

Lloyd Bridge (Swansea)

Modelling the impact of plant shoot architecture on leaf cooling: coupled heat and mass transfer simulations

Abstract

Plants display a range of striking architectural adaptations when grown at elevated temperatures. In the model plant *Arabidopsis thaliana*, these include elongation of petioles and increased petiole and leaf angles from the soil surface. The potential physiological significance of these architectural changes remains speculative. We address this issue computationally by formulating a mathematical model for heat and mass transfer in and around shoots and performing finite element simulations, investigating the hypothesis that elongated and elevated plant configurations may reflect a leaf-cooling strategy. This sets in place a new basic model of plant water use and interaction with the surrounding air, using a transpiration term which depends on saturation, temperature and vapour concentration. A two-dimensional multi-petiole shoot geometry is considered, with added leaf-blade shape detail. Our simulations show that increased petiole length and angle generally result in enhanced transpiration rates and reduced leaf temperatures in well-watered conditions. Furthermore, our computations also reveal plant configurations for which elongation may result in decreased transpiration due to decreased leaf liquid saturation. We offer further qualitative and quantitative insights into the role of architectural parameters as key determinants of leaf cooling capacity.