Some Considerations When Determining Leaf Gas Exchange Responses to Vapor Pressure Deficit

The leaf to air difference in water vapor pressure (VPD) affects the stomatal conductance of leaves in many circumstances, and often affects rates of photosynthesis as well. The response of stomatal conductance to VPD also affects how transpiration rate and leaf energy balance change with VPD. The change in stomatal conductance with VPD is a component of "water saver – water spender" or "isohydric – anisohydric" spectra of adaptations of plant species or cultivars.

The response of stomatal conductance to VPD often varies substantially with leaf temperature and with ambient CO_2 concentration. Therefore these two variables, along with light (PAR) should be controlled to be reasonably constant during determination to stomatal response to VPD. Boundary layer conductance should also be high and constant to improve the accuracy of the stomatal conductance measurements. Although stomata respond to the internal rather than the external CO_2 concentration, ecologically it is more useful to keep the external concentration constant, since this is the more natural situation, realizing that any changes in internal CO_2 with change in VPD are probably also influencing the stomatal conductance.

Because stomatal opening responses are often slower than closing responses, determining steady-state responses is more quickly accomplished when starting at low VPD and then increasing VPD. The number and magnitude of changes in VPD to impose is a matter of experimental design: i.e. many measurements per leaf, vs. a few measurements on many different leaves. One cannot safely assume that responses of either stomatal conductance or photosynthesis are linear with VPD.

Choosing a "low" VPD (or high humidity) to begin requires considering several factors. Above all one should try to avoid condensation inside the cuvette or in the tubing connecting the cuvette with the analyzers, because condensation invalidates the measurements and drying everything out takes a lot of time. There is a warning message when the rH inside the cuvette exceeds 70% to help avoid condensation problems.

Some considerations are the leaf temperature relative to the ambient outside temperature, the light level, the flow rate through the cuvette and leaf area exposed, and the magnitude of stomatal conductance. There are relatively few circumstances where one can measure leaf gas exchange at VPD lower than 1.0 kPa (except at low temperatures).

How long it takes for leaf gas exchange to stabilize after first placing a leaf into the cuvette depends on the species characteristics, and how closely the cuvette environment matches the leaf environment prior to insertion, but several minutes are usually required.

How quickly stomatal conductance changes in response to a change in VPD is also quite variable: generally several to many minutes are required for stable values. A caution is that large step increases in VPD may initiate cycling of stomatal conductance in some species. If that happens, abandon hope (at least for that particular leaf), although it is fun to watch! In C_3 species at high light, it is usual for photosynthesis to decrease as VPD increases, but this may not happen in C_4 species, despite decreased stomatal conductance.

References

Bunce, J. A. (1993). Effects of doubled atmospheric carbon dioxide concentration on the responses of assimilation and conductance to humidity. *Plant, Cell and Environment, 16*(2), 189-197. doi:10.1111/j.1365-3040.1993.tb00860.x

Bunce, J. A. (2006). How do leaf hydraulics limit stomatal conductance at high water vapour pressure deficits? *Plant, Cell and Environment, 29*(8), 1644-1650. doi:10.1111/j.1365-3040.2006.01541.x

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