Relative Relative Humidity

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RELATIVE HUMIDITY is a measure of the amount of water in the air. Relative Humidity is measured on a relative scale rather than a linear scale (like measurements of temperature and distance) for example. Although this may make Relative Humidity a little harder to understand, its role in plant health is extremely important. It is possible to make the Relative Humidity a little more friendly to the plants through the use of equipment for greenhouse humidity control.

UNDERSTANDING RELATIVE HUMIDITY

The potential water-holding capacity of air greatly increases as the temperature in the air increases. For example, air at 60ºF (~16ºC) can hold over five times as much water as the same air at 20ºF (~ -7ºC). So, as the warm days of spring or fall cool at night, the air cools to where it reaches the point of saturation—what is called the dew point—and water or frost settles out on automobiles, grass, and the rooftops of our houses. In parts of the world where there is higher relative humidity, this is a common occurrence when there are marked temperature differences between day and night. Many less humid parts of the world have infrequent dew formation, even though there are considerable temperature differences between day and night. The air holds so little water that it does not reach saturation even at the lower nighttime temperatures.

HOW DOES RELATIVE HUMIDITY AFFECTS PLANTS?

Plants not only contain a large proportion of water, they move large volumes of water through their tissues. Although water is used in photosynthesis, most of the water taken in by a plant is used in transpiration. That is, the water is taken in by the roots and evaporated through the leaves into the air. This process cools the plant. The relative humidity in the air can affect the flow of water through the plant: the higher the relative humidity, the more slowly transpiration occurs. If environmental changes that affect the transpiration rate are rapid enough, plant tissue damage can occur.

MEASURING RELATIVE HUMIDITY

Before anything can be done to alter the relative humidity in the greenhouse, it needs to be measured, and the measurement must be entered into the environmental control system of the greenhouse. Many hobby greenhouses don't have sophisticated enough environmental control systems to measure relative humidity and operate equipment to change it on a schedule that provides adequate control. Although you may be in that situation now, an understanding of what can be done will enable you to do some things now and incorporate additional equipment capabilities in the future. You may also gain an understanding of the reason for some of the plant damage you see in your greenhouse.

NORMAL PLANT OPERATION IN THE GREENHOUSE

As plants grow, they take up water and fertilizer ingredients through the roots and send them up to the rest of the plant. The water is either used in photosynthesis or given off in transpiration. This process occurs over a fairly wide range of temperatures and relative humidity conditions. Tomato plants will operate without damage with relative humidity ranging from 45 per cent up to about 100 per cent. Lower relative humidities can stress the plants by allowing them to spend excessive energy pumping water through their tissue into the air.

Rapid changes in the relative humidity can severely stress a plant. A relative humidity increase or decrease of as little as 20 per cent in a few minutes can cause tissue damage because the plant cannot adapt quickly enough. Rapid decreases in relative humidity can be brought about by suddenly bringing in large volumes of dry outside air for greenhouse cooling purposes.

A drop in greenhouse temperature due to nightfall or sudden cloud cover can quickly bring about an increase in relative humidity. If the plant has been rapidly taking up water, it will continue doing so because any adjustment in plant water uptake occurs slowly. The water taken up after the rise in relative humidity cannot be given off as freely into the air through the leaves and instead may be stuffed into fruit or foliage to an extent that it does cell damage. Some examples of such cell damage will be described later and are shown in some of the accompanying pictures.

Tomato plants will wilt at the top when the sun comes out brightly after three or more days of cloudy weather. During the cloudy days, the plants have slowed the rate at which they take up the water through the roots. On the sunny day, the water needs of the plant are suddenly greater because the temperatures are likely higher and the relative humidity in the surrounding air is often lower. It is easier for the plant to give off water into the air because of the lower relative humidity; due to the higher temperature, the plant needs to give off more water to keep itself cool. The grower needs to help the plant through this adjustment period by both increasing the relative humidity in the greenhouse and making it easier for the plant to take up water by lowering the fertilizer content in the solution being fed. If sufficient adjustments are not made soon enough, plant tissue damage may occur.

