Biology Lab Design

Factors affecting the rate of transpiration

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Introduction

There are several factors which can affect the rate transpiration of plants; these could either increase the rate of water uptake or decrease the rate of water uptake. These factors could be internal or external. In this investigation we will be looking at the external factors which affect the rate of respiration, such as temperature, light intensity... etc.

Transpiration is known as the loss of water vapour through the stomata of the leaves. It is needed to keep the cells of the spongy and palisade mesophyll cells moist as this allows carbon dioxide to dissolve before diffusing into the cells for photosynthesis.

A suction force is created on the column of water below it in the xylem when water is evaporated. The upwards force on the column of water created by transpiration and the downwards force due to gravity created a tension in the column of water.

As there is a difference in the upwards pull, which is greater than the downwards pull, the column of water moves up the xylem. As the cohesion tension theory explains it, water molecules are polar, meaning that they stick to one another. If one molecule moves, it pulls adjacent molecules.

The water is able to evaporate out of the leaf through diffusion as the leaf has a high water potential and the air has a low water potential, making it possible for water molecules to pass down the concentration gradient from the spongy and palisade mesophyll cells into the leave's internal air spaces before diffusing out into the air.

Teachers aim

Investigate rate of water loss of a plant under different environmental conditions.

General aim

To investigate the impact of different factors on the rate of transpiration using a potometer.

Hypothesis

I predict that when the leafy shoot will be placed in windy conditions, the rate of transpiration (water uptake by the plant) would increase. When the leafy shoot will be placed in dark conditions there will be a significant decrease in the amount of water uptake by the shoot, thus resulting in a lower transpiration rate. The third hypothesis that will be tested is that when half the leaves are removed, there will be a significant decrease in transpiration thus a reduced rate of water uptake by the leafy shoot.

Variables

Variables		Units	Range
Independent	The time interval	minutes	2-16
Dependent	The change in length of water uptake by plant	cm	-

Controlled variables are maintained at a constant

Controlled Variables	Units	Possible effect(s) on results	Method of Control
Amount of wind being produced by fan	-	If there is high amount of wind being produced, the stomatal pores of the leaves will open thus causing an increase in transpiration rate. If there isn't enough wind being produced, the layer of water vapour found surrounding the plant will limit the transpiration rate.	All windows and doors will be shut; the fan placed directly above the apparatus set up will be switch on to level 3.
Constant room temperature	°C	Unfortunately for us, on the day of the experiment, the room temperature was high (30 °C) This caused the plant to transpire thrice as fast as it does at a temperature of 20 °C. Therefore, the results obtained were not for normal conditions.	The apparatus will be placed on a wooden surface so that heat is not conducted. This could affect the experiment. Moreover, the door will be closed, the windows shut and the fans switched off in order to prevent and interference with the experiment
Time interval	minutes	It is important to allow the experiment to settle down before any counting is made. This will enhance the accuracy of our experiment and allow the plant to equilibrate with external conditions.	A stopwatch is used to monitor the time interval from the start of the experiment to the end. The leafy shoot is first left to equilibrate for about 1 minute and then distance moved over two minute intervals are counted.

Apparatus

1 x 1 Potometer
1 x 1 fan
2 x 1 retort stand and clamp
1 x 1 stop watch

1 x 1 thermometer
1 x 1 Balsam leafy shoot
1 x 1 beaker
1 x 1 candle
1 x 1 match box
1 x 1 30 cm ruler
1 x 2 syringe with needle
50 ml DCPIP
1 x 1 black polythene bag
1 x 1 rubber bung

Method

1. The apparatus was set up as shown on the protocol diagram.
2. The conical filter flask was filled with water.
3. The leafy shoot was transferred from the water filled beaker to the sink and a slanting cut was made few centimeters above the last cut in water.
4. The shoot was fit into the bung of the flask under water and pushed in to make a tight fit.
5. The end of the rubber bung with wax was sealed using a candle and matches.
6. DCPIP, the indictor, was inserted into one end of the graduated capillary tube using a syringe.
7. The shoot was left to equilibrate for 5 minutes as it adjusts to its external conditions whilst regularly replacing the water taken up.
8. The time taken for the water to move 30 cm along the capillary tubes were measured every 2 minutes.
9. When the blue indicator reached the end of the graduated section of the tube, it was returned to its original position using a syringe.
10. Steps 7 to 9 were repeated for windy conditions, dark conditions, and for when half the leaves were removed.
11. Results obtained are tabulated and a graph is drawn to compare the rate of uptake of water over a certain period of time.

