Humidity and plants

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Water is a vital element for plant life. Most plants parts consist for 85 to 98 % of water. Water is needed to build some molecules, water fills plant cells, water acts as a transport medium, provides cell turgor and cools the plant. This article describes these various functions of water in plants and the effects that air humidity may have on the plant's water economy. A following article will demonstrate in more detail the effects of humidity on growth and production of greenhouse vegetable crops.

Transpiration
Leaves exposed to the sun would get overheated if they were not cooled by water evaporating from the leaves, called transpiration. Transpiration is a passive process. It is the same thing that happens to a layer of water on a concrete floor: when the sun shines the water evaporates. So it is actually the sun's energy and not the plant itself that drives the transpiration. It is important that the water transpired from the leaves is replaced immediately by new water. This has to come from the root-zone, into the roots, through the vessels into the leaves. This stream of water is called the transpiration stream or the xylem stream. If the xylem stream is not able to supply enough water to the shoot, the plants start wilting. But before the plant shows any visible sign of wilting, the plant slightly closes its pores (stomata) in an attempt to protect itself from wilting. But this cannot save the plant. Closure of pores reduces the transpiration and hence also reduces leaf cooling. If water uptake is insufficient, the leaves will continue to loose water, get warmer, and ultimately get 'cooked'.

Water as transport medium
Plants are built out of carbon (C), hydrogen (H), oxygen (O) and about 15 mineral elements (N, P, K, S, K, Ca, Mg, Fe etc.). The mineral elements are taken up by the roots and carried upwards by the transpiration stream (xylem), that runs from the roots towards the shoot. Carbon is taken up as carbon dioxide (CO_2) by the leaves and transformed into sugars (carbohydrates). Again water is the vehicle for transport: the assimilates are carried by the 'phloem sap', the water that moves from the leaves towards the growing organs. Water also delivers the amino acids and plant hormones in the plant. So water facilitates all internal transport within the plant.

Water for growth
Plants grow because of photosynthesis, which is uptake of CO_2 through the leaves. The leaves turn it into sugars (carbohydrates or assimilates). Photosynthesis needs light and thus takes place at daytime only. Sugars consist of carbon (C), hydrogen (H) and oxygen (O). Both H and O are obtained from water, which is the first way how water contributes to growth. The next contribution of water to plant growth is by filling new plant cells. This causes an increase in weight (growth). This happens mainly at night. Although much water is taken up at day, it does not directly make the plant grow, as the water uptake at daytime is needed to compensate for the water loss by transpiration. At night, in contrast, the transpiration is very limited as there is no sun shine. Then most of the water taken up is available for growth, which explains that increase of plant weight happens mainly at night.
However, the fact that growth occurs at night is not a reason to give much water at night. When not much water is needed for transpiration, just a small amount of water (a few % of the uptake at day time) is sufficient to cover the growth. This is usually available in the root-zone.

Water for turgor

Another function of water is providing firmness to the plant cells by putting an outward pressure on the cell walls. The cell walls then provide inward pressure. The pressure and firmness are called ‘turgor’. Turgid plant cells are pumped full with water and cannot be compressed, like a balloon filled with water. Plant cells that have lost a (small) part of their moisture, don’t have this turgor and are floppy. This is the case when leaves suffer from ‘water stress’ (actually ‘drought stress’ would be a better name).

In young cells, turgor stimulates the cells to expand and grow (older cells are not able to grow anymore). If young cells do not experience sufficient turgor pressure, they don’t expand very much. Therefore leaves that have water stress for a longer period of time, i.e. leaves with little turgor, usually stay smaller than leaves with normal turgor.

Air humidity and water status

What does humidity have to do with water and transpiration? There are many linkages. Air humidity affects the plant processes like transpiration, water uptake, nutrient transport, cell turgor and growth. Also plant transpiration increases the humidity of the greenhouse air. The linkages may be complex but they are very logical.

High humidity restricts the transpiration, because very humid air is almost saturated with water vapour and cannot absorb much more. If very humid conditions and much sun shine were to occur at the same time, the plants would get very hot due to low transpiration and lack of leaf cooling.

Also, at times of reduced transpiration, the water uptake is low, and therefore transport of nutrients from roots to shoots is restricted. If the high humidity conditions last for a longer period of time (e.g. a week) then the plants may suffer deficiencies. Especially shortage of calcium is very common in those conditions.

It is obvious that low humidity stimulates the transpiration, which is good. But at very low humidity the leaves loose so much water that the xylem flow cannot completely replace the water losses, and thus plants can not maintain turgor in the plant cells. Then the cell walls are not pressed outwards, and the plant cells not stimulated to grow. Therefore a low humidity for a long period of time generally results in shorter plants and smaller leaf area.

Different responses

These general rules do not always give the same results. For instance high humidity in cucumber may increase leaf area (through the turgor effect) and therefore may increase growth and production. In contrast, the same conditions in tomato may cause calcium deficiency in the young leaves (due to reduced nutrient transport), which reduces leaf area and hence reduces growth and production. In a next article we will look more closely at effects of humidity on vegetable crops.