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Lemna coursework

Introduction

Lemna are small water plants found in ponds. Typical of plants, they reproduce asexually. When they reproduce they form a bud on the edge of a leaf, which, when big enough, will eventually separa te from the mother leaf and can then reproduce itself. Sometimes lemna plants can have up to 3 or 4 buds. Exactly the same as plants in soil, they use the sun's energy for **photosynthesis**, and water, but they have to take all their nutrition to grow and rep roduce from the water. I am going to look at how lemna are affected by deficiencies in nitrogen, iron and magnesium.

Question

How do lemna plants cope in environments lacking certain mineral salts – nitrogen, iron and magnesium?

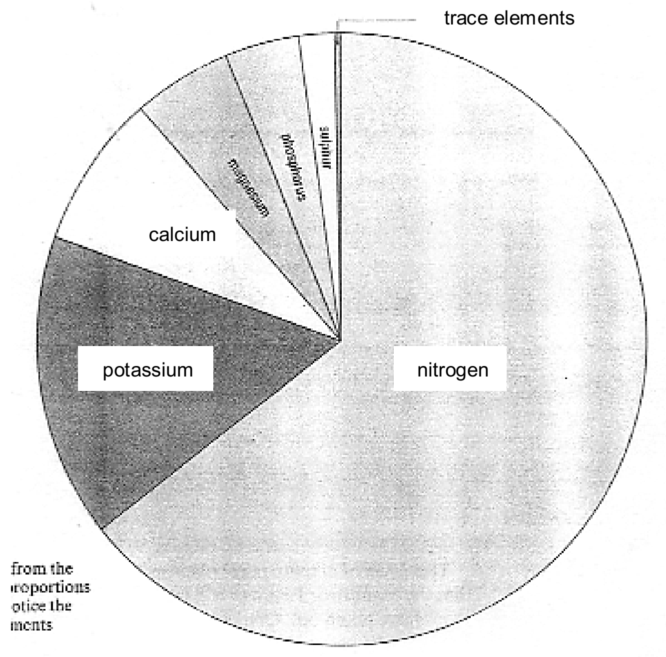
Photosynthesis equation

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \text{glucose} + \text{oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$$

Prediction

I predict that the lemna in the complete culture solution will thrive, growing and reproducing at a high rate. This therefore means that by the end of our experiment these lemna will be the greatest in number. I also think that they will remain green and healthy, and should have no abnormalities or death s. This is because the lemna have all the mineral salts that they could ever possibly need in order to grow and reproduce. To photosynthesise, plants need **carbon dioxide** and **water** as basic raw materials. However, they also need many different **mineral salts**, which help the plant to grow, make chlorophyll and photosynthesise among other things. All green plants need, in order of importance, nitrogen, potassium, calcium, magnesium, phosphorus, sulphur and other trace elements which are needed in tiny quantitie s, which include iron, copper and manganese. I have shown the importance of these minerals in the form of a pie chart. See following page.



A **complete culture solution** contains all of these minerals; therefore these lemna will live the most successfully. I think that over the weeks we will see the lemna in the complete culture solution being healthy and green, gradually building up larger roots and leaves.

Therefore, for the solution containing no **nitrogen** ions, I predict that the final outcome will be that there is the least amount of lemna. I say this because nitrogen is the most important mineral salt for plants. They get the nitrogen from nitrates in the soil (or in this case the water). It is essential for the production of amino acids, proteins, and chlorophyll. What happens is that the nitrogen ions combine with glucose to form amino acids. Proteins help with growth, therefore I would expect to see small leaves, perhaps with some loss of colour due to chlorophyll not being produced so quickly. Chlorophyll is what makes plants green, therefore a lack of it would result in the yellowing of the leaves and eventual complete loss of colour. With no nitrogen, the lemna will be unable to make much amino acids or proteins, so they will not be able to grow as rapidly. Along with this the root of the lemna will be reduced in size, making the plants less able to take in water and other vital minerals. As a result, I think the plants will lose their colour (become **chlorotic**) because they will not be able to make chlorophyll very easily.

