TIPS, TRICKS & TECHNIQUES

Measuring Transpiration with a Simple Low-Cost, Single-Leaf Potometer

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Abstract

Transpiration is one of the most important water-related phenomena in plant physiology. Various types of semi-quantitative methods for demonstrating this process are available, one of which is the potometer. We offer here a better design for the single-leaf potometer resulting in an easy-to-make, unbreakable, and basic instrument that can reduce the cost of laboratory work in biology instruction and provide a tool that students might use for science fair projects.

Key Words: *potometer; transpiration; plant physiology.*

○ Introduction

Terrestrial plants live their lives between the soil and the atmosphere. Soil acts as a water source, and atmosphere is a sink that draws water out of plants. The water moves continuously from soil to roots, through vascular tissues to leaf cells, and finally to the atmosphere. This movement of water is regulated by hundreds of small openings called stomata found typically on the lower surface of the leaves. The loss of water from the aerial portion of plants in the form of vapor is known as transpiration. Techniques used to demonstrate transpiration and measure transpiration rates are relatively simple and require little in the way of equipment, whereas other techniques can be carried out only with elaborate experiment and sophisticated measuring devices. One semi-quantitative method suitable for classroom demonstration and investigations of transpiration is the potometer. A potometer measures the rate of water absorption, rather than directly determining the rate of transpiration, and is based on the assumption that the rate of water absorption is approximately equal to the rate of transpiration. As such, this approach is perfect for indirectly measuring transpiration. A variety of potometers have been designed by different investigators and are often named after their designers, but each of these has some flaw, from expense to difficulty of use. The device described here should appeal to biology teachers both for its zero to low cost and for its ease of application.

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○ General Procedure for the Use of a Potometer

All potometers require that a plant stem be cut under water and fitted into a tube that, in turn, is inserted into the apparatus lid. Next, the entire apparatus is made airtight and filled with water such that no air bubbles remain anywhere in the system. At the start of data collection, an air bubble is introduced in a graduated capillary tube, and the movement of the air bubble is used to measure water uptake by the twig as an indirect but accurate measure of the rate of transpiration. The results are typically expressed as the amount of water transpired in ml/dm2 leaf area/minute.

○ Problems with Existing Potometers

While teaching, I discovered that many educators find it difficult to set up existing potometers, particularly those developed by Farmer and Ganong. The main problem typically encountered in the use of these instruments relates to making the apparatus watertight. In case of Farmer's potometer, there are three holes in a single stopper, resulting in an increased chance of water leakage; other existing devices have similar limitations.

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○ A New Potometer Design

To support classroom experimentation, I have designed a simple, single-leaf potometer by using a plastic water bottle and some plastic tubing. The beauty of this set-up is that no stopper, sealant, nor even a burette stand is required. One trick is that in setting up the potometer, the plant stem selected should be just the right diameter to fit tightly in the hole in the stopper so that no sealant or grease is necessary.

○ Preparation of Single-Leaf Potometer

To prepare this new potometer, one requires a used plastic bottle of 500 mL, plastic tubing (the petiole of the leaf used must completely fill the inside diameter of the tubing), and a thick needle that is smaller than the size of the tube used. Before beginning, review the three figures included with this article to see a close-up of the tubes in the top of the potometer (Figure 1), and the operation of the device both with water alone (Figure 2) and with stem and colored water (Figure 3).

○ Preparation of the Potometer

1. Using a thick needle or sharp probe, make two holes in the lid of the bottle that are slightly smaller than the diameter of the plastic tubing, as shown in Figure 1. When the tubes are inserted in the holes, the system will become air tight.
2. Cut two pieces of tubing 5–8 cm in length, perhaps with the help of a paper cutter.
3. Attach a ruler or piece of graph paper to tube A to act as a scale.
4. Insert the tubing in the holes made in the lid of bottle. As shown in Figure 1, the changing level in tube A as shown on the scale will show the rate of transpiration. Tube B contains the leaf. Both tubes extend well below the water level in the bottle.
5. The single-leaf potometer is ready to use!

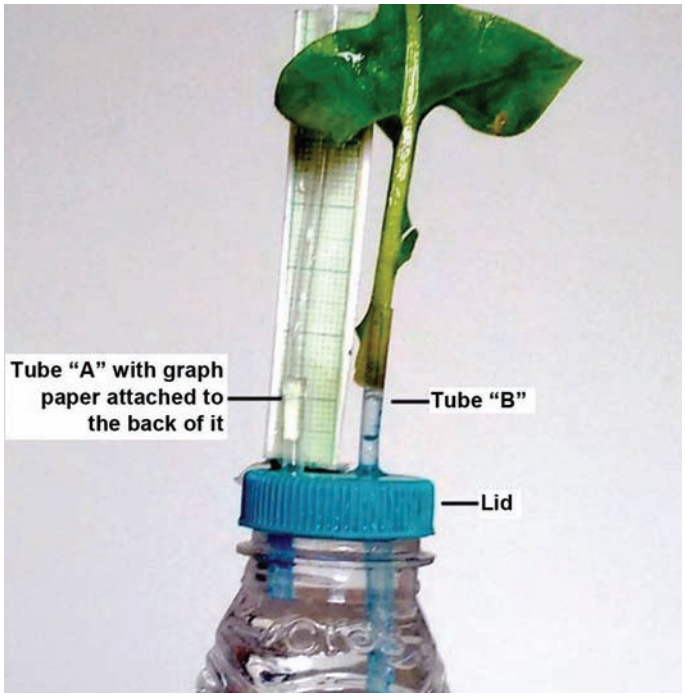

Figure 1. Close-up of the tubes in the top of the potometer.

Figure 2. Operation of the single-leaf potometer with water.

Figure 3. Operation of the potometer with stem and colored water.

○ Setting up the Potometer

1. Fill the water bottle up to the mouth with tap water. Food coloring or methylene blue dye can be used to make changes in the water level easier to observe in the transparent tube.
2. Recap the lid of the bottle with the two tubes A and B tightly inserted.
3. In tube B, insert a leaf with a long petiole that is just slightly thicker than the diameter of tubing. In this way, tube B will be water- and air-tight.
4. The apparatus is ready for the demonstration of transpiration or for experiments with the degree or rate of transpiration. Leaves of *Gerbera spp.*, *Ficus relegiosa*, *Philodendron spp.*, and *Plumeria pudica* have been used successfully in this device.
5. After a few minutes you will notice that water flows down tube A, and up and out of the system through the leaf in tube B.
6. To record data, mark the initial level so you can take reading after intervals of every five minutes or so. This will allow you to calculate the rate of transpiration.
7. In this apparatus as described here, 1 cm of water in tube A is equal to 0.08 mL. To determine the amount of water in the length of tubing in your apparatus, fill it with water though a syringe and calculate the capacity in mms of water.
8. Transpiration results are typically expressed in ml/dm2 leaf area/min.
9. You can make modifications to this device by increasing the size of tube B to accommodate larger stem diameters. Thus, the transpiration rate of a small stem can also be determined by this potometer.

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