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Palmetto

Protecting Endangered Plants in Panhandle Parks • Native or Not? *Carica papaya* • Water Science & Plants

Water Science & Plants

by Ginny Stibolt

Without water, life as we know it would not exist. Plants and animals contain high percentages of water and depend upon its unique properties to survive. Humans are attracted to bodies of water for both their beauty and their usefulness for many aspects of our lives.

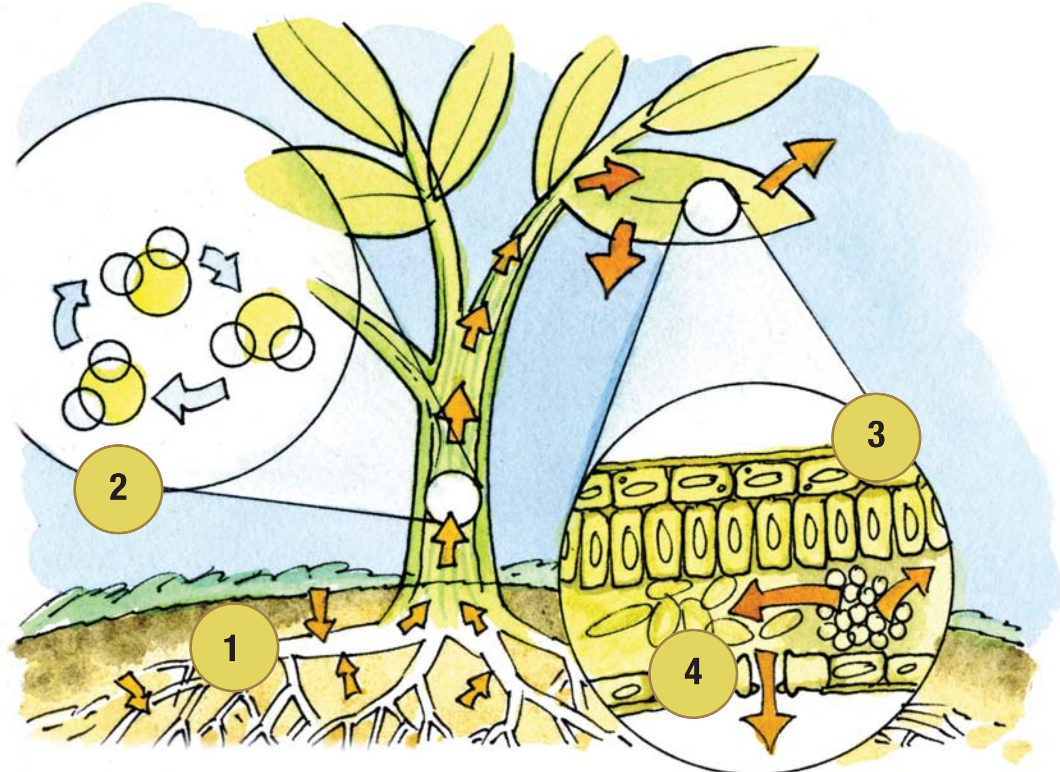

Figure 3: Water moving through a plant
1. Water is taken into roots. 2. Water moves up xylem tubes. 3. Water is released into leaves. 4. Water evaporates from stomata.

Water's unique properties

Water is made up of two hydrogen atoms and one oxygen atom giving it the familiar chemical formula of H_20. The hydrogen atoms attach themselves to one side of the oxygen, covering about 1/3 of a circle, and so that the molecules look very much like Mickey Mouse ears (Figure 1). The side of the molecule with the hydrogen atoms has a slight positive charge and the oxygen side is slightly negative. Water molecules act like little magnets and are attracted to each other and form weak bonds, called hydrogen bonds. You notice this self-attraction, called cohesion, when water beads up into droplets on leaves or flower petals (Figure 2).

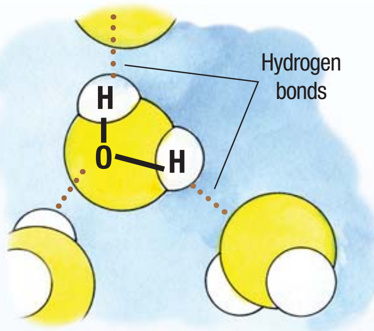

Figure 1: Water molecules

Water's polarity makes it a good solvent that can break apart, absorb, and carry organic materials such as sugars, other carbohydrates, and nutrients.