Lettuce crops can also experience rapid increases and decreases in relative humidity because of temperature changes and cooling system air exchanges in the greenhouse. Either the rapid increase or the rapid decrease in relative humidity can cause leaf tissue damage in lettuce plants.

TISSUE DAMAGE EXAMPLES

Blossom end rot of tomato fruit occurs when the young, still-expanding cells in the blossom end of the fruit are either overstuffed with water because of excess water in the plant or are collapsed because too much water has been taken out of the fruit by the plant as it slowly adapts to changing environmental conditions. The developing fruit acts like a shock absorber for water conditions in the plant. When the fruit's limited tolerance capabilities are exceeded, cell damage occurs.

The only cell division that takes place in the developing tomato fruit is in the seeds. All the other cells of the fruit are already present; they simply enlarge and mature. The cell growth process takes place from the stem out toward the blossom end of the fruit. The final stage of cell maturation is the building of a calcium-based cell wall. Mature plant cells have the fortification of that cell wall. Young, still-expanding cells in the blossom end of the fruit may not yet have been fortified with the calcium-containing cell wall.

When environmental conditions cause extra water to be sent to the developing fruit, the mature cells do not accept it because of the fortified cell wall. Less mature cells at the blossom end can accept enough water to over-expand and burst. Conversely, if environmental conditions cause water to be drawn out of the fruit, the mature, fortified cells do not give up their water while the young, expanding cells give up water to the point of cell collapse. The burst or collapsed dead cells show up as a brown or black patch on the blossom end of the fruit. It usually takes 10 to 14 days after the damage occurs for the blossom end rot symptoms to be visible on the fruit.

Tomato leaf cells are all formed by the time the leaf is visible. Small tomato leaves grow by cell expansion, not by cell division. Each tomato leaflet generally expands starting from the base, then out to the mid rib, and then to the end of the leaflet. Secondary expansion also occurs through secondary veins toward the perimeter of the leaflet. The leaf cells closest to the outside edge of the leaflet are the last ones to fully expand and be fortified with a cell wall. They, therefore, are the cells that remain subject to bursting or collapsing for the longest period as the leaf goes through its growth process.

If a water shortage occurs in the leaf because of a sudden drop in relative humidity (or another cause), the outer cells of the leaf and the cells toward the tip of the leaflet are the most likely to run short of water. If the water shortage lasts long enough, water will be extracted from some of the immature cells in areas of the leaf. This can be severe enough to collapse and kill the cells.

When the water supply is reinstated, the remaining living cells continue their growth and expansion process. Because the dead cells do not expand and fill in the area they were to have occupied, there is often tissue distortion around the patch of dead tissue. The living cells expand but the overall leaf expansion does not occur because of the death of the collapsed cells. When this occurs, the damage usually takes place at the outer edge of the tomato leaflets farthest from the plant stem.

CUCUMBER LEAF EXPANSION AND POSSIBLE CELL DAMAGE

All the cells of a cucumber leaf are formed while it is still very small. Because the cucumber forms almost a big half circle, the leaf expansion progresses a little differently than in the tomato leaf. It progresses out along several veins that radiate out from where the leaf blade connects to the leaf petiole. There is a slight secondary expansion out from each main leaf vein toward the adjacent leaf vein.

The more common cell death pattern in cucumber leaves is the death of the cells around the perimeter of the leaf due to the lack of water getting to them and the resulting collapse of the outer few cells of the leaf. This usually involves only a few layers of cells around the outside of the cucumber leaf. In severe situations, a quarter of an inch or more layer of tissue around the leaf margin can be involved.

Severe leaf water shortages that occur in a relatively short period of time in leaves that are still expanding can cause the death of rather large, inverted V-shaped patches of cells between the major veins of the cucumber leaf. This pattern is most likely to occur because there are large numbers of cells in the areas toward the leaf margin that have not yet fully expanded and built cell walls. The uninjured tissue behind the dead cells will continue to grow and have a puckered appearance next to the dead tissue. This can be seen in leaves of the accompanying picture of the top part of a cucumber plant.

In the photo, fruit toward the top of the cucumber plant has aborted. They are drying up from the blossom end toward the stem end of the fruit. While water shortage played a role in the abortion of these fruit, not all aborted cucumber fruit can be explained by a water shortage in the plant. Other factors such as the fruit load on the plant are also possible causes.