Protocol diagram

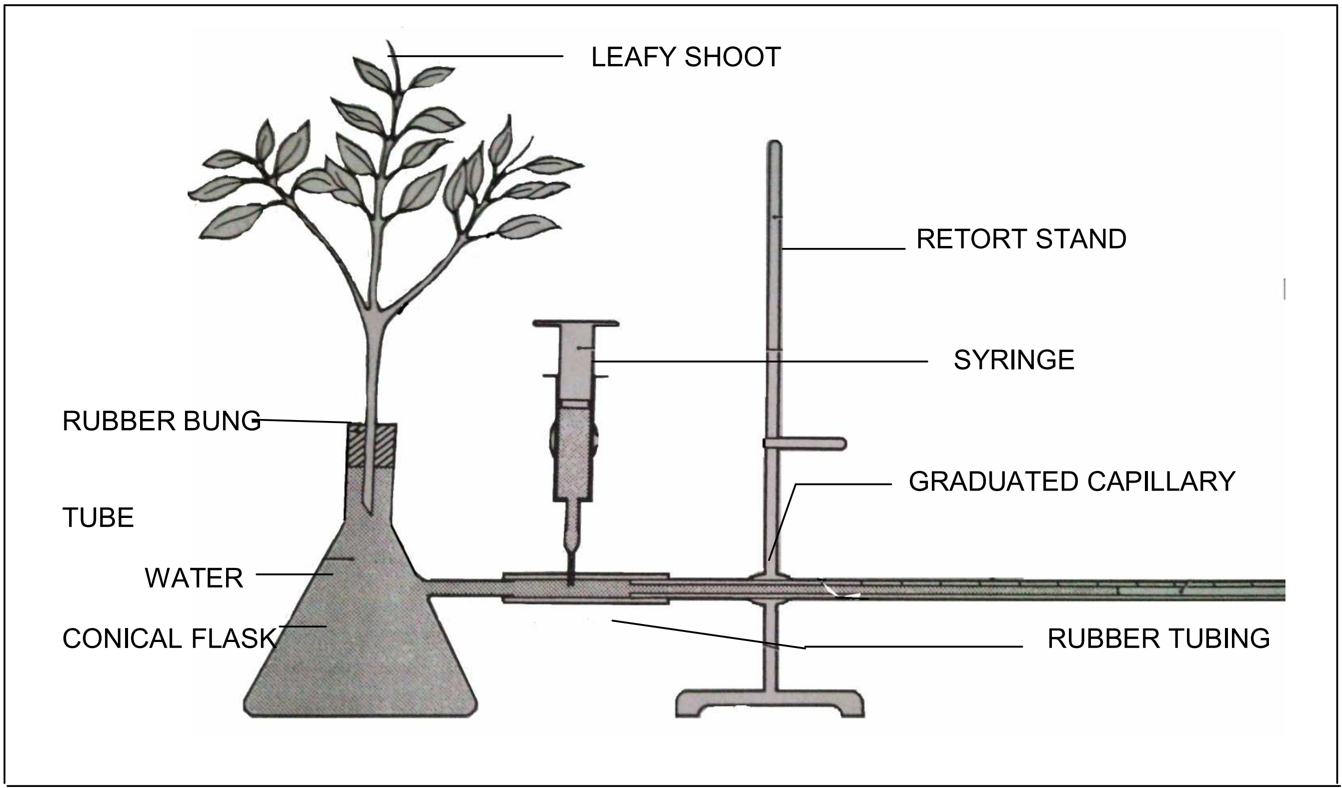


Figure 1 showing the protocol diagram of the potometer

<u>Photo's of setup in normal, dark and half the leaves removed</u>