Figure 2

Water is highly unusual as well, because it can exist simultaneously as a gas (water vapor), liquid, and a solid (ice). The solid form is unique because it is less dense than the liquid due to its crystalline structure and floats on the liquid. Water readily evaporates into the atmosphere and gathers as mist or clouds.

Knowing how plants deal with and take advantage of water's unique chemistry makes us better caretakers for both wild and cultivated landscapes.

Osmosis and root hairs

Starting at the bottom, near the tip of the roots, there are thousands of single-cell extensions on the root's surface called root hairs that absorb water from the soil. Root-hair cells have a semi-permeable cell membrane that allows water and some materials that are dissolved in water, such as nutrients, to flow into the cell. Everything else is blocked from entry into the plant.

Water will equalize over an area and when there is less water within the root hair cells than in the surrounding soil, then the water flows across the cell membrane to equalize that pressure. Once water fills the root hair cells, it moves into neighboring cells and builds up pressure that pushes water up into the plant; this is called root pressure. Then the process of transpiration, as discussed below, carries the water farther up the plant.

Root hairs usually last just a few weeks before they are reabsorbed into the root tissue – a root must be growing in order to develop new root hairs. We need to keep this in mind when irrigating plants; water needs to be applied to the region where new roots are growing. Roots of established trees and shrubs

More than 90% of the water that enters a plant runs straight through it and evaporates into the air. A full-grown oak tree could transpire more than 400 gallons of water on a summer day.

might be growing yards away from the trunks or stems.

When a plant is transplanted, most of its delicate root hairs are rubbed off as soil falls away from roots, so these plants need a lot of water in the planting hole and frequent irrigation until new root growth begins and the plant regains its network of root hairs. The larger the plant, the longer the time period when additional irrigation is necessary for the establishment of that plant. This close attention and adequate irrigation during its establishment period vastly increases the chances of a plant's survival. A drought-tolerant native plant needs the same care after transplanting as other plants. It only becomes truly drought tolerant after it is fully established in its new location.

Before we leave water's interaction with roots and soil, let's kill an old gardeners' tale. For years we've been advised to lay a thick layer of gravel or potshards in the bottom of our pots and containers to aid drainage. It was shown 100 years ago that this is false, but even today, so-called gardening experts and master gardeners continue to pass this myth on as if it were fact. Because of water's tendency to hang together, it will be reluctant to jump gaps created by a coarse medium such as gravel. It won't move away from the fine medium of soil until it's completely saturated. In order to create the best drainage in your container gardens, use taller pots and use all soil with just a screen or leaves covering the drainage holes. You can test for the effectiveness of the taller pots with a simple cellulose kitchen sponge: Completely saturate the sponge and hold it in the horizontal position over the sink until it stops dripping. Then turn it so that it is vertical and after a short delay the sponge will give up more of its water. So if you wish to grow a large pot of prickly pears, make it a tall one. On the other hand, if you wish to grow some hooded pitcher plants and other native bog plants use a shallow pot so the soil retains the moisture more efficiently.

Transpiration

After water enters the root tissues, there is pressure that begins to push the water higher in the plant. But it would not go very far up the tubular, water-carrying cells in plants, called xylem, without the suction effect of evaporation through the pores in the leaves and stems called stomata (Figure 3). For many years it was thought that capillary action (movement of a liquid up a narrow tube) accounted for much of this movement, but more advanced measuring techniques show that capillary action is not a major factor in water movement through the xylem.

More than 90% of the water that enters a plant runs straight through it and evaporates into the air. A full-grown oak tree could transpire more than 400 gallons of water on a summer day. The larger the plant's biomass, the higher the volume of transpiration. The area near large plants

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is cooled by the transpiration process and on a hot day, the temperatures may be up to 20 degrees cooler than nearby spaces without large plants.

The transpiration rate is also an important factor in planting rain gardens. Rain gardens are designed to collect rainwater in swales. The water will be both absorbed by the plants and also percolate into the soil to refresh our aquifers. A rain garden should not have standing water for more than three days – the more biomass in the rain garden plants, the higher the transpiration rate and the faster water is sucked from the soil.

The remaining 10% of the water that is absorbed into the plant's cells serves several purposes: it carries nutrients, it keeps the cells turgid and it will also be used by the plant for photosynthesis during the daylight. When the soil is dry, this whole process slows down. The guard cells around each stomate are highly sensitive to water supply and when they become flaccid, the stomata close up, and the evaporation of water is slowed to protect against severe wilting. We need to pay attention to the wilting of plants – especially seedlings – and irrigate before permanent damage is done to the plant's tissue.

