurements and adding our solutions.

Results

The plants did not grow as expected. Raw data was analyzed as follows: change in growth from first measurement at week 3 to final measurement at week 4, growth of plants from one week to the next to analyze the rate of growth, total growth by cube by week. Table 1 below provides analysis of the change in growth from week 3 to week 6, calculated by subtracting the measurements of week 3 from those made at week 6. Plants with the greatest growth, measured in centimeters are highlighted in yellow on Table 1. Cubes of the Control 1, pH 2 treatment and pH 4 treatment all resulted in plants with substantial growth. Cubes 5 and 6 had plants with the greatest change in growth. Cube 5 had two drops of pH 4 and Cube 6 had one drop of pH 4. The fourth cube in both cubes 5 and 6 did the best. It had the largest growth increase overall. The second plant in Cube 5 was also among the largest growers.

Table 1 Change in Growth From Week 3 to Week 6

Plant	**Control 1**	**Cube 1**	**Cube 2**	**Cube 3**	**Cube 4**	**Cube 5**	**Cube 6**	**Cube 7 (control 2)**
1	8.5 CM	13 CM	16 CM	10 CM	8.5 CM	16 CM	10.5CM	8 CM
2	17 CM	11.5 CM	7.5 CM	10 CM	11.5 CM	21.5 CM	14.5CM	14 CM
3	20.25 CM	6.5 CM	17.5CM	19.5 CM	14.5 CM	11.25CM	16.5CM	13 CM
4	11 CM	15.5 CM	6 CM	15 CM	12 CM	23.5 CM	25 CM	11 CM

Treatments
Control 1 None
Cube 1 – 1 Drop of pH2
Cube 2 – 2 Drops of pH2
Cube 3 – 3 Drops of pH2
Cube 4 – 3 Drops of pH4
Cube 5 – 2 Drops of pH4
Cube 6 – 1 Drop of pH4
Cube 7 – Control 2 None

No pattern was seen in analysis of the data for growth of each individual plant by week. Analysis of total growth by cube shows that the plants obtained the greatest growth the first week of treatment from week three to week four. Growth slowed considerably from week four to week six. (Figure 1).

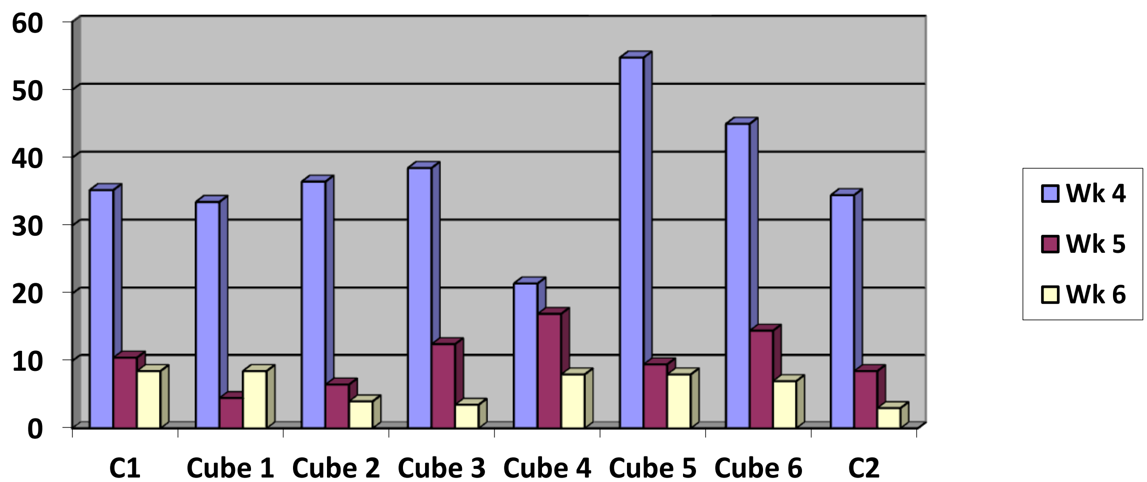

Figure 1 Total Growth of Plants in Centimeters by Cube Weeks 4-6

Discussion

Results of this study are inconclusive. No pattern of growth or deterioration as it relates to pH was observed in the plants. Cubes 5 and 6 produced the greatest growth in both weeks four and five.   Three plants in Cubes 5 and 6 were also the greatest growers overall but on the other hand, there were five other plants in these cubes that were among the medium growers. At the end of week six, one plant in Control 1 and one in Cube 3 were also among the highest growers. Based on the hypothesis the two control cubes should have produced the most growth, since their pH should have been closest to the 6.6 preferred by *Brassica rapa*.   Some yellowing of leaves was seen but this was minor and can be attributed to color variation. None of the plants wilted, withered, dropped leaves, dropped blossoms or otherwise showed signs of stress.

Evaluation of the results indicates improvements that could be made to future studies of this topic. Our objective was to observe changes in growth from the affects of application of acidic solutions, not to kill the plants outright, so we applied the solutions slowly and in low volume. The once weekly application of acidic solution could have been too infrequent to have any effect in the time period. The solutions may also not have been strong enough to produce any observable results.   We also did not measure the pH of the soil or the water before adding any solution so cannot really know the final pH of the cubes. We assumed neutral pH from the soil and water and perhaps this was not a correct assumption to make. The study would have benefitted from an analysis of the appropriate acidic solution volume and frequency as well as understanding the baseline pH.   We thought we were providing even light conditions by putting the grids under the lights facing different ways (north one time, south another but never east or west.) A complete rotation of the grids so that east-west presentations were included may have provided more uniform light conditions. The orientation to the light may explain the growers in Cubes 5 and 6.

Acid precipitation consists of chemicals, sulfur and nitric oxides, which may have more of an effect on growth than pH alone. No determinate study has identified acid precipitation as harmful to plants and the literature suggests the affect may only be seen in the long-term. (Campbell et. al., 2006). Some experiments studied used atomizers to apply the pH solutions to the plants directly. Given the quick growth of these plants they may have produced more of a response to the atomizer. In the Georgia amaranth study, Singh and Whitehead altered the pH of the soil before the plants were potted which may have been a better approach. However, we wanted to mimic the effects of acid rain over time so applied the solutions gradually rather than all at once. The duration of the experiment may not have been long enough to test the hypothesis. Acid rain's harmful effect on plants is due to changing the pH of the soil which does not permit the plant to readily access the nutrients. In this experiment the fertilizer pellet may have overcome the amount of acid solution applied. Also, longer time may also be required to overcome the nutrients in the growing medium even without the fertilizer pellet. If this is true then a much longer study would be required and most likely a different plant should be considered because *Brassica rapa* is a fast grower.

Conclusions

The hypothesis was not confirmed. The growth and appearance of *Brassica rapa* was not affected by the application of acidic solutions to simulate the pH of acid rain. The volume of solution applied or the frequency of application may have been enough for an effect to have been seen, particularly since *Brassica rapa* is a fast-growing plant. Research indicates that other studies have seen results that confirm the hypothesis. Several changes in the methods have been provided for consideration by others wishing to conduct a similar study.

Literature Cited

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