CELLULAR RESPIRATION

LAB REPORT

Name

Date

Course Name

Introduction

Cellular respiration is an important pathway for a plant cell to meet its energy requirements. During respiration, oxygen is taken up by the cell and used to metabolize organic compounds such as fats, proteins, and carbohydrates releasing energy in the form of ATP. This process takes place in the mitochondria of the cell through three important metabolic pathways – Glycolysis, Krebs cycle, and oxidative phosphorylation. During glycolysis, glucose is converted into two pyruvate molecules releasing two ATP and two NADH molecules in the process. These molecules enter the Kreb's cycle where they are converted into a considerable amount of energy for the cell. The pyruvate is further converted to acetyl-CoA in mitochondria, which is finally converted to the high energy molecule, ATP. These reactions involve the consumption of oxygen and the release of carbon dioxide releasing about 32 to 34 molecules of ATP. When the energy requirement of the plant cell is low, the metabolic pathways are shut down through feedback inhibition resulting in very little oxygen consumption.

This experimental setup was prepared to compare the differences in the rates of cellular respiration between germinating and non-germinating seeds. Given that the energy requirements for germinating seeds is higher, it is hypothesized that the rate of respiration for germinating seeds should also be higher as compared to that of non-germinating seeds. Oxygen consumption and release of carbon dioxide is used to measure the rate of respiration for germinating and non-germinating seeds. Increase in water level in the test tubes is noted at regular intervals and the results are compared.

Materials

- Distilled water
- Desk lamp, with a 100W incandescent light bulb
- Paper towels
- Tap water
- Timer
- Cotton balls
- Glass beaker – 100 ml
- Pipettes – long stem and short stem
- Petri dishes – 90 mm
- Test tubes – 13 x 100 mm
- 24-well plate
- Yellow food colouring – 0.5 ml
- Millet seeds – 2 packets of 200 seeds each
- 0.5 M sodium hydroxide solution – 0.5 ml

Methods

1. The outline of the bottom of a 90 mm petri dish was traced on a paper towel and 4 cutouts were prepared.
2. Two of the paper towel circles were placed at the bottom of two petri dishes.
3. A short-stem pipette was filled with tap water and was used to moisten the paper towels placed in the petri dishes.
4. One packet of millet seeds was divided among the two petri dishes and the seeds were spread evenly on the damp paper towels.
5. The petri dishes were covered with their lids and were placed in two different dark and warm locations for germination of seeds.
6. During the entire germination process, the moisture of the paper towel was checked twice a day and water was added to the paper towel as required.
7. The seeds were allowed to germinate for 3 to 4 days until they had sprouted.
8. Two test tubes were taken and were labelled as ‘N’ for not-germinated and ‘G’ for germinated. The test tubes were divided into smaller parts in increments of 0.5 cm.
9. A fresh packet of millet seeds was opened and 100 seeds were counted and added to the test tube labelled ‘N’.
10. To the test tube labelled ‘G’, 100 germinated seeds selected from the petri dishes were added.
11. A cotton ball was divided into 8 smaller pieces and one piece was added to each of the test tubes above the seeds. The test tubes were held in a vertical position by placing them in a 24-well plate.
12. Using a short stem pipette, 5 drops of distilled water were added to each of 2 empty wells in the 24-well plate.
13. Using the same pipette, 5 drops of 0.5 M sodium hydroxide solution were added to the distilled water in the two wells. This gave 10 drops of 0.25 M sodium hydroxide solution in both the wells.
14. One of the pieces of the cotton ball was placed in a well containing the sodium hydroxide solution and was moved around to absorb the solution completely.
15. This sodium hydroxide-absorbed cotton ball was placed in one of the test tubes over the dry cotton ball.
16. Another piece of cotton ball was dipped in the sodium hydroxide solution and added to the second test tube over the dry cotton ball.
17. A 100-ml glass beaker was filled with 50 ml distilled water and 2 drops of yellow food colouring was added to the beaker and mixed well.
18. One of the test tubes was inverted in the glass beaker and was held in place using tape about 5 mm above the bottom of the beaker.

