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Science Investigation – 10B
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An Investigation into Plant Growth
Environmental Factors that Affect Plant Growth

This unit we looked at different ways of improving plant growth and how do different environmental factors affect the growth of plant. The experiment was mostly to find out which factors would affect the growth of the plant and how. This report mainly focuses on how deficiency of phosphorus affects the growth of a radish plant and why.

Research question

How does the deficiency of phosphorus affect the plant growth as measured by number of leaves, surface area of leaves and root length? How much time will a plant take to grow or how healthy a plant will be if the plant does not obtain the required amount of phosphorus from the Sach solution?

The independent variables of this experiment were complete sach solution and sach solution without phosphorus, which were measured using a measuring cylinder. The amount of complete sach solution and sach solution without phosphorus were balanced in the following ways:

- 100% complete sach solution to 0% sach solution without phosphorus
- 75% complete sach solution to 25% sach solution without phosphorus
- 50% complete sach solution to 50% sach solution without phosphorus
- 25% complete sach solution to 75% sach solution without phosphorus
- 0% complete sach solution to 100% sach solution without phosphorus

The dependant variables of this experiment were the number of leaves, the surface area of leaves and the root length of the plant. The number of leaves was measured by counting them and the surface area was measured by using a graph paper. All the data was collected in a table. The following were the control variables of the experiment:

- The type of seed was a control variable. For every set of data, a red radish seed was used. In each tube, one seed of the plant type was planted.
- The amount of light received by the plants was a control variable. Every time the plants were placed in the same place which was next to the window. So, daily they received the same amount of light.
- The tubes were also a control variable. The tubes in which the plants were placed were all of the same size. They all had a volume of $22cm^3$.
- The water retaining gel powder was also a control variable as well. In each tube about 2.2g of it was used.
- The weighing scale used to measure the plant gel was also a control variable. To measure the powder, every time the same weighing scale was used.

Hypothesis

My prediction for this experiment was that the deficiency of phosphorus will lead to limited growth of the plants. As the amount of phosphorus will decrease, plant growth will slow down. Due to slow plant growth, there will be fewer leaves than normal and the

leaves will not fully develop; they will not have large surface areas and will die in less time. Also, the leaves will contain a purple pigment and will be dark green. The root development of the plant will slow down and lengthwise they will be very small.

Phosphorus plays an important role in plant growth. It is a very essential nutrient for plants as it helps in energy transfer and storage during photosynthesis. Normally, with the presence of phosphorus, the roots of the plant flourish and it plays an important role in the ability of plants of better tolerance of soil born diseases. But its deficiency might lead to slow growing, weak and stunted plants that might be dark green with older leaves showing a purple pigmentation. Also roots will grow slower than usual and the plant might die before full growth.

I expect the graph to have a positive correlation which has a gentle slop because of slow plant growth. As the plant will grow slowly, the graph will have a steady gentle slope. The points will be pretty much very close to each other.

Apparatus

For the experiment I required twenty five tubes for five treatments; there were about five replicates for each treatment so that our results did not contain any complications. We also required complete sach solution, sach solution without phosphorus, water retaining gel powder, measuring cylinder to measure the amount of the sach solutions, beakers that contained the sach solutions, syringes also to measure the amount of water or sach solutions, weighing scale to measure the amount of plant gel, tube holders to hold all the tubes, markers to mark the tubes, graph paper to measure surface area of leaves, pipettes to mix solutions and flasks to mix solutions in. The following diagram explains how the experiment was set up and also the method used to carry out the experiment.

