The Effect of Nutrient Deficiencies on the Growth of Plants

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Abstract

The purpose of this experiment was to find out how certain nutrient deficiencies would effect the growth of plants in a hydroponics system. In the experiment pumpkin seedlings were grown in water culture solutions with controlled nutrient deficiencies. The four types of water culture solutions used in the experiment were complete nutrition, potassium deficient, nitrogen deficient, and iron deficient. The height of the plants were measured daily for seven days, and the total amount of growth was calculated. The experimenter hypothesized that the pumpkin seedling grown in the complete nutrient solution would have the greatest amount of growth. The result of the experiment was the plants grown in complete nutrition and potassium deficient solutions grew the same amount, and grew more than any of the other plants. The iron deficient plant grew the least, and the nitrogen deficient plant grew slightly more than the iron deficient plant. Since the complete nutrition plant did not have the highest amount of growth the hypothesis was not supported. Besides the amount of growth other observations were made during the experiment. The iron deficient plant showed light green leaves and dark splotches. The nitrogen and potassium deficient plant showed yellow and brown areas on the leaves. However the complete nutrition plant showed almost no discoloration or damage to the leaves. These observations prove that complete nutrition is best for overall plant growth. This experiment would benefit agronomists and the study of plant nutrition by providing information about what nutrients are necessary in plant growth.

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Research Paper

Introduction

The essential items in the process of photosynthesis are sunlight, carbon dioxide, chlorophyll and water. However, many plants also require nutrients found in fertile soil. These nutrients play a part in producing substances that provide structure and energy for the plant. Research shows that there are more than one hundred elements in soils of different kinds, and there are 16 essential nutrients. The question the experimenter hopes to answer is whether all of these nutrients are necessary for plant growth, and whether the absence of one specific nutrient will have an effect on plant growth. In this experiment the experimenter will grow plant seedlings in a hydroponics system. Hydroponics is a system of growing plants using mineral nutrient solutions, without soil. It is necessary to use a hydroponics system because it is almost impossible to control the nutrient intake of a plant that is growing in soil. Each seedling will be grown in a water culture solution with a controlled nutrient deficiency. The four water culture solutions that will be used in this experiment are complete nutrition, nitrogen deficiency, potassium deficiency, and iron deficiency. The hypothesis is the plant seedling grown in the complete nutrition solution will have the greatest amount of growth.

Experiment

Once the problem statement and hypothesis were decided by the experimenter the first step in the experiment was deciding what type of plant and which nutrient solutions to use. Plant type did not matter as long as the seedling would sprout in a short amount of time, and as long as there would be rapid growth. So the experimenter decided on
pumpkin seedlings. For the nutrient solutions iron, potassium, and nitrogen were chosen because they all play a part in photosynthesis.

The next step in the experiment was to gather all of the materials. The materials used to grow the pumpkin seedlings were one mini-greenhouse, moist soil, fertilizer pellets, and 30-40 pumpkin seeds. This many seeds were required so that seedlings of equal size could be selected. The materials used to build the hydroponics system were 12, 500 ml glass bottles with plastic lids, two aquarium air pumps, plastic tubing, and plastic T-valves. To make the water culture solutions a plant nutrition kit was used. The kit includes 10 stock solutions which were mixed together to make the nutrient solutions.

After all of the materials were gathered the next step was to plant the pumpkin seeds. First the experimenter filled each square of the mini-greenhouse with moist soil and 2 fertilizer pellets. Then the pumpkin seeds were placed in the greenhouse and covered with a thin layer of soil. The mini-greenhouse was placed under a lighting system and watered every day.

When the seedlings were about three inches tall they were carefully flooded out of the soil. It was important to make sure the roots of the seedlings were clean before placing them in the water culture solution. The seedlings were kept on a wet paper towel to maintain moisture.