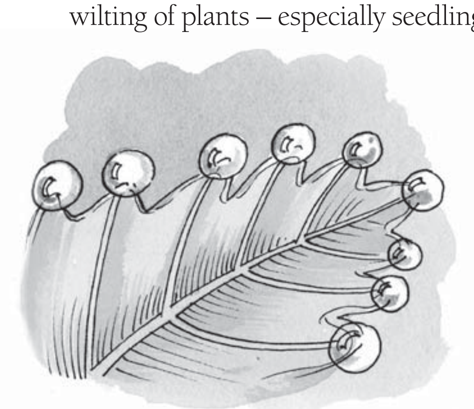

Figure 4: Water is excreted through pores called hydathodes.

Guttation

When the temperature lowers at night, less water evaporates into the air. Nighttime temperatures put the brakes on the transpiration rate, but in many types of plants, the root pressure is not immediately reduced, so there is a flow of water from the leaves at night to relieve the pressure. This is called guttation.

The water is excreted as liquid through specialized pores called hydathodes at the ends of veins (Figure 4). If the plant is a salt tolerant plant, you can often see a build up of salt crystals near these pores.

This excreted water is often confused with dew, but the source of the water is not the same. The water from guttation comes through the plant, while dew is formed when water vapor in the air condenses on plant surfaces in the cool night air. Dewdrops form randomly on plants and will not form neat droplets at the ends of veins or at the tips of narrow blade-like leaves. Some of the water – both from dew and guttation – on plant surfaces may be absorbed through the plant's stomata the next morning when the temperature rises again, but most of it will either drop to the ground or evaporate into the air.

Most people recommend that we irrigate, if needed, in the morning so plants have all day to cycle the water, because dry plant surfaces at night are less vulnerable to fungus attacks, and so less water is lost to evaporation during irrigation. Perhaps the most compelling reason is, if you water at night much of the water may be out of reach of the roots by the time the plant is ready to restart the transpiration cycle.

Water drops act like little magnifying lenses or prisms and if you look closely you can often see rainbows in the drops. They are beautiful, and contrary to the old gardeners' tale, the water drops on leaves in the full sun will not burn the leaf tissue. So you may irrigate without fear in the middle of the day if your plants – again particularly seedlings – are wilting in the Florida heat.

Photosynthesis

Photosynthesis is the process wherein green plants combine carbon dioxide (CO_2) and water (H_2O) with energy from sunlight to form sugar ($C_6H_{12}O_6$) and oxygen gas (O_2). For most vascular plants, the water is supplied by transpiration flow and the carbon dioxide is available from the air through the open stomata. (Respiration is the equal and opposite chemical reaction, and all organisms respire as they gain energy for living.)

When it gets too hot and plants close up their stomata to preserve water, most plants cannot continue photosynthesizing because they don't have ready access to water and carbon dioxide. Some heat-loving plants have adapted to make better use of the sunlight in the heat.

Water: it's a limited resource

Before we knew better we wasted much of our water and used up or spoiled many water resources. Water, especially usable fresh water, is a limited resource. As landscape managers we can do our part and create water-wise landscapes planted with native plants that have adapted to survive in Florida's climate and its seven-month dry season.

About the Author

Ginny Stibolt is a lifelong gardener who earned an M.S. in Botany from the University of Maryland. She blogs for The Florida Native Plant Society at http://fnpsblog.blogspot.com, The Lawn Reform Coalition at http://www.lawnreform.org, and writes on Florida gardening for *The Florida Times Union*, (Jacksonville). Ginny is the author of *Sustainable Gardening for Florida*, (ISBN 13: 978-0-8130-3392-1) published by The University Press of Florida.

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We welcome articles on native plant species and related conservation topics, as well as high-quality botanical illustrations and photographs. Contact the editor for guidelines, deadlines and other information.

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The purpose of the Florida Native Plant Society is to conserve, preserve, and restore the native plants and native plant communities of Florida.

Official definition of native plant:

For most purposes, the phrase Florida native plant refers to those species occurring within the state boundaries prior to European contact, according to the best available scientific and historical documentation. More specifically, it includes those species understood as indigenous, occurring in natural associations in habitats that existed prior to significant human impacts and alterations of the landscape.

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