Geophysical Research Abstracts
Vol. 14, EGU2012-2302, 2012
EGU General Assembly 2012

Change in hydraulic properties and leaf traits in a tall rainforest tree species subjected to long-term throughfall exclusion in the perhumid tropics

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A large-scale replicated throughfall exclusion experiment was conducted in a pre-montane perhumid rainforest in Sulawesi (Indonesia) exposing the trees for two years to pronounced soil desiccation. The lack of regularly occurring dry periods and shallow rooting patterns distinguish this experiment from similar experiments conducted in the Amazonian rainforest. We tested the hypotheses that a tree's sun canopy is more affected by soil drought than its shade crown, making tall trees particularly vulnerable even under a perhumid climate, and that extended drought periods stimulate an acclimation in the hydraulic system of the sun canopy. In the abundant and tall tree species Castanopsis acuminatissima (Fagaceae), we compared 31 morphological, anatomical, hydraulic and chemical variables of leaves, branches and the stem together with stem diameter growth between drought and control plots.

There was no evidence of canopy dieback. However, the drought treatment led to a 30% reduction in sapwood-specific hydraulic conductivity of sun canopy branches, possibly caused by the formation of smaller vessels and/or vessel filling by tyloses. Drought caused an increase in leaf size, but a decrease in leaf number, and a reduction in foliar calcium content. The d13C and d18O signatures of sun canopy leaves gave no indication of a permanent down-regulation of stomatal conductance during the drought, indicating that pre-senescent leaf shedding may have improved the water status of the remaining leaves. Annual stem diameter growth decreased during the drought, while the density of wood in the recently produced xylem increased in both the stem and sun canopy branches (marginally significant). The sun canopy showed a more pronounced drought response than the shade crown indicating that tall trees with a large sun canopy are more vulnerable to drought stress.

We conclude that the extended drought prompted a number of medium- to long-term responses in the leaves, branches and the trunk, which may have reduced drought susceptibility. However, unlike a natural drought, our drought simulation experiment was carried out under conditions of high humidity, which may have dampened drought induced damages.