Name Period Date

Sustainable Agriculture Lab: Transpiration

Driving Questions

How is a plant's rate of transpiration affected by the environment and its structure?

- What affects do wind, light, and humidity have on the rate of transpiration?
- How does the structure of vascular tissue in a plant relate to its function?

Background

Plants lose an astonishing amount of water by transpiration, the loss of water vapor from leaves. The average maple tree loses more than 200 liters of water per hour during the summer. If plants lose so much water, then how do they survive?

The amount of water and gases that are allowed to enter and exit the leaf are controlled by the stomata, small openings in the leaf surface which open into air spaces that surround the mesophyll cells of the leaf. When the stomata are open, carbon dioxide and oxygen gas can be exchanged between the inner leaf space and the atmosphere, a process that is beneficial to photosynthesis and carbohydrate synthesis.

However, this poses a problem. If the stomata are open on a hot, sunny day, a tremendous amount of water can evaporate through transpiration. Because of this, plants must maintain a balance between open stomata that promote water loss and closed stomata that prevent gas exchange. The opening and closing of the stomata is influenced by temperature, light intensity, air currents, and humidity.

Materials and Equipment

For each student or group:

- Data collection system
- Barometer/low pressure sensor
- Sensor extension cable
- Compound light microscope
- Electronic balance (1 per class)
- Disposable pipet
- Wide, shallow bowl or tub filled with water
- Heat sink - large beaker or aquarium filled with water
- Plant seedling, 12 to 15 cm tall
- Prepared slides: monocot and dicot stem
- Large base and support rod
- Utility clamp
- Three-finger clamp
- Glycerin, few drops
- Spray bottle filled with water
- 100-watt light source
- Knife (or single-edge razor blade)
- Petroleum jelly, 2 to 3 g
- Transparent plastic bag
- Scissors
- Fan

Procedure

Part 1 – Measuring transpiration rates under different conditions

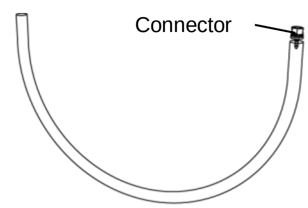
Set Up – Room Conditions

1. Start a new experiment on the data collection system. �1.2 Connect a barometer sensor to your data collection system using the sensor extension cable. �2.1

2. Display Barometric Pressure (hPa) on the y-axis of a graph with Time on the x-axis. �7.1.1

3. If it has not been done already, cut the plastic tubing to a length of approximately 20 inches.

4. Put a drop of glycerin on the barb end of the quick-release connector and insert the barb into one end of the plastic tubing. The barb will not insert all the way into the tubing; however, be sure that it is in far enough to not fall out easily.



5. Use a knife or single edge razor blade to cut the stem 2 to 3 cm above the soil. Immediately immerse the cut end of the seedling in the bowl of water.

6. While keeping the cut end of the stem submerged in the water, shave the stem to a 45-degree angle. Continue holding the stem under water.

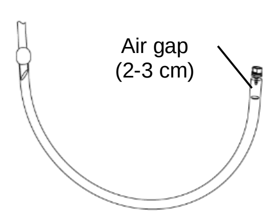
7. Place the tubing into the bowl of water.

8. Place the pipet into the open end of the tubing and pull water into the tubing using the pipet. If there are any bubbles in the tubing, use the pipet to remove them.

9. Once the tube is completely filled with water and has no air bubbles, insert the plant stem (still under water), cut-end first, into the tubing. **AVOID CREATING ANY AIR BUBBLES IN THE TUBING.**

10. Raise the tubing out of the water in a U-shape.

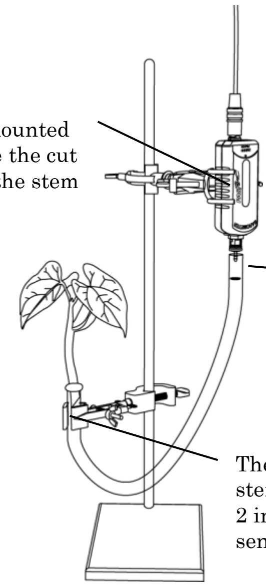
11. Adjust the level of the tubing so that there is a 2- or 3-cm air gap between the barb end and the water. Water will spill out of the tubing to achieve this level. Be sure that water in the tubing always stays in contact with the plant.



12. Spread petroleum jelly around the end of the tube to create an airtight seal between the top edge of the plastic tubing and the plant stem. If you see any water leaking out of the end of the tubing near the plant, add more petroleum jelly. Be sure that the petroleum jelly does not come in contact with the cut end of the plant stem.