For the lemna in the solution containing no **iron** ions, I predict that we will not see such slow growth. The plants should not be affected very much at all, because iron is only a trace element needed in plants. This means that it is needed, but it can survive without, and will not die straightaway. I therefore predict that over the weeks we will see that many of the lemna plants remain green and healthy, while some begin to turn yellow. This is known as **"chlorosis"**, and is caused by lack of chlorophyll. Plants need iron for the formation of chlorophyll, which is what makes the plant appear green. Chlorophyll is also vital in the production of food for the plant, as you can see in the word equation. Also, iron is necessary for many enzyme processes that help respiration and the metabolism of the plant. So I expect to see that the plants may appear smaller, fewer in number, and with yellow spots on the leaves. This discolouring will affect the younger leaves the most. Eventually some will turn brown and die. This is typical of an iron deficiency.

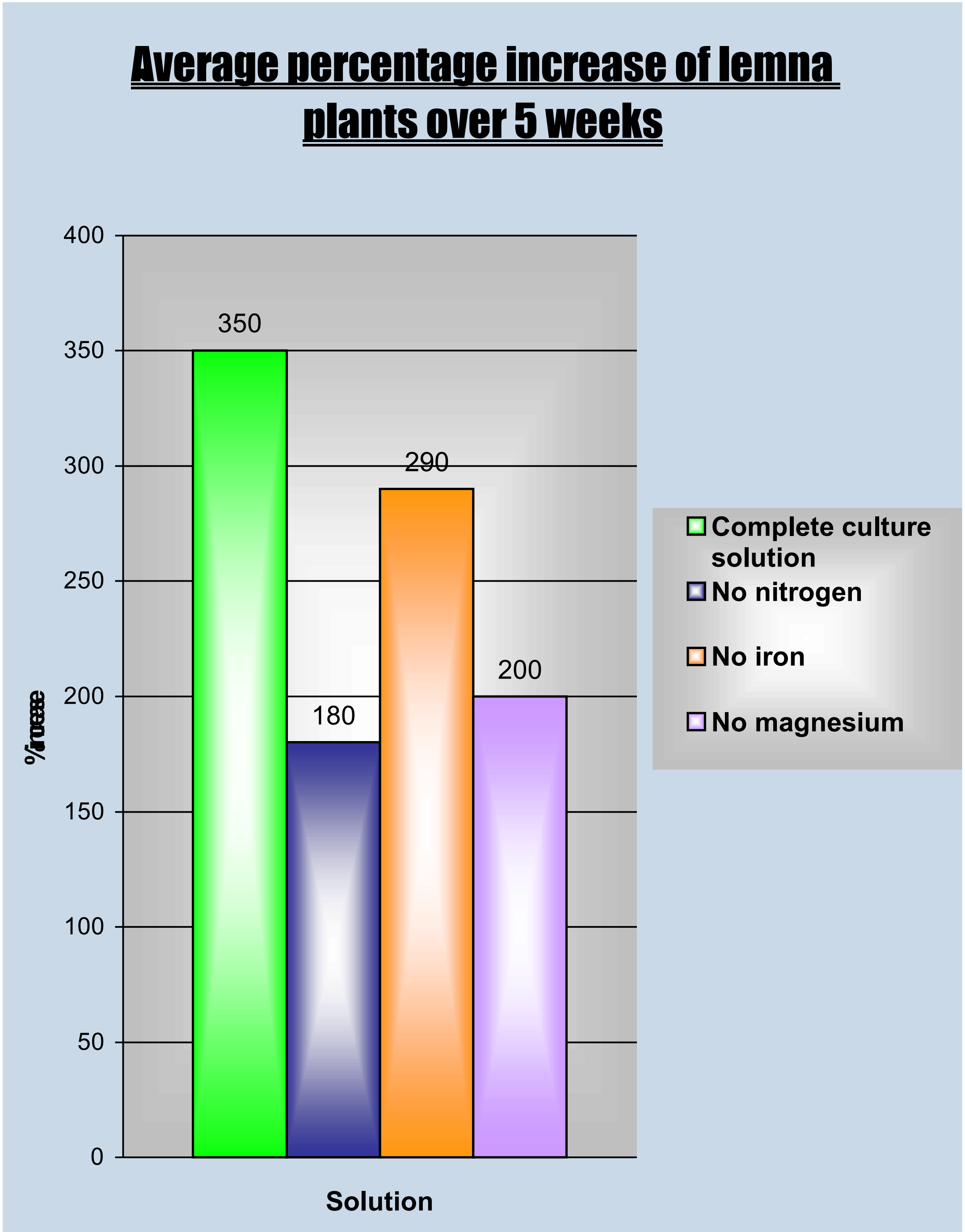
Finally, for the solution containing no **magnesium** ions, I predict that there will be less lemna than in the complete culture solution and the solution containing no iron, but more than in the solution containing no nitrogen. This is because magnesium is more important to plants than iron but less important than nitrogen to plants. Magnesium is one of the raw materials of chlorophyll, and also helps to activate some enzymes involved in energy transfers. Therefore, I predict that in the lemna lacking in magnesium we will see yellow patches on the leaves. Chlorophyll is what makes leaves on plants green, and because magnesium deficiency affects the formation of chlorophyll, the leaves will not be able to be so green. We may even see a complete loss of colour. I think that the amount the lemna increase in number will be a lot less great than that of the complete culture solution. I also think that the lemna will have small roots due to not being able to grow quickly enough. Again, this will result in the plants not being able to take in as much mineral salts, and they may become deficient in other minerals.