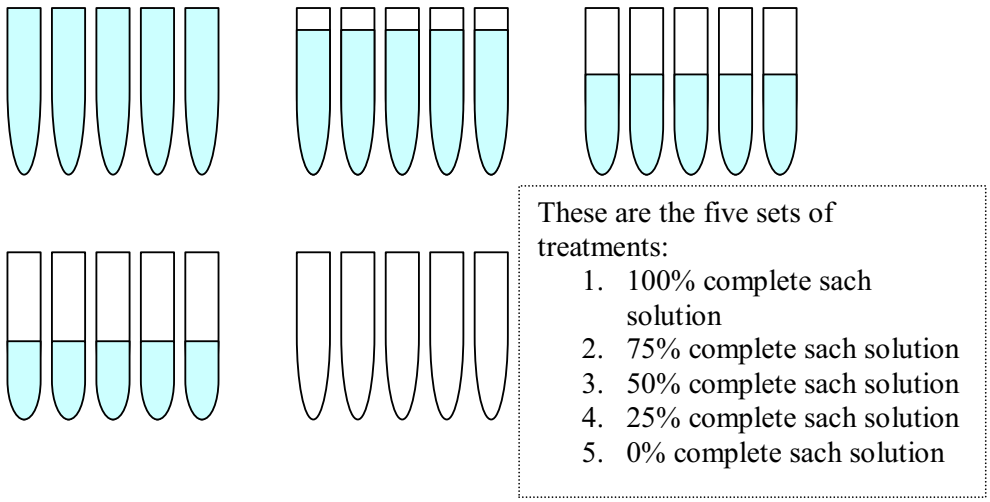

Figure 1: how the experiment was set up and the arrangement of the tubes

We started off the experiment by gathering all required equipment for the experiment and setting them up for the experiment to begin. Figure 1, is a demonstration of how the tubes were set up in five treatments and what proportions of the two types of solutions were used for the different treatments.

- The first treatment contained tubes that contained 100% of complete sach solution. The tubes of this set were each filled up with 22ml (volume of the tube) of complete sach solution; a solution containing all necessary minerals required for plant growth.
- The second treatment contained tubes that contained 75% of complete sach solution and 25% of sach solution without phosphorus. The tubes of this set were each filled up with 16ml of complete sach solution and 6ml of sach solution without phosphorus.
- The third treatment contained tubes that contained 50% of complete sach solution and 50% of sach solution without phosphorus. The tubes of this set were each filled up with 11ml of complete sach solution and 11ml of sach solution without phosphorus.
- The fourth treatment contained tubes that contained 25% of complete sach solution and 75% of sach solution without phosphorus. The tubes of this set were each filled up with 6ml of complete sach solution and 16ml of sach solution without phosphorus.
- The fifth treatment contained tubes that contained 100% of sach solution without phosphorus. The tubes of this set were each filled with 22ml of sach solution without phosphorus; a solution that contained all necessary minerals required for plant growth except of phosphorus.

The tubes of each set were first filled with 2.2g of water retaining gel powder. Water retraining gel when mixed with compost, can help to keep the plants moist by absorbing and retaining water. This powder was then mixed with the mixed solutions of complete sach solution and sach solution without phosphorus. The proportions of the sach solutions were measured using a measuring cylinder.

The seeds that were planted were red-radish seeds. These seeds take a while to grow and one of these seeds was panted in each tube of the different treatments, after the gel was ready to use. Everyday these tubes were needed to be filled with water; it was filled to the top of the tube, so that the plants could absorb/use as much water as possible.

The tubes were then labeled which treatment they belonged to; the treatments were labelled according to the amount of complete sach solution they contained, for example: 100% s; s standing for complete sach solution, 75%s, 50%s, 25%s and 0%s. Also, each tubes in the different sets, were labelled 1, 2, 3, 4 or 5, so that taking measurements was not very complicated. This made it easier for us to notice the progress of each plant.

Once the experiment was set up, the tubes were placed in a tube holder, in order. Our experiment was then placed next to the window. This was the place where we always placed our experimental set up after taking results, so that the plants received the same amount of light every day, in order to conduct a fair test.

As my dependant variables were the number of leaves, the surface area of the leaves and the root length, every day I measured the root length using a ruler and the number of leaves by counting them. I measured the surface area of the leaves at the end, as not many seeds had germinated at the beginning, using a graph paper. I placed the leaves on the graph and counted the number of boxes they covered.

The results were then recorded in a table. The table below shows the progress that the plants made during the 10 day cycle and the effects of the deficiency of phosphorus, on plants.