After the seedlings were flooded out of the soil the experimenter was ready to build the hydroponics system. The first step in doing this was to open two, ½ centimeter holes in each of the twelve lids. Then the experimenter cut the plastic tubing into seven strips. Each piece of the tubing was about 30cm long. After the lids and tubing were
The experimenter connected the tubing to the air pump and four bottles using the plastic T-valves.

Now that the seedlings were removed from the soil and the hydroponics system was built the next step was to make the various nutrient solutions. First the experimenter referred to the nutrient solution composition sheet included in the plant nutrition kit to see which solutions were needed to make the nutrient solutions. Then the experimenter measured the stock solutions into a beaker. When the mixtures were complete the experimenter poured each mixture into one of the glass bottles. 200ml of water was added to each bottle to thin the mixture. Now the experimenter labeled each bottle with the name of the solution in it.

The final step of the experiment was to insert the seedlings into the bottles through the holes on the lids, and close the lids tightly. Now the experimenter turned the air pump on and the setup was complete. The height of each seedling was measured for seven days. This process was repeated three times to obtain more accurate data.

**Discussion**

The results of the experiment were that the pumpkin seedlings grown in the complete nutrient solution and the potassium deficient solution had the highest amount of growth. Both plants grew an average of 5.3cm. The nitrogen deficient plant had the next highest amount of growth with 2 cm, and the iron deficient plant had the lowest amount of growth at 1.8 cm. As can be seen on the graphs there is a very small difference between the data of the bottom two plants, and there is no difference between the data of the top two plants. However there is a fairly significant gap between the plants with the highest amount of growth and the lowest amount of growth. When looking at data from
each trial it can be seen that there is a significant difference between the data of the first and third trial, and the second trial. This is probably due to an error made by the experimenter. However all of the data follows a pattern in showing that the plants grown in complete nutrient and potassium deficient solutions have the highest amount of growth, and the plants grown in the iron and nitrogen deficient solutions have the lowest amount of growth.

Though the dependent variable in the experiment was the growth of the plants, other observations were made. Towards the end of the experiment some of the plants started to show changes in color. In the nitrogen deficient plant brown splotches were found on various leaves. In the potassium deficient plant dark green and black splotches were found on leaves. The iron deficient plant showed the most noticeable signs of discoloration. As new leaves came in the color of the plant became a very light green color, much lighter than any of the other plants. In one of the trials the plant started to show black splotches and eventually dried up and stopped growing. These changes in color are nutrient deficiency symptoms. In all three trials the complete nutrient plant showed no discoloration, and the leaves were almost perfect. These observations show that an environment with all of the essential nutrients is best for overall plant development.

The hypothesis, which states that the plant seedling grown in the complete nutrient solution will have the highest amount of growth, was not supported by the data. Although the plant grown in the complete nutrient solution did have one of the highest amounts of growth, it tied with the potassium deficient plant. Overall, the data proves three main points. The first point is that when a plant seedling was grown in an
environment lacking either nitrogen or iron the growth of the plant was not as rapid or vigorous as the plant grown with nitrogen or iron. The next point is that in the seedling stage of the plant the absence of potassium did not affect the growth of the plant. The third point is that an environment with all of the essential nutrients was best for overall plant development.

To see if the above three points are supported by published data and commonly held beliefs the basics of plant nutrition must first be established. In the study of plant nutrition most published data refers to the 16 essential nutrients. These are the nutrients which are required for a plant to complete its life cycle, are not replaced by other nutrients, and are directly involved in plant metabolism. The 16 essential nutrients are broken up into 3 categories, primary nutrients, secondary nutrients, and micronutrients. Primary nutrients are required most often and in the largest quantities. Secondary nutrients are required less, and micronutrients are only required in small amounts. In the experiment there were nutrient solutions lacking either potassium, nitrogen, or iron. Potassium and nitrogen belong to the primary nutrient category and iron belongs to the micronutrient category.

