Topic : 13.2
Subtopic : Germination
Title : Conditions for germination
Research Question : 1. How does the temperature, presence of water, and oxygen affect germination?
2. What is the best condition for germination to take place
Objective : To investigate into the condition for germination and to find the best condition for the process to take place.
Hypothesis : Germinations requires suitable temperature, water and oxygen to occur. This is because these three factors are needed to recoil the seed to its previous from the dormant state.
Variable :

1) Experiment 1
- i) Independent : The availability of water
- ii) Dependent : The development of the seed
- iii) Constant : Number of seeds, type of plant of seeds, temperature, availability of oxygen.

2) Experiment 2
- i) Independent : The availability of oxygen
- ii) Dependent : The development of the seed
- iii) Constant : Volume of water, temperature, number of seeds and type of plant

3) Experiment 3
- i) Independent : Temperature
- ii) Dependent : The development of the seed
- iii) Constant : Availability of oxygen, Volume of water, Number of seeds and type of plant

Results

Data collection

Table 1: Development of seeds under different amount of water

CONDITIONS	**OBSERVATIONS**
1. Soaked peas, dry cotton wool	- The seed does not develop
2. Soaked peas, wet cotton wool	- There is development of the seed but the plant produced is not so healthy compared to seeds in 3.
3. Soaked peas, wet cotton wool and covered with water	- The seed grew into a healthy plant with significant shoot and root grown

Table 2: Development of seeds under different availability of oxygen.

CONDITIONS	OBSERVATIONS
A) Cress seed with pyrogallic acid and sodium hydroxide solution (lack of oxygen)	- The seeds did not develop into plants
B) Cress seed with water but without pyrogallic acid sodium hydroxide solution (oxygen is available)	- Some of the seeds grew into plants - Shoots and roots are long - Only a few seeds show no growth

Table 3: The development of maize grains in different temperature

CONDITIONS	OBSERVATIONS	LENGTH ± 0.05 cm	
		Root	**Shoot**
1. In the fridge (less than 0°C)	- seeds showed no development - no change to the condition of seed	-	-
2. 20°C	- a few of the seeds grew - radical appeared	0.60	-
3. Room temperature (30°C)	- most of the seeds grew - both radical and plumule are present	1.10	1.20

Discussions

Germination can be defined as the onset of growth of the embryo, usually after a period of dormancy. This process is regulated by both internal and environmental factors. There are three main factors that affects germination; water, oxygen and suitable temperature.

In experiment 1, the soaked peas in cotton and covered with water are the only seeds that germinate properly. The condition of the availability of water is fulfilled. This is because in the soaked peas in cotton and covered with water, the seeds are able to absorb a large amount of water to allow the start of metabolic processes. The absorption of water stimulates the production of amylase to break down starch to maltose which then provides energy for germination and growth to occur.

In experiment 2, the cress seed with oxygen are the ones that germinate. Oxygen is needed for aerobic respiration. Although seeds can respire anaerobically, but ethanol produced usually reaches toxic level. The production thus inhibits the germination process. Thus, oxygen is needed to allow germination to occur.

In experiment 3, the seeds in the most suitable temperature of 30°C are the ones that germinate the fastest with significant radical plumule. Germination involves many enzymatic and hormone reaction such as the breaking down of starch to maltose by amylase and the gybrellic acid action. As usual, at optimum temperature of 30°C, the enzyme and hormone work at its maximum and thus makes germination can occur. This proved that suitable temperature is needed for germination.

Limitations and recommendations

LIMITATIONS	**RECOMMENDATIONS**
1. Pyrogallic acid and sodium hydroxide used in experiment 2 absorbs both oxygen and carbon dioxide.	1. A control experiment should be set up using sodium hydrogen carbonate rather than water to make sure that carbon dioxide is also absorbed.
2. The temperature of 20°C and 30°C is quite hard to made constant	2.The apparatus should be placed in an incubator set to 20°C and 30°C
3. The three experiments were not done using the same light intensity. This might distort the accuracy of the data obtained	3. A light source should be placed at a constant distance to ensure same light supply.

Conclusion.

Germination requires suitable temperature, water and oxygen to occur. This is because these three factors are needed to recoil the seed to its previous from the dormant state. Hypothesis accepted.