19. The second test tube too was inverted in the beaker and held in place beside the first test tube.
20. A desk lamp was set up and placed about 1 foot away from the beaker to act as a source of warmth for the seeds.
21. Using the 0.5 cm markings on the test tube, the height of water in each of the test tubes was observed and recorded. The procedure was continued every 10 minutes for 2 hours.
22. At the end of 2 hours, all data was recorded and compared between the germinated and non-germinated seeds.

Results

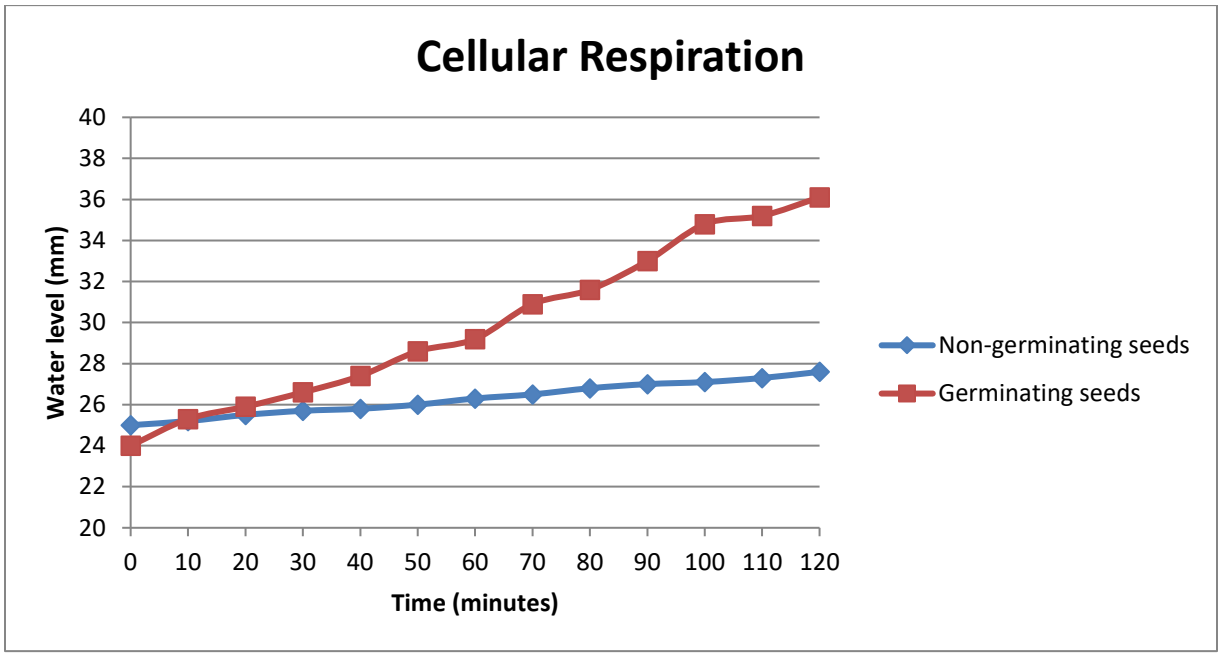
The experimental setup was prepared with the germinating and non-germinating seeds and the level of water in the test tubes was measured every 10 minutes. Apart from measuring the rise of water level in the test tube, qualitative observations were also noted and recorded. The qualitative and quantitative results of the experiment are given in Table 1 below.

