Effect of Surface Area on Transpiration

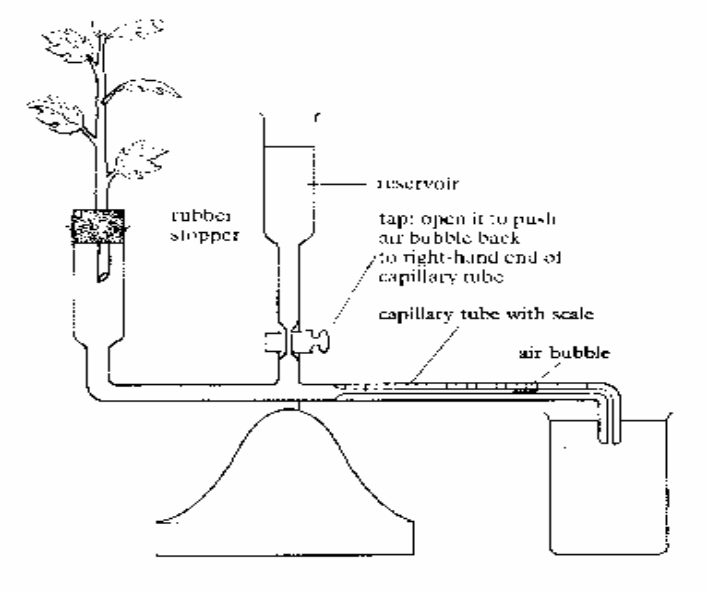
Most of the water entering a plant does so via the root hairs. It travels across the root cortex to the xylem, ascends in the xylem to the leaves and is lost by evaporation from the surface of the mesophyll cells before diffusing out through the stomata. This process is called **transpiration**, and the flow of water from the roots to the transpiring surfaces forms the **transpiration stream**..
Transpiration is the loss of water vapour from the surface of a plant, and may occur from:
1) **stomata:** by evaporation of water from cells and diffusion of the water vapour through stomata, the pours found in the epidermis of leaves and green stems (about 90%).
2) **waxy cuticles**: by evaporation from the outer walls of epidermal cells through the waxy cuticle covering the epidermis of leaves and stems (about 10%, varying with thickness of cuticle).

The aim of this experiment is to find out how the surface area of a plants leaves effects transpiration.

Equipment: Potometer(short rubber tubing, rubber bung, graduated capillary tube), small electric fan, stand and clamp, stop clock, Vaseline, leafy shoot (laurel).

METHOD

Although safety is important while planning a scientific experiment, there will be little or no safety aspects, to consider, because there are no flammable liquids or flames present in the experiment.
To work out how the surface area of the the plant(laurel), effects transpiration, we need to know how much water is taken up by the plant.
A potometer will be used for measuring water uptake by the shoot. The potometer consists of a length of capillary tubing which can be attached to the cut end of the stalk. The capillary tube is filled with a continuous supply of water.
The stalk of the plant is submerged into the capillary tubing containing water, and the water uptake by the plant is measured by using an air bubble as a marker.
To set up the potometer Immerse the potometer in water and make sure it is completely filled. Now put the cut stalk (but not the leaves) into the water and cut off the last centimetre of the stalk at an angle under water. Then, with the potometer and stalk still under water, attach the stalk to the potometer. The object is to ensure that the water in the xylem of the plant is continuous w ith the water in the potometer: there must be no air bubble in the system.
Now remove the plant and potometer from the water and mount them in a fixed position. The end of the capillary tube should rest in a beaker of water and any air bubbles in the capi llary tube should be expelled by letting in water.



Smear Vaseline on the joints between the stalk and the potometer so as to prevent water leakage.

The set up will look like this:

Effects of environmental factors on transpiration

LIGHT-effects transpiration because stomata usually open in light and close in darkness. At night therefore, and only small amounts of water are lost through the waxy cuticle.
As stomata open in the morning, transpiration rates increase.

TEMPERATURE- the higher the temperature, the greater the rate of evaporation of water from mesophyll cells. It increases the capacity of air to absorb water from leaves and it warms the water inside leaves making it evaporate more quickly. Direct sunlight has the same effect since it warms leaves to a higher temperature than the atmosphere. Transpiration in therefore generally faster on warm, sunny days than on cold dull ones.

HUMIDITY- generally, transpiration only occurs when there is a lower humidity level (concentration of water vapour) in the atmosphere than exists in the air spaces inside the leaves. Transpiration stops when the atmosphere is saturated with water vapour, and resumes when the air becomes drier.

