Nutrient enrichment changes water transport structures of savanna woody plants in Brazil

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Abstract

Nutrient enrichment of a neotropical savanna on dystrophic soil resulted in changes in structural anatomical traits in leaves and sapwood. Increased xylemic structures resulted in higher xylem conductivity. While decreasing in stomata length minimized stomatal conductance (stomatal pore index), altering water use efficiency under higher vulnerability to cavitation in savanna woody plants. The study indicates that eutrophication of these water and nutrient-limited tropical ecosystems might induce significant changes in the soil-plant-atmosphere water balance.

Keywords: eutrophication, nitrogen, phosphorus, Cerrado, plant anatomical adjustment, water relations,.

1. Introduction

Brazilian savanna vegetation is mostly distributed on dystrophic soils and nutrient limitation is a significant determinant of ecosystem functioning. A previous study indicated that the removal of nutritional limitation increased growth, optimization of water transport and a decrease of stomatal conductance (Bucci et al., 2006). However, studies on anatomical mechanisms that explain such responses are still lacking. Also, it is not known if the patterns of response differ at species and at the community scale. Here we hypothesize that additions of N, P and N+P change the soil chemistry, causing anatomic structural adjustments, minimizing water loss due to water transport increases as a result of the growth of xylemic structures. Consequently, there would be an increased vulnerability to cavitation due to water safety limits under changing water use efficiency conditions.

2. Material and Methods

The study was conducted in a long-term nutrient addition experiment in a savanna in Central Brazil (Brasilia, Federal District). We evaluated the effects of N, P and N plus P additions on hydraulic anatomical traits in five dominant woody species. We used two approaches: looking for emerging patterns within each species and aggregating all species. The structural equation model (SEM) was used in the aggregate approach.

3. Results

Soil moisture and nutrient addition influenced the hydraulic traits at the anatomical level, increasing the xylem vessels lumen. Consequently, the theoretical specific xylem conductivity (K_{tx}) increased in four species in N+P and P plots. Another hydraulic adjustment was the decrease in the stomatal pore index (SPI) with species-specific responses regarding the intrinsic water use efficiency (iWUE). Four species had higher vulnerability to cavitation index (l_{vul}) under N+P and P fertilization. In the aggregate species approach, the K_{tx} showed a positive effect, while SPI was negatively affected by fertilization. The l_{vul} was not relevant, while iWUE decreased (Fig. 1).

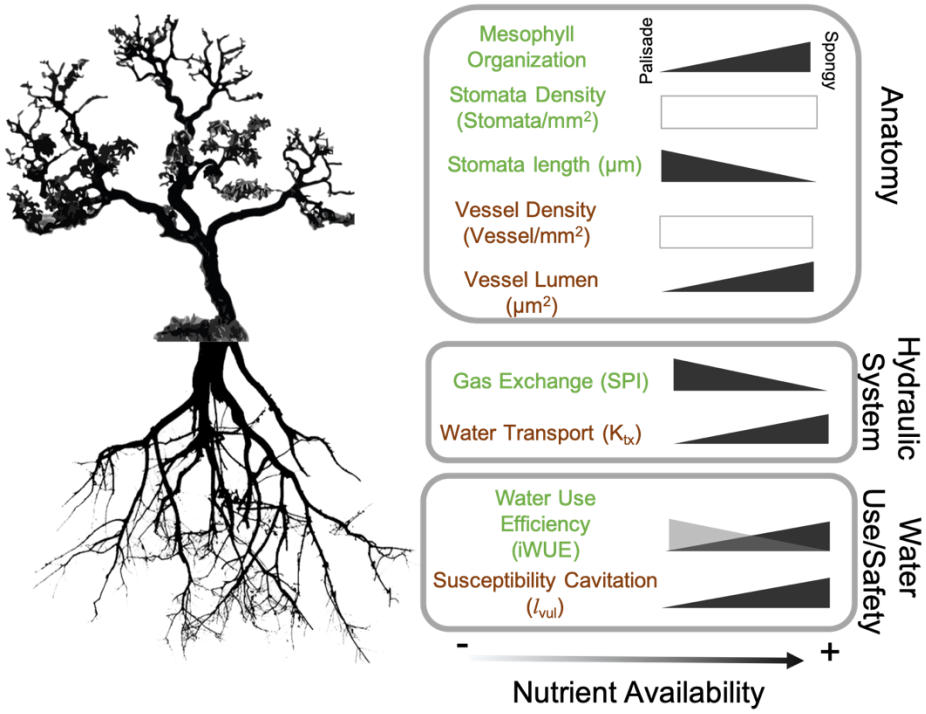

Figure 1. Leaf (green) and wood (brown) hydraulic traits quantified in five species of typical Cerrado vegetation. Black triangles: relationships predicted in the hypotheses; grey triangles, relationships opposite to the predicted and white rectangle: relationship neither positive nor negative.

4. Discussion

Nutrient enrichment resulted in anatomical changes, optimizing water transport with a hydraulic safety cost and minimizing water loss (Goldstein et al., 2013). The greater limitation by P in Cerrado vegetation (Nardoto et al., 2006) might explain the interspecific convergence in response to P addition associated to N enrichment. Despite clearly convergent responses, idiosyncrasies influenced aggregated approach.

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