Time (minutes)	Distance (N): mm	Distance (G): mm	Observations:
0	25	24	Normal
10	25.2	25.3	Tiny air bubbles start appearing at the sides of the test tube
20	25.5	25.9	Tiny air bubbles start appearing at the sides of the test tube
30	25.7	26.6	Tiny air bubbles start appearing at the sides of the test tube
40	25.8	27.4	An insoluble white precipitate has started to form
50	26.0	28.6	An insoluble white precipitate has started to form
60	26.3	29.2	An insoluble white precipitate has started to form
70	26.5	30.9	Increase in the amount of the white precipitate
80	26.8	31.6	Increase in the amount of the white precipitate
90	27.0	33.0	Increase in the amount of the white precipitate with distinct bubbling
100	27.1	34.8	Increase in the amount of the white precipitate with distinct bubbling
110	27.3	35.2	Increase in the amount of the white precipitate with distinct bubbling

Time (minutes)	Distance (N): mm	Distance (G): mm	Observations:
120	27.6	36.1	Increase in the amount of the white precipitate with distinct bubbling

Table 1: Measured increase in water level in two test tubes containing germinating and non-germinating seeds along with qualitative observations

From Table 1, it is evident that the water level is found to increase in the test tube containing germinating seeds whereas the increase in water level in the test tube containing non-germinating seeds is minimal. This proves that cellular respiration takes place at a much faster rate in germinating seeds as compared to non-germinating seeds. A graph of the results is given below where a clear increase in water level in the test tube containing germinating seeds is evident.



Graph 1: Graph showing a marked increase in water levels in test tube containing germinating seeds as compared to the test tube containing non-germinating seeds

From Graph 1 above, it can be clearly seen that the germinating seeds had a faster rate of respiration as compared to non-germinating seeds.

Discussion

In this experiment, oxygen consumption is used to measure the rate of cellular respiration of germinating and non-germinating seeds. In germinating seeds, a lot of energy is required for growth which increases oxygen uptake and respiration rate in these seeds. On the other hand,

non-germinating seeds are dormant and do not require a lot of energy in their dormancy thus showing low rate of cellular respiration.

As the seeds use up the available oxygen for respiration, carbon dioxide is released which collects as tiny bubbles at the sides of the test tube. The sodium hydroxide solution in the cotton balls reacts with the carbon dioxide forming an insoluble precipitate. As the carbon dioxide is removed by reaction with sodium hydroxide, a vacuum is created in the test tubes which lead to the rise in water levels to fill the gap. Hence, the rise in water level in the test tubes is directly proportional to the rate of cellular respiration of the seeds.

From the experimental results, it is evident that the germinating seeds have a faster rate of respiration due to a marked increase in the water level in the test tube. This is because these seeds have high energy requirements for germination thereby increasing their oxygen consumption. On the contrary, non-germinating seeds are in a dormant state and their energy requirements are low. However, they require a small amount of energy to survive which accounts for a slight rise in water level in the test tube containing non-germinating seeds.

Conclusion

This experiment was performed to observe and analyze the changes in cellular respiration between germinating and non-germinating seeds. The germinating seeds were initially kept in favourable conditions of moisture and temperature to allow them to start germinating. In this situation, the enzymes in the seeds started using the stored energy reserves to produce ATP, which in turn increased the rate of cellular respiration. As cellular respiration involves the consumption of oxygen and the release of carbon dioxide, this was used to differentiate between the rates of respiration in germinating and non-germinating seeds.

According to the standard laws of fluids, both fluids and gases flow from an area of high pressure to an area of low pressure. In this experiment, sodium hydroxide removed the carbon dioxide as and when it was released which was in direct correlation with the consumption of oxygen. The removal of carbon dioxide from the test tube created an area of low pressure above the seeds and water flowed in to this region to balance the pressure. When more carbon dioxide was released as in the case of germinating seeds, the disturbance in pressure was greater corresponding to a higher increase in the water level. On the other hand, in the case of non-germinating seeds, the oxygen consumption and release of carbon dioxide was minimal due to their lower energy requirements. As a result, the rise in water level in the test tube was also minimal.

Thus this experiment serves to prove that the rate of cellular respiration in germinating seeds is considerably faster than the corresponding rate for non-germinating seeds due to their higher energy needs.