Table 1

		Number of leaves					Root length (cm)					Surface area of leaves (cm^2)				
		100%	75%	50%	25%	0%	100%	75%	50%	25%	0%	100%	75%	50%	25%	0%
Day 2	1	0	0	0	0	0	0	0	0	0	0	Not applicable				
	2	0	0	0	0	0	0	0	0	0	0					
	3	2	1	0	0	0	0.6	0.8	0	0	0					
	4	0	2	0	2	0	0	1.1	0	0.3	0					
	5	1	0	0	2	2	0.4	0	0	1	0.6					
Day 5	1	0	2	1	2	2	0	1	1.1	1	1	Not applicable				
	2	2	0	0	1	0	1.2	0	0	0.4	0					
	3	2	2	0	0	0	0.6	0.8	0	0	0					
	4	0	2	0	2	2	0	1	0	0.8	1.2					
	5	1	0	0	2	2	0.6	0	1.6	0	2.1					
Day 8	1	0	0	1	2	2	0	1	0	1.5	2.8	Not applicable				
	2	2	0	0	1	0	1.2	0	0	1	0					
	3	2	2	0	0	0	0.7	1.3	0	0	0					
	4	0	3	2	3	2	0	3.1	0	2.6	1.3					
	5	1	1	0	2	2	0.7	0	4.2	0.4	2.3					
Day 9	1	0	0	2	2	2	0	1.2	0	2.6	3.3	Not applicable				
	2	2	1	0	2	0	1.2	0	1	0.9	0					
	3	2	2	1	0	0	1.0	2.9	0	0	0					
	4	0	4	2	4	2	0	4.6	0	5.4	1.8					
	5	1	2	0	2	2	0.7	0	6.1	0.9	2.9					
Day 10	1	0	2	1	2	4	0	1.6	0	3.1	3.6	0	1	3.5	2.5	4
	2	2	2	2	3	0	1.3	0	1	2.4	0	1.5	1	5.5	2.5	0
	3	2	1	0	0	0	1.1	3.3	0	0	0	0.5	0.5	0	0	0
	4	0	4	0	4	2	0	4.7	0	5.5	2	0	6	0	7	1.5
	5	1	0	4	2	4	0.8	0	6.6	1	4.7	1.5	0	3.5	1	2

The table above contains results of the experiment. The experiment was based on what environmental factors affect the plant growth. My experiment was based on how the

deficiency of phosphorus would affect the plant growth. The three variables that I measured were the root length, the number of leaves and the surface area of leaves which was measured at the end, as shown by the table above.

The 1-5 numbers in bold letters on the left hand side of the table are the number of tubes and 100% - 0% number on the top are the percentage of complete sach solutions present in each treatment.

The table above shows us how the plants developed in ten days. The table shows that the plants grew very slowly; even though the data was not collected on regular bases, we can see the slow progress of the plants.

The following are some observations made in the end on the plant growth cycle. The following observations discus the difference between the growths of plants of different treatments:

- The plants growing in 0% of complete sach solution and 100% of sach solution without phosphorus developed very fast; good plant growth. The leaves were bright green and seemed very healthy and the plants themselves seemed very healthy. Also root and stem growth was very good.
- The plants growing in 25% of complete sach solution and 75% of sach solution without phosphorus developed very well; amazing plant growth. The plants seemed very healthy and they had long stems and roots. The leaves were bright green and had large surface areas.
- Not many seeds planted in 50% of complete sach solution and 50% of sach solution without phosphorus, germinated. Only three plants had germinated but had long stems and roots. The leaves were darker than leaves of the plants planted in 0% and 25% of complete sach solution. The leaves also contained a purple pigment.
- Seeds planted in 75% of complete sach solution and 25% of sach solution without phosphorus, did not really germinate. Only two plants germinated and had relatively long stems and roots. The leaves were dark green and the stems of the plants were turning purple. Also, the tips of leaves were growing black.
- Seeds planted in 100% of complete sach solution did not germinate very well either. Only two plants germinated and were very small plants. They were dying and hanging loose. The roots were very small and the stems were completely purple. The leaves were almost black in colour.

Around eight out of twenty five seeds that were planted, did not germinate which is a good sing. Most of the plants were not very healthy; they had short stems and leaves and dark leaves. The plants took a while to grow which is probably due to the seed type because radish seeds take a while to germinate; they take long to grow.

The surface area of the leaves was taken in the end and in order to do that I had to pluck the leaves. I had placed the leaves on a graph and counted the number of squares they covered in order to find out the surface area of the leaves, as previously mentioned. The surface area of the leaves also suggests that the plants growing in 0% of complete sach solution and 25% of complete sach solution developed rather faster than the others. The leaves for plants of these two treatments had very large surface area compared to the other plants.