Figure 1 showing half the leaves removed

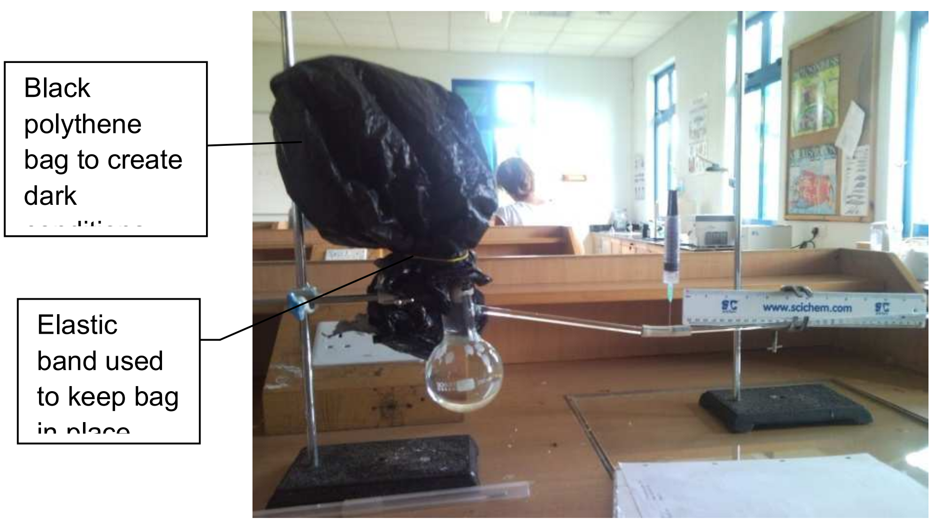


Figure 2 Showing dark conditions

Data collection

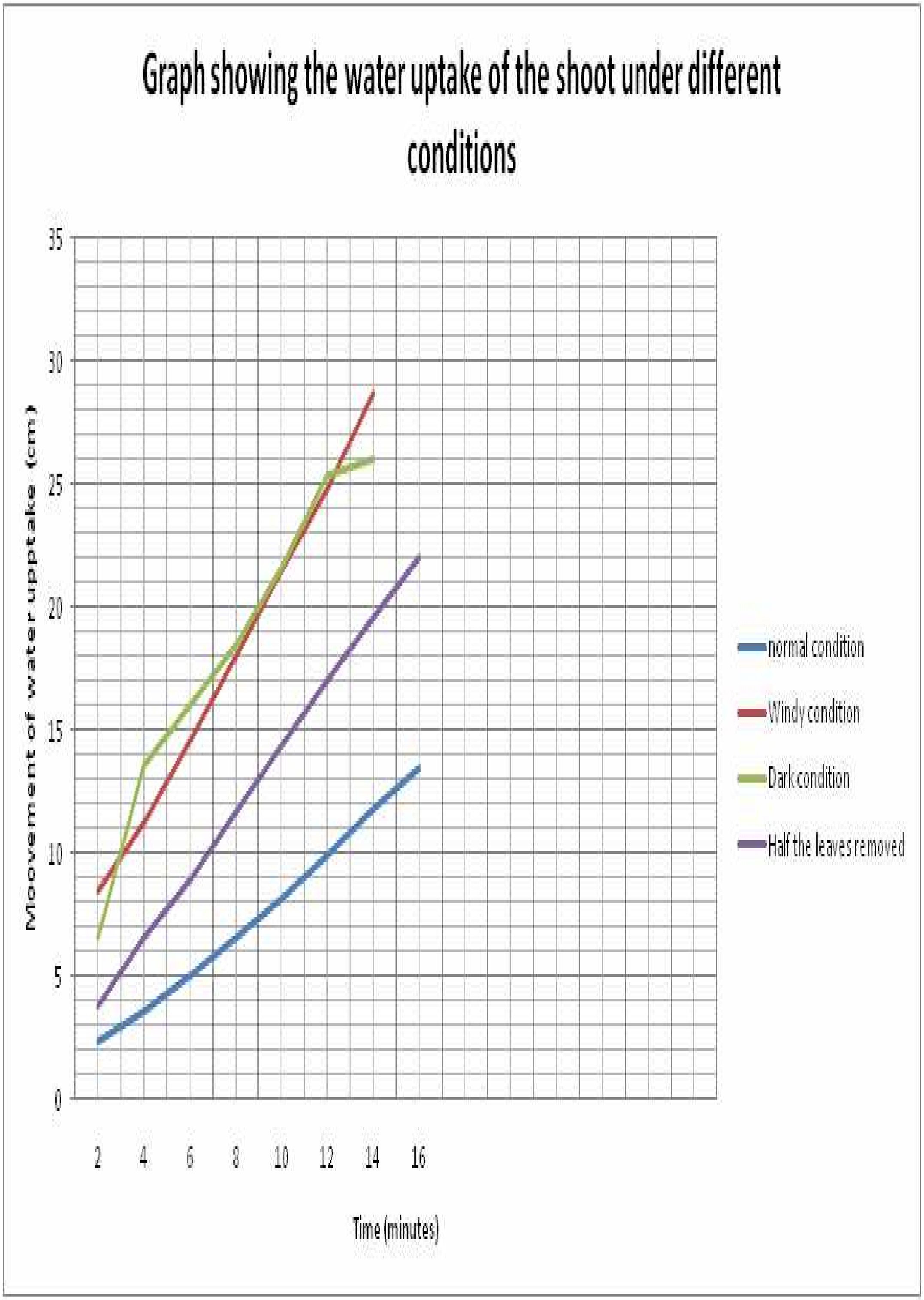
Table containing raw data & processed data