Results

	Number of lemna plants in each solution			
Week	**Complete culture**	**No nitrogen**	**No iron**	**No magnesium**
1	10	10	10	10
	10	10	10	10
	10	10	10	10
	10	10	10	10
	10	10	10	10
Average	**10**	**10**	**10**	**10**
2	18	16	21	19
	20	10	17	19
	14	10	14	14
	34	23	26	28
	20	15	20	11
Average	**21**	**15**	**20**	**18**
3	32	28	32	28
	27	19	24	21
	19	10	20	11
	52	31	33	37
	24	25	29	14
Average	**31**	**23**	**28**	**22**
5	44	29	37	29
	50	30	37	32
	35	21	46	27
	64	35	41	48
	33	24	32	16
Average	**45**	**28**	**39**	**30**
Percentage Increase Week 1-5	**350%**	**180%**	**290%**	**200%**

	Other observations taken for eac h solution (summarised)			
Week	**Complete culture**	**No nitrogen**	**No iron**	**No magnesium**
1	All plants green and healthy	All plants green and healthy	All plants green and healthy	All plants green and healthy
2	All with buds about to separate, all green and healthy	All with buds, some plants turning yellowish	All with buds, all green and healthy	Many with buds, green and healthy although slightly small
3	All plants green and healthy, large roots	Some dead, small roots, loss of colour, small, sediment at bottom	Some dead, some yellowish	Some yellowed, some dead, small roots, sediment at bottom
5	All green and healthy, large roots and leaves	Lots of dead sediment at bottom, colour loss, small roots	Mostly dying, many dead, loss of colour, sediment at bottom	Loss of colour, some yellowish, lots dead, lots of sediment at bottom

Graphs


Average percentage increase of lemna plants over 5 weeks
400
350
300
250
200
150
100
50
0
350
180
290
200
Complete culture solution
No nitrogen
No iron
No magnesium
Solution

Conclusion

I conclude that the lemna that were the most successful were the ones in the complete culture solution. This is because they had all the minera l salts that they could ever ask for, meaning they were able to make **chlorophyll**, **proteins**, **enzymes**, and all the things that are vital for a plant's survival. By the fifth week, there were 45 lemna plants, so they had been growing and reproducing at a high rate. As you can see from the line graph, the number continues to increase reasonably steadily. This was as expected because I knew that these lemna would have everything they needed in the way of minerals, and there would be nothing stopping them making steady or even rapid progress, which was exactly what we saw. Also, over the weeks the plants remained green and healthy. To photosynthesise, plants need carbon dioxide and water as the raw materials, but they also need mineral salts essential for making d ifferent substances that the plant needs to grow, reproduce, respire and all the other processes a plant has to do to stay alive. Plants need many different mineral salts, and a complete culture solution contains all of them in the right quantities, as wat er plants get their nutrients from the water rather than the soil.

The lemna that were the least successful were those in the solution with no nitrogen ions in it. They only reached 28 in number. They were also the least healthy of all the lemna. They showed signs of **chlorosis** (loss of colour due to lack of chlorophyll) and their roots were reduced in size. Many of the lemna died. This is typical of nitrogen deficiency. On the line graph you can see that the lemna were increasing in number but not as steadi ly as in the other solutions. This shows that they were having the most difficulty in growing and reproducing. All plants need nitrogen to make amino acids, proteins, and chlorophyll. It combines with glucose to form amino acids, which are essential if the plant is going to grow well. This is why the lemna had small roots. Chlorophyll is a green substance found in most plants, and it is what gives them their green appearance. With a shortage of chlorophyll plants will not look green. This is why these lemna did not look green, but yellow – the plants were not able to make chlorophyll so well.

