BY ERIK RUNKLE

The Boundary Layer and Its Importance

MICHIGAN STATE UNIVERSITY EXTENSION FLORICULTURE TEAM

Erik Runkle is professor and floriculture extension specialist in the department of horticulture at Michigan State University. He can be reached at runkleer@msu.edu.

The boundary layer is a thin zone of calm air that surrounds each leaf. The thickness of the boundary layer influences how quickly gasses and energy are exchanged between the leaf and the surrounding air. A thick boundary layer can reduce the transfer of heat, CO_2 and water vapor from the leaf to the environment.

Knowing which factors influence the boundary layer and then regulating them is important in controlled-environment production. In many growing situations, a moderately thin boundary layer is desired, whereas a thicker boundary layer can be desirable during propagation and when plant growth regulators are applied as foliar sprays.

There are several factors that influence the boundary layer thickness including characteristics of the leaves themselves. Leaves that are larger in size, are not dissected, and have pubescence or hairs typically have thicker boundary layers. A dense canopy including very tight spacing of plants impedes air movement and increases boundary layer thickness. The environmental factor with the greatest influence on boundary layer thickness is wind speed. This is one of the reasons why at least some air movement in a greenhouse is advised, and why adequate air movement inside growing rooms (vertical farms) is critical. Inside a greenhouse with no ventilation (passive or active) and with no horizontal airflow from fans, the boundary layer can become thick enough to impede photosynthesis and thus, plant growth.

The boundary layer can be considered as the microclimate that surrounds each leaf and growing point of each plant. When the boundary layer is thick (no air movement, leaves are crowded together), the microclimate around the plant becomes increasingly different from the surrounding air. This can mean that the temperature of the plant can become substantially warmer than the air during sunny conditions, and that the relative humidity becomes high, which reduces water loss (transpiration) from the plant. The concentration of CO_2 around the leaf also can be reduced if the uptake of CO_2 for photosynthesis is faster than replenishment from surrounding air.

When the air is completely calm and the boundary layer is thick, water loss from the leaf decreases and thus, water uptake through the plant is diminished. This can result in nutritional deficiencies, such as calcium, especially when the temperature is warm enough to drive rapid leaf development and expansion. It doesn't take much air movement to reduce the boundary layer thickness; a recommended wind speed created by horizontal airflow fans in a greenhouse is 50 to 100 feet per minute (around one foot per second).

There can be situations when a thick boundary layer is desired, such as when plant growth regulators are applied as foliar sprays or during propagation of cuttings. Research has shown that the efficacy of PGR sprays increases as the drying time of the spray increases, which is why PGR applications are recommended during slow-drying conditions, such as in the morning and on cloudy days. During propagation of cuttings, a major goal is to reduce water loss from the leaf, especially during the first several days in propagation. This is accomplished by delivering a high humidity and turning off fans.

Knowing which factors influence the boundary layer and then regulating them is important in controlled-environment production.

Generally though, a thick boundary layer is undesirable since the microclimate surrounding leaves and shoots becomes more different than the air. Humidity increases, CO_2 concentration decreases, temperature becomes more different from the air, and water (and thus nutrient) uptake decreases. This can hamper photosynthesis and also create conditions that are more favorable for pathogens.

Two GPN articles provide useful information on the importance of horizontal air flow and installing fans in greenhouses for desirable results: www.gpnmag.com/grower-101-horizontal-air-flow and www.gpnmag.com/fanning-uniformity-greenhouse-0. By ensuring proper air movement, you can avoid extreme boundary layer thicknesses and the problems that can arise when air movement is inadequate. gpn