Conclusion

The results above show that as the amount of phosphorus decreases, the plant growth increases which does not commensurate my hypothesis. The data above does not support my hypothesis very well because my hypothesis stated that as the amount of phosphorus decreases, the plant growth will slow down; a deficiency of phosphorus would lead to slow and incomplete plant growth. But the data above suggests that a deficiency of phosphorus will lead to fast and healthy plant growth. The plants growing in sach solution with low amount of phosphorus are very healthy and have long roots and stems which is not what my hypothesis suggested.

Phosphorus plays an important role in plant growth. Phosphorus classified as a component of macronutrient such as ribonucleic acids (RNA), deoxyribonucleic acids (DNA), adenosine triphosphate (ATP) and adenosine diphosphate (ADP), is very essential for plants as it plays an important role in energy storage and transfer reactions during the process of photosynthesis. Phosphorus provides the energy required by all organic processes. RNA and DNA are the two nucleic acids components of the genetic information. Most seeds are high in phosphorus; meaning that they already contains phosphorus which helps the plants spend the first few days of its growth period without depending on the soil that it grows in.

In soil, phosphorus is commonly found in chemical forms that cannot be immediately absorbed by plants, so the farmers have to apply phosphorus to the soil for rapid pant growth. Phosphorus is absorbed by the roots of the plant; which is why root growth stops due to deficiency of phosphorus, mostly in the ionic form of either $H_2PO_4^-$ or HPO_4^{2-}. The ionic form that is mainly absorbed depends on the pH of the soil. $H_2PO_4^-$ is normally absorbed by plants growing in low pH soils whereas HPO_4^{2-} is absorbed by plants growing in high pH soils. The best pH range for phosphorus uptake is pH 6.5 and 7.5. Although, seeds are already rich in phosphorus, the availability of phosphorus in soil is very low as it is tied up in poorly soluble components.

With the presence of phosphorus, the roots of the plants flourish; the roots are healthier and are of good length. Also with its presence plants develop resistance against soil born diseases such as avocado root rot. Phosphorus helps keeping plants safe from insects and soil born diseases which is the reason why many farmers use fertilizers highly rich in phosphorus as this helps them protect their plants from soil. Most annual plants require large amount of phosphorus as they begin to grow, such as, lettuce or legumes. Deficiency of phosphorus might lead to slow growing, weak and underdeveloped plants. The leaves might be dark green with black edges and will be showing a purple pigmentation. The stems will turn red as time passes by. Also, deficiency of phosphorus leads to poor growth of plant roots; the roots are fairly small and very thin. Its deficiency might harm many processed related with energy storage and transfer. It will affect bud and seed development and the fruit quality and size might be poor.

Excessive use of phosphorus could also be dangerous for plants. It might lead to deficiencies of iron and zinc which are also two important components used by plants for plant growth and development. It could also induce potassium deficiency which could also be problem for the plant.

An observation made during the experiment was the rate of plant growth. The plants grew very slowly. Maybe this was due to the type of seed or due to the deficiency of phosphorus but as I mentioned earlier that the results do not support my hypothesis, so

it was probably due to the seed type. Radish seeds a bit longer to germinate due to slow inner plant development.

The data above shows that the deficiency of phosphorus leads to healthy plant development. As mentioned earlier, the plants growing in 0% and 25% of sach solution grow or develop faster than the plants planted in 100%, 75% and 50% of complete sach solution which does not support my hypothesis. The plants for the last two treatments (25% s and 0%s) seem to be developing very well without any problems. The stem and root growth is very good and the leaves seem very healthy and were bright green. But the plants for the rest of the treatments (100%s, 75%s and 50%s) were almost dying. The leaves were dark green with black edges and had weak stems. They had short roots and the leaves contained a purple pigment, which his basically the opposite what my hypothesis suggests.

My results also show how slow the plants grew. On day 2, 18 seeds out of 25 did not germinate. On day three, about 11 out of 25 seeds did not germinate. On day 8, 10 out of 25 seeds did not germinate and until day 10, there were 8 seeds that did not germinate, remaining. This shows that the plants grew very slowly even after the supply of all the minerals.