WIND- Air movements carry away water vapour from leaves and this prevents air around them from becoming saturated with water vapour. Consequently, depending upon temperature and humidity, transpiration is faster on a windy day than in still air.

The best conditions for a higher rate of transpiration are the same as those needed for drying washing on a line: a warm, dry, sunny, windy day.

Fair Test

A fan will be set 1meter away from the plant, and will supply the heat and wind needed to cause the plant to transpire, thus causing water uptake by the xylem of the stalk.. The strength of the fan will remain constant as will the distance that it is set apart from the plant. The light intensity and the humidity of the room will be kept constant as much as possible.
The variable that will be changed Is the surface area of the plant. This will be done by starting with 10 leaves on the plant, and then after 2 minutes of the fan blowing on the plant, 2 will be removed. The water uptake for each number of leaves will be recorded, and two will be taken away every two minutes and the results recorded until there are no leaves left. 5 results will be taken for each number of leaves and an average will be made. All the other factors which alter the transpiration rate will be kept constant

Prediction

I predict that the higher the surface area of the leaves, the more water uptake will occur.
This is because, greater surface is accompanied with greater amount of stomata. More stomata means more water vapour can be lost by evaporation from the surface of the mesophyll cells before diffusing out through the stomata.
The graph of water uptake against surface area should therefore be, a reasonably straight line.

Obtaining

The experiment was performed with precision and skill; and 5 results were taken for each number of leaves, and an average was made. The amount of water uptake, is recorded in cm as read of the capillary tube on the potometer.
After the experiment the leaves were put onto graph paper, and the surface areas were recorded in mm^2.

Water uptake

Leaves	1	2	3	4	5	Average(cm)
10	2.1	2.2	2.1	2.2	2.2	2.16
8	0.8	1.4	1.4	1.5	1.5	1.32
6	0.5	0.7	0.8	0.8	0.9	0.74
4	0.6	0.7	0.6	0.5	0.6	0.6
2	0.4	0.4	0.5	0.5	0.5	0.46
0	0.2	0.3	0.3	0.3	0.2	0.43

Surface Areas(mm^2)

- 10 leaves- 61 862
- 8 leaves - 51 718
- 6 leaves - 32 954
- 4 leaves - 28 652
- 2 leaves - 15 724

Water uptake(average)	Surface area(mm)
2.16	61 862
1.32	51 718
0.74	32 954
0.6	28 652
0.46	15 724
0.43	0

Analysis

From the graphs I can make the simple conclusion that as the surface area of the leaves Increases so does the water uptake. This proves my prediction was correct although, the graph is not in a straight line as I predicted.
This is due to immature leaves at the top of the plant, which are not as big or developed as the ones lower down. This would mean that the waxy cuticle layer on these leaves would be thinner, and thus let more water out through the cuticle.
This would cause the graph to shoot up towards the end, due to they're being a sudden increase in transpiration, when all leaves are accounted for.
There is little change in water uptake between 0 and 4 leaves. This is due to the more mature leaves being near the bottom of the plant. These leaves would have thicker cuticles which would cause less transpiration. When the leaves where removed, they were removed from the top of the plant, so I was left with four mature leaves at the bottom. This causes the graph to start with almost a straight line with little increase in water uptake.

Evaluation

The experiment was performed with a high level of accuracy, with few clear anomalous results Although, the first result of the column where 8 leaves are used looks out of place. The surface areas of the leaves were measured very accurately using graph paper which enabled me to measure to the nearest mm^2. Vaseline was rubbed on the ends of stems after leaves had been removed, which enabled me to minimise water loss. In spite of this there are still factors which could have altered the results. The experiment was done by many people in the same room. After the fans where switched on the temperature in the room would have gradually increased, which in theory could cause transpiration to increase as the experiment went on. Also, it was impossible to make the fan blow on all leaves equally. It is inevitable that some leaves has more heat and wind on them than others. This could cause less transpiration is some leaves, than others.

Further work:
Another experiment that could be done can measure the transpiration rate through the waxy cuticles of the leaves.
Using the same method as the main experiment, use 4 leaves. Measure the water uptake over 2 minutes, then coat the bottom layer of each leaf(lower epidermis) thoroughly, and again measure the water uptake. There should be less water uptake when the lower epidermis is covered in Vaseline. Then cover both the upper and lower epidermis in Vaseline and measure the water uptake. Again there should be considerably less water uptake.