The lemna in the solution containing no iron ions was not very far behind the lemna in the complete culture solution in terms of number. There were only 6 more in the complete culture solution. As you can see on the line graph, they were only a little below the rate of the lemna in the complete culture solution. This supports my theory that the lemna would not be affected very much, as iron is only a **trace element**. However, it is needed, and the reason for it being needed is that it helps in the production of chlorophyll. This is why we saw some chlorosis in the lemna. Chlorophyll is what makes plants appear green, and if a plant is lacking in chlorophyll for some reason then it is impossible for it to look green. If the plants were larger ones with veins in the leaves the veins would have kept their green colour, as this is what happens in an iron deficiency. Iron deficiencies affect the younger leaves first, although it is impossible for us to tell which leaves had been affected. The thing that I did not predict was that some of the lemna would die. This is how my results undermine my prediction. I did not mention that many of the lemna would be dead at the end of the fiv e weeks.

The lemna in the solution containing no magnesium ions was the second least successful. Plants need a lot of different mineral salts, and they are, in order of importance, nitrogen, potassium, calcium, magnesium, phosphorus, sulphur and finally the trace elements. So magnesium is the fourth most important mineral salt to a plant. This is why we saw only two more lemna than in the solution with no nitrogen. Magnesium is an essential raw material in chlorophyll, and this explains why the lemna lost their green colour and turned yellowish. Without the green substance chlorophyll plants cannot appear green. Magnesium also helps to activate some enzymes involved in energy transfers. Magnesium deficiency causes plants not to be able to grow so well, therefore they are reduced in size. This is because it directly affects photosynthesis. We saw this through the size of the roots. You will notice on the line graph that the line for no magnesium is very close to the line for no nitrogen, only a little above. This proves that nitrogen is a more important mineral salt than magnesium.

On the line graph, you can see that as the weeks go by the number of lemna increases, despite the lack of mineral salts. This was to be expected, as although some of the lemna didn't have all the minerals they needed, they had most of them and were able to make some progress, even if it was very slight.

If you look at the bar chart, it becomes clearer that nitrogen is an important element to plants. Those lemna did not make much increase in number over the weeks, at 180% increase, compared to the 350% increase of the complete culture solution lemna. If plants have not made much progress in terms of growth and reproduction, it means they are not coping well in their conditions. As you can see, the bar for no iron is not very much shorter than the complete culture solution bar, at 290% increase. This is just emphasising the fact that iron is a trace element that plants do need, but only in small quantities. The no magnesium is very close to the no nitrogen bar at 200% increase. This also shows that magnesium is something that plants need to survive. Looking at percentage increase just clarifies the evidence we have, as it is difficult to look at it in the form of a line graph.

Evaluation

The procedure we used was probably not very suitable, because living things can never be too reliable. They do not photosynthesise at a steady rate, therefore you must be very lucky to get the plants at a good time for photosynthesis. I think that luck must have been with us, because we managed to achieve fairly accurate results, except for the anomalies highlighted in yellow in the results table. Because we used the results of 5 different groups it was like using repeated readings, and added to the accuracy of our results.

However, I think that because lemna plants are so small, it was difficult to make the other observations accurate. For example, in the lemna with no iron, we should have been able to see that the veins were still green, but because they are so small we could only vaguely see the yellowness. It would have been more suitable to use larger plants where you can see the symptoms more easily.

To make our results more reliable, we could perhaps have checked the lemna daily. This would give us a more accurate and reliable line graph, as the data would be closer together. As it is we are only able to estimate what the values in between each week were.

We had 7 anomalous results. This sounds like a lot, but because we repeated our result 5 times it does not matter a great deal. The reason for these anomalies is quite simple. It was because living things do not photosynthesise at a steady rate. They have periods of photosynthesising well, and periods of photosynthesising badly. This results in us not achieving the results we might have expected. Another thing that might have happened is that the plants had a lack of carbon dioxide. We could solve this by adding sodium hydrogen carbonate to the solution, to provide the plants with extra carbon dioxide. Of course, the anomalies could have been due to our bad judgement of whether or not the lemna had a bud on it when we chose them, or perhaps the health of them was not too good.

For further work to our experiment, we could investigate further mineral deficiencies. This would involve using a wider range of variables. For example we could use a solution containing no phosphorus ions, or one with no calcium ions. We could even put some lemna in some distilled water, which does not contain any minerals, and observe how they coped. We would count how many there were over several weeks and also make other observations as we did in this experiment.