Condition	Length moved after 2 minute intervals (cm)														Mean length (cm)
	2	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	
Normal	2.3	3.6	5.0	6.5	8.1	9.9	11.8	13.4	15.0	16.9	18.5	20.2	22.3	24.2	12.69
Windy	4.8	8.4	11.2	14.6	18.0	21.4	24.8	28.7	-	-	-	-	-	-	16.49
Dark	5.5	9.7	13.5	16.0	18.4	21.6	25.3	26.0	-	-	-	-	-	-	17
Half the leaves removed	3.8	6.5	8.9	11.7	14.3	17.0	19.6	22.0	24.9	27.0	29.8	-	-	-	16.86

No further readings could be obtained for transpiration in windy conditions, dark conditions and for when half the leaves were removed because the indicator had already reached the end of the capillary tube, thus having moved 30cm in the lapse of 16 minutes and 22 minutes respectively.

Error analysis

Thermometer: ± 0.5°C


Graph showing the water uptake of the shoot under different conditions
Moovement of water upptake (cm)
35
30
25
20
15
10
5
0
2
4
6
8
10
12
14
16
Time (minutes)
normal condition
Windy condition
Dark condition
Half the leaves removed

Conclusion

It can be concluded that when the leafy shoot was exposed to windy conditions, the rate of water uptake has increased. This can be explained by the fact that the air currents have removed the water vapour surrounding the shoot, opening stomatal pores and thus increasing a rate of transpiration.

When the shoot was enclosed in a dark plastic bag, the rate of water uptake increased considerably. My hypothesis regarding the rate of uptake in dark conditions needs to be refuted. This could have been due to the fact that the experiment was done during 10am and 1pm (the hottest time of the day). This in turn increased the transpiration rate of the plant; so instead of a slow water uptake, there was a relatively faster one. The length moved after 2 minutes was 5.5 cm and after 6 minutes it had increased to 13.5.

When half the leaves were removed, there was a rapid uptake of water at first. However, as the plant equilibrated to the new conditions, the rate of water uptake decreased gradually.

Evaluation

My investigation aimed at showing the impact of different external factors on the rate of water uptake by a leafy shoot; in this case, a shoot from the Balsam plant was taken. The experiment took roughly about 3 hours 30 minutes to complete as the set up of the equipment took a lot of time as well as the preparation of the shoot and adjustments which had to be made to limit air loss from the rubber bung.

An unbalance in the pressure between the potometer and the graduated capillary tube would disrupt cohesion tension in the shoot. Seeing as only 3 environmental conditions were tested, a broader understanding of the effect of external factors on the rate of water uptake by a leafy shoot would be possible if other conditions were tested for, such as humidity, increased light intensity and vaselining the upper and lower epidermises of the leaves.

More readings over a longer period of time could have been taking to obtain more accurate average. Moreover, an estimate of the water loss per unit in leaf area could have been derived by measuring the volume of water lost and then removing all the leaves in order to determine the surface area.

Overall, I would have preferred looking at more factors which could have influenced the rate of water uptake by the Balsam leafy shoot, but because of time restraints I could not do so. It was interesting to see how external factors affect the rate of transpiration in plants.