Now that the basics of plant nutrition have been established the three points proven by the experiment can be compared to published data and commonly held beliefs. The first point proven by the experiment is when a plant seedling was grown in an environment lacking nitrogen or iron the growth of the plant was not as rapid or vigorous as the plant grown with iron or nitrogen. In studies done over the 16 essential nutrients it is said that iron and nitrogen both play a vital role in plant growth. The data of the experiment would support this theory because when either iron or nitrogen was not
present in the nutrient solution the growth of the plant decreased. Although iron and nitrogen both play a role in plant growth each of the two nutrients also have a set of functions which they do not share with each other. Some of nitrogen’s other functions in a plant are it effects energy reactions in the plant, it aids in the production and use of carbohydrates, it is a necessary component of vitamins, and it is directly involved in photosynthesis. Some of iron’s other functions in a plant are it acts as an oxygen carrier, and it promotes formation of chlorophyll. The differences in the functions of the nutrients could be associated with the difference of the data in the experiment.

The second point proven by the experiment is that in the seedling stage of a plant the absence of potassium did not affect the growth of the plant. In published data it is said that potassium’s main role is aiding fruit formation. Since the plants used in the experiment were in their seedling stage no fruit formation occurred. An inference that could be made from looking at the results of the experiment and the published data is that potassium is not a necessary nutrient in plant growth until fruit formation occurs. However this statement cannot be assumed to be true since potassium has other roles in a plant such as protein formation and aiding photosynthesis. Though the absence of potassium did not affect the growth of the plant, it did affect leaf development and caused discoloration. This means that for a completely healthy plant to grow potassium is necessary even when there is no fruit formation.

The third point proven by the experiment is that an environment with all of the essential nutrients was best for overall plant development. This point was supported by every set of published data found by the experimenter, and no conflicting information was found.
Though almost all of the results of the experiment were congruent with published data and commonly held beliefs there are many factors which could have altered the outcome of the experiment. One factor is that even in a hydroponics system it is almost impossible to a completely control the nutrient intake of the plant. This is because the plant itself contains nutrients which cannot be removed before conducting the experiment. Another factor that could have altered the data is that the plants used in the experiment were not all the same size even though the experimenter tried to get them close.

There were also faults in the procedure of the experiment itself. One problem is that only one type of plant was used in the experiment which decreases the accuracy of the overall results. Another problem is that the plant’s growth was only recorded for seven days, which is only a short part of the life cycle. If more accurate data was to be obtained the experiment would have to be extended over the whole life cycle of the plant. If the experiment was repeated again the experimenter would test plants for deficiencies of each of the 16 essential nutrients.

Other experiments that could be conducted include the effect of nutrient concentration on plant growth, and the effect of plant type on nutrient requirements.

**Conclusion**

In summary, the experiment conducted shows that nutrient deficiencies do have an effect on plant growth, and an environment with all of the essential nutrients is best for overall plant development. The absence of iron and nitrogen affects a plant by reducing its growth, and causing discoloration. The absence of potassium has no effect on plant
growth in the seedling stage, but does affect overall growth by causing discoloration.

The experiment also proves that plants can survive in a homemade hydroponics system.

This data could be useful to agronomists by providing information about what nutrients are helpful in crop growth, and benefits the study of plant nutrition.
Tables and Graphs

The Effect of Nutrient Deficiencies on Plant Growth

<table>
<thead>
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<th>Type of Nutrient Deficiency</th>
<th>Total Amount of Plant Growth (cm)</th>
<th>Average (cm)</th>
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<tbody>
<tr>
<td></td>
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<tr>
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<td>9.5</td>
</tr>
<tr>
<td>Minus Potassium</td>
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<td>11</td>
</tr>
<tr>
<td>Minus Nitrogen</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Minus Iron</td>
<td>1.5</td>
<td>2.5</td>
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The Effect of Nutrient Deficiencies on the Growth of Plants
The Amount of Growth for Plants Grown without Nitrogen

![Bar Chart 1]

The Amount of Growth for Plants Grown without Iron

![Bar Chart 2]
Pictures
Acknowledgements

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Works Cited


