SYMPOSIUM PAPERS

Xylem Hydraulics and the Soil–Plant–Atmosphere Continuum

Opportunities and Unresolved Issues

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Received for publication July 23, 2002. Soil and xylem are similar hydraulically. An unsaturated conductivity curve for soil is called a *vulnerability curve* for xylem—but the underlying physical basis is the same. Thus, any transport model that treats unsaturated soil conductivity would benefit by also incorporating the analogous xylem vulnerability curves. This is especially the case for crop plants, which as a group have relatively vulnerable xylem. Although the cohesion–tension mechanism for xylem transport has withstood recent challenges, a number of gaps remain in our understanding of xylem hydraulics. These include the extent and mechanism of cavitation reversal and thus hysteresis in the vulnerability curve, the structural basis for differences in air entry pressure (=cavitation pressure) for different xylem types, a quantitative model of xylem conductivity, and a mechanistic understanding of how stomata regulate plant water status. Improving the representation of xylem hydraulics in models of crop water use is necessary to achieve a mechanistic link between soil water availability and canopy water use. An important additional knowledge gap concerns the hydraulics of the living tissues of absorbing roots and transpiring leaves, which are more complex than in xylem and less amenable to mechanistic modeling at present.

Abbreviations: cryo-SEM, freezing-stage scanning electron microscopy • SPAC, soil–plant–atmosphere continuum • Ψ, water potential