Broad crowned trees and the hydraulic limitation hypothesis

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Abstract

The hydraulic limitation hypothesis (HLH) provides a physiological explanation of what limits height in trees. It states that resistance to water flow increases with pathway length, causing water potential to decrease and, as a consequence, the premature closing of stomata thus limiting photosynthesis and growth. The existence of broad crowned trees, however, appears to present a challenge to the HLH as vertical growth is more limited than that of longer horizontal shoots. This suggests that pathway length may not be the main factor leading to height limitation, because water is travelling a longer distance in the horizontal stems than in the vertical ones. In this thesis I investigated the HLH and factors influencing tree shape and height in *Acacia papyrocarpa* Benth, a broad crowned tree from south-eastern Australia.

Mature, isolated *A. papyrocarpa* trees from two different sites were found to have asymmetric crowns with a non-random, northerly orientation. This orientation could not be explained by wind direction, or loss of branches due to mistletoe infection. The most likely explanation is that the northerly orientation maximises light interception during the Southern Hemisphere winter.

At two sites with contrasting water availability, trees were taller at the more mesic site whereas phyllode $\delta^{13}C$ at the top of the canopy was similar in trees from both sites. These results are in agreement with a water limiting mechanism. However, in trees with longer horizontal pathways than vertical ones, phyllode $\delta^{13}C$ of the longest horizontal stems was lower than that at the top of the tallest vertical stems. Thus, longer path length did not result in more conservative water use as has been argued for the HLH. Because there were no differences in light environment or in hydraulic conductivity between branches sampled at the two canopy positions, the difference in phyllode $\delta^{13}C$ suggests that the effects of gravity on water transport could be more important than pathway resistances.

Following these results, I had planned to quantify some effects of gravity on water status in small trees, however, preliminary measurements of xylem pressure potentials in fully hydrated leaves showed a large variability that overcame the intra-canopy differences that gravity would be predicted to generate. In attempting to account for this variability I measured balance pressure (BP) on fully hydrated, non-transpiring detached leaves from 4 different species. BP in such leaves should be close to 0 kPa, however, it ranged from 3 kPa to 200 kPa or higher, despite a calculated measurement error of only 2 kPa. The variability in BP could not be solely accounted for by differences in species, hydration time, plant water status, light history, or leaf position on the plant. Leaf area and LMA, however, did explain up to 61% of BP variability in some species. The negative non-linear relationships between these leaf characteristics and BP suggest that leaf growth was causing part of the disequilibrium. In order to reduce confounding factors during pressure chamber measurements, leaves need to be selected carefully to avoid the large variability that may be associated with leaf growth.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except were due reference has been made in the text.

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