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# Coordination and transport of water and carbohydrates in the coupled soil-root-xylem-phloem leaf system

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In response to varying environmental conditions, stomatal pores act as biological valves that dynamically adjust their size thereby determining the rate of $CO_2$ assimilation and water loss (i.e. transpiration) to the atmosphere. Although the significance of this biotic control on gas exchange is rarely disputed, representing parsimoniously all the underlying mechanisms responsible for stomatal kinetics remain a subject of some debate. It has been conjectured that stomatal control in seed plants (i.e. angiosperm and gymnosperm) represents a compromise between biochemical demand for $CO_2$ and prevention of excessive water loss. This view has been amended at the whole-plant level, where xylem hydraulics and sucrose transport efficiency in phloem appear to impose additional constraints on gas exchange. If such additional constraints impact stomatal opening and closure, then seed plants may have evolved coordinated photosynthetic-hydraulic-sugar transporting machinery that confers some competitive advantages in fluctuating environmental conditions. Thus, a stomatal optimization model that explicitly considers xylem hydraulics and maximum sucrose transport is developed to explore this coordination in the leaf-xylem-phloem system. The model is then applied to progressive drought conditions. The main findings from the model calculations are that (1) the predicted stomatal conductance from the conventional stomatal optimization theory at the leaf and the newly proposed models converge, suggesting a tight coordination in the leaf-xylem-phloem system; (2) stomatal control is mainly limited by the water supply function of the soil-xylem hydraulic system especially when the water flux through the transpiration stream is significantly larger than water exchange between xylem and phloem; (3) thus, xylem limitation imposed on the supply function can be used to differentiate species with different water use strategy across the spectrum of isohydric to anisohydric behavior.