A hydraulically based model framework for the grass leaf meristem

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The rate with which lateral buds/meristems in grasses are formed is likely under control of the apical meristem. But as far as initiation and outgrowth, and the appearance of successive leaves and tillers are concerned, grasses display a remarkable level of coordination of leaf and tiller initiation and appearance, which are associated to onset and cessation of leaf cell division. Therefore, the growth kinetics of a specific leaf have propagated, 'downstream' effects on growth dynamics of successive leaves, and, consequently, largely impact plant productivity.

Furthermore, the grass leaf is an interesting model to study meristem behavior, because cell division, elongation and maturation occur simultaneously in spatially distinct zones. The kinetics of leaf growth are complex and are impacted by environmental variables such as air temperature and relative humidity, availability of water, nitrogen and phosphorus.

We now present a model that integrates short-term leaf growth dynamics (minutes–to–hours) to whole-leaf growth rate patterns (days-to-weeks). Thereto, we conceived four zones in a growing grass leaf, differing in hydraulic, visco-elastic and meristematic properties. Closest to the leaf base, there is the cell division zone (DZ), which is meristematic, highly elastic, a strong sink for carbohydrates and fully enclosed by the the pseudostem, shaped by the sheaths of the older leaves of the tiller (and hence, not transpiring). Distal to the cell division zone, there is the cell elongation zone, where cells have stopped dividing, but are still highly elastic, are elongating, are strong sinks and fully enclosed. In the following zone, cells are maturing, whereby growth has stopped, and cells have become less elastic, but are still enclosed and not transpiring. In the most distal zone, cells are mature (and thus no longer growing and less elastic), but are exposed to the atmosphere, and therefore transpiring and photosynthetically active.

A crucial feature in this model is the timing of cell division cessation, which is triggered by the appearance of the leaf tip. As a result, from tip appearance, final (maximum) leaf length is approximately fixed, and leaves which are enclosed in larger pseudostems, become larger, as has been documented by many observations of leaf growth coordination in grasses.

This model provides a framework to investigate putative (molecular) mechanisms underlying this coordination, which appears not to be controlled by the apex, and explore dynamics in sink metabolism underpinning leaf growth.

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