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Plant gas exchange: Theoretical considerations on the level of single stomata

Plant gas exchange: Theoretical considerations on the level of single stomata Land plants require gas exchange between leaf interior and atmosphere to obtain sufficient amounts of CO2 for photosynthesis. Stomata, micropores on the leaf surface, are the gateways for plant gas exchange. The stomatal pore is formed by two guard cells whose shape change (caused by changing turgor) controls the aperture width. This in turn controls stomatal conductance. Tight control of stomatal conductance is necessary since diffusional CO2 influx through open stomata is accompanied by water vapour loss (= transpiration). Besides stomatal pore area that is controlled by the guard cells, the actual stomatal conductance is dependent on various other anatomical traits, such as stomatal density and depth and shape of the stomatal pore [1, 2].

The entire diffusion pathway is, however, more complex in reality. In most cases, it is still unclear where evaporation inside the leaf occurs. If cutinization does not reach beyond the stomatal channel, i.e. if internal cuticles are absent, then evaporation should occur close to the stomata [3, 4]. If internal cuticles are present, evaporating sites are seated more deeply within the leaves. Shifting evaporation deeper into the mesophyll by cutinization beyond the stomatal channel can lead to a substantial decrease in stomatal conductance for water vapour (with all other parameters constant) [4].

Details of leaf internal diffusion of water vapour and CO2 are of interest, due to different aspects. For example, measurement of stomatal conductance for water vapour is used also for analyses of photosynthesis, implicitly assuming that diffusion pathways of CO2 and water vapour are mostly identical. In ecophysiology, various modifications of stomata are ascribed to adaptations to environmental conditions. For example, arrangement of stomata in stomatal crypts, that are depressions of the leaf surface in which stomata are seated, should restrict water loss. It is, however, questionable whether this really happens, or if other functional benefits may linked to these kind of structures. Furthermore, variations in stomatal structure and/or arrangement add more parameters to the stomatal pathway, thereby altering the contribution of the controllable stomatal channel to overall conductance.

As a whole, important details of stomatal diffusion are still not well understood. Analyzing gas diffusion on the level of single stomata, and within the mesophyll, can contribute substantial information to various topics in ecophysiology and plant physiology.

References

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