Evaluation

Most of the results that I achieved do not support my hypothesis. They suggest that the deficiency of phosphorus leads to healthy plant growth which is something that I am not sure about. Scientific researches suggest that a deficiency of phosphorus might lead to weak and underdeveloped plants. But my results do not support the statement.

As previously mentioned above, the treatments were named according to the amount of complete sach solution present in them; we had named the treatments as follow: 100%s, 75%s, 50%s, 25%s and 0%s. This might have caused a problem during the mixing of the solutions; we might have used the wrong solutions for the treatments. I guess we might have mixed up the wrong amount of the solutions for the treatments due to some confusion which led to such results. Basically the results are opposite my hypothesis which could mean that we might have got mixed up with the names of the treatments. Next time this could be changed by mixing only one type of solution at a time because in our case we were mixing all the five solutions at a time which could be the reason why we got everything mixed up. I would also name the different treatments differently, so it is easier for and my partner to remember which one is which and avoid such incidents.

These results could have also been affected by the seed quality. Every seed is different; it is not necessary that they might carry the same amount of minerals in them. Maybe some of the seeds were highly rich in phosphorus and others were not. So, the seed type could have been a reason behind the variations in the plant growth of the plants.

Another reason could be the amount of light. As our experiment was placed next to the window, some of the plants that were far away from the window could have been affected; they might have not received the same amount of light as the ones next to the window did. This could have also been a problem that caused the plants to grow differently. The plants next to the window, received more light which could have helped those plants grow better than the rest.

During the experiment, I faced a few problems. The first one would be that I was not able to take results regular bases. This could be problem because this way I do not know the small changes that the plant while growing. For example; which side the plants turn to or at what point the plants stared to weaken. Also, then I would have been able to include observation made on regular bases.

Another problem would that not all seeds germinated. About 8 seeds did not germinate by the end of the 10 day cycle. Maybe this was due to some genetic mutation present in the seeds. Those seeds might have not been as healthy as the others. They might have contained an unknown mutation. Or maybe the minerals present in the sach solution, were not enough for them to germinate.

One of the other problems that I faced could be managing the tubes in order. Every time after we took results, I had to take care the tubes were placed in the same position as before because if they weren't then it wouldn't have been possible to conduct a fair test. The results could have then contained many more variations and we would have not been sure about them.

During the process a few changes were made to the experiment. First we had decided to use sulfur instead of phosphorus. But as we weren't aware of the systems of a deficiency of sulfur would cause, we decided to do phosphorus.

Another change would be the use of $22ml^3$ tubes. We had first decided to use the $11ml^3$ but then we realized that mixing the solutions will then be a problem as too was small number. We then might have had to do a lot of calculations to calculate 75% or 25% of the solutions.

Another change that I made during the experiment was the change of the dependant variable. I changed my dependant variable from leave colour to root length because leave colour could be mentioned in the observations made. I chose to do root length because roots are normally affected by the deficiency of phosphorus. Deficiency of phosphorus might lead to short and underdeveloped roots, as mentioned earlier.

Next time I could get much more steady and accurate results by labeling all the treatments differently, so that I do not get confused when mixing and poring the solutions into the tubes. Another change I would make, will be the changing the position where the experiment was kept. I would keep my experiment next to the windows because then not all of my plants will get enough sunlight which might lead to inaccurate results.

Another change I would make is using different type of seeds. I would use different seeds in order to make it easier for me to different results for each day. Because most of the results for the different days are the same and I would like to avoid that so that the plant progress is clearer than before.

Another change I would make is, by having more treatments. This time we had five treatments, next time I would like to have eight treatments so that we could identify the small variations in plants too. This way it will be easier for us to understand the affects of the deficiency of phosphorus better.

Maybe, next time I could video my plants. This will helpful because then we don't have to take that many results and we will then be able to identify each change that the occurred in plant growth. It will also tell us that if the plant received enough light the entire time or not or if the plant was watered well not. Making a video could be very useful also to identify the stages at which the changes took place. For example, at what point the plant started to die or at which point the purple pigmentation in leaves began to

appear. To conclude, I don't think that the method requires any changes and cold be redone by the changes made above.