LETTUCE TISSUE DAMAGE

Since the leaves of the lettuce plant are the part of the plant that we eat, we don't want them to be too tough to chew. Lettuce leaves are fairly delicate and therefore can be damaged relatively easily by sudden changes in water availability and the relative humidity in the air.

When something happens to interrupt or slow the flow of water through the lettuce leaves, the cells at the outer margin of the leaf are the ones that get shorted first and most severely. As noted earlier in this article, a sudden drop in the relative humidity in the air in the greenhouse is one of the things that can lead to a shortage of water within the plant. If they collapse and die, there will be a layer of dead cells around the margin of the leaf. The cells toward the middle of the leaf survive and continue to grow. The resulting tissue is puckered and bubbled because its expansion is restricted by the surrounding dead cells.

The Bibb lettuce picture with the puckered leaves shows the type of damage that can occur from a sudden lack of water in the plant. Notice that the outer leaves of the plant are not affected. The cells in those leaves were fully expanded and mature when the stress on the plant took place. The cells in the margins of the younger leaves are the ones that collapsed and died.

When excess water builds up in the lettuce plant, the cells in the leaves at the growing point of the stem can be over-supplied, possibly causing them to burst and die. This is what has happened at the growing point of the Bibb lettuce plant having the open centre. This is called latex tip burn in lettuce. When lettuce plants start to close in over the middle of the plant, excess water is more difficult to dissipate than when the plant is more open. Latex tip burn is, therefore, more likely to occur during the later stages of lettuce growth than during the earlier stages of growth.

Latex tip burn will often take out the whole growing point of the plant. All the cells in the growing point burst, resulting in plant death. The crop is terminated if this happens because normal plant growth will no longer be possible. If the plant is left in the greenhouse to continue to grow, secondary growth will start at the buds at the lower leaves of the plant. The small secondary heads on the plants in the accompanying picture resulted from growth after the terminal bud of the plant was killed by latex tip burn.

Even if the growing point is not completely inactivated by the latex tip burn, the lettuce plant will not grow normally and should be harvested. If there are enough leaves on the plant to be useful, they can be eaten. The rest of the plant should be discarded.

HOW RELATIVE HUMIDITY CAN BE CONTROLLED

The leaf and fruit damage described above can be reduced or eliminated if the rapid changes in the relative humidity in the greenhouse can be slowed enough so the plants can adjust to the changes without tissue damage. An environmental control system capable of tracking and changing the relative humidity in the greenhouse is the ideal solution. Because such a system is relatively expensive for a small greenhouse, many hobby greenhouses have a very limited capability of tracking and modifying the relative humidity in the greenhouse.

Air exchange and heating are generally used to lower the greenhouse relative humidity. An evaporative cooler, a mist system, or a few water sprinklers can be used to increase the moisture in the greenhouse air. The control of the greenhouse relative humidity takes a secondary position to the control of temperature within the greenhouse. If the temperature in the greenhouse is high enough or even too high, heat should not be used to lower the relative humidity in the greenhouse. If the greenhouse is being heated, not much water should be evaporated to increase the greenhouse relative humidity because evaporating water takes additional heat energy. The relative humidity control system must be properly integrated with the heating and cooling systems in the greenhouse to provide the optimum environment for plant growth and development.

If you are not ready to buy a larger, more highly equipped greenhouse at this time, there are a few things you can do to minimize plant damage in the greenhouse due to rapid relative humidity changes. Generally speaking, make efforts to prevent situations that can create rapid changes. For example, on warm, sunny days do not leave the greenhouse closed up until ten o'clock in the morning. This allows excessive heat to build up. Avoid leaving the greenhouse cooling fans on after the temperature has started to drop in the greenhouse, due either to cloud cover or the onset of evening. Also, avoid leaving the wet wall on all night, which could generate excessive moisture in the form of high relative humidity, potentially causing condensation on the plants.

Last, make a point to stay aware of the environment changes in your greenhouse. The more closely in tune you are to temperature and relative humidity changes in it, the better able you will be to make the needed adjustments that will minimize plant damage.

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