Note: If air bubbles do form around the cut end of the stem, pull the tubing away from the stem. Use the pipet to refill the open end of the tubing with water. Put the stem back into the water in the tubing.

13. Secure the plant seedling in an upright position with the utility clamp, base, and support rod.



14. Mount the barometer/low pressure sensor to the support rod with the three-finger clamp. The pressure port should be above the cut end of the stem. This will prevent water from entering the pressure sensor.

15. Align the quick-release connector on the tubing with the connector on the pressure port of the sensor. Push the connector onto the port and then turn the connector clockwise until it clicks (about one-eighth turn). Make sure that no water enters the sensor. There should be a 2- to 3-cm air pocket between the water level and the pressure port.

Note: Do not move the barometer sensor up or down on the support rod while recording data.

Collect Data – Room Conditions

17. ☐ Start recording data �6.2

18. ☐ Adjust the scale of the graph to show all data. �7.1.2

19. ☐ Record data for 600 seconds (10 minutes). After 10 minutes, stop recording data. �6.2

20. ☐ Name this data run "Room Conditions". �8.2

21. ☐ Explain the importance of collecting data at room condition?

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Set Up – Increased air movement

22. ☐ Restore the pressure in the tubing to the initial amount by carefully disconnecting and then reconnecting the tubing to the sensor.

23. ☐ Place the fan about 1 meter from the plant seedling. Put the fan on a low setting so it blows a light breeze over the seedling.

Collect Data – Increased air movement

24. ☐ Start recording data. �[6.2] Adjust the scale of the graph to show all data. �[7.1.2]

25. ☐ Record for 600 seconds (10 minutes). After 10 minutes, stop recording data. �[6.2]

26. ☐ Name this data run "Wind". �[8.2]

27. ☐ What are the independent and dependent variables in this experiment?

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Set Up – Increased light intensity

28. ☐ Remove the fan.

29. ☐ Restore the pressure in the tubing to the initial amount by carefully disconnecting and then reconnecting the tubing to the sensor.

30. ☐ Place the light (100-watt) about 1 meter from the plant seedling, and place the heat sink between the light and the plant.

31. ☐ What is the purpose of the heat sink?

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Collect Data – Increased light intensity

32. ☐ Start recording data. �[6.2] Adjust the scale of the graph to show all data. �[7.1.2]

33. ☐ Record for 600 seconds (10 minutes). After 10 minutes, stop recording data. �[6.2]

34. ☐ Name this data run "Light Intensity". �[8.2]

Set Up – Increased humidity

35. ☐ Remove the floodlight.

36. ☐ Restore the pressure in the tubing to the initial amount by carefully disconnecting and then reconnecting the tubing to the sensor.

37. ☐ Mist the plant with the spray bottle and then cover the plant with a transparent bag. Make sure to leave the bottom of the bag open.

Collect Data – Increased humidity

38. ☐ Start recording data. �[6.2] Adjust the scale of the graph to show all data. �[7.1.2]

39. ☐ Record for 600 seconds (10 minutes). After 10 minutes, stop recording data. �[6.2]

40. ☐ Name this data run "Humidity". �[8.2]

41. ☐ Save your experiment. �[11.1]

42. ☐ What other environmental conditions can be tested to see their effect on transpiration?

Analysis

Table 9.2: Individual transpiration rate

Run	Initial Pressure (hPa)	Final Pressure (hPa)	Change in Pressure (hPa)	Rate of Transpiration (hPa/s)	Surface Area of Leaves (cm^2)	Rate of Transpiration per Area [(hPa/s)/cm^2]
#1 Room						
#2 Wind						
#3 Light						
#4 Humidity						

1. Find the initial and final pressure values (hPa) for all four runs. �[9.1] Record in Table 9.2.

2. Calculate the rate of transpiration for all four runs.

Rate of Transpiration = [Initial pressure (hPa) – Final pressure (hPa)] ÷ time (s)

3. Calculate the rate of transpiration per area for all four runs.

Rate of transpiration per area = Rate of transpiration ÷ Surface areas of leaves

8. Record in Table 9.2.

Analysis Questions

1. How did the pressure change in the plastic tubing? Does a decrease in pressure in the tubing correspond to an increase or a decrease in water loss through the seedling's stomata? Explain.

2. State whether wind, light, and humidity increase or decrease transpiration when compared to the control. Explain each of the conditions and their role in transpiration.

3. Why is it important to calculate the leaf surface area?

4. How does gas exchange affect transpiration?