Effects of soil nitrogen (N) deficiency on photosynthetic N-use efficiency in N-fixing and non-N-fixing tree seedlings in subtropical China

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Introduction

Background: Soil nitrogen (N) deficiency can affect the photosynthetic N-use efficiency (PNUE, the ratio of the photosynthetic capacity to the leaf N), mesophyll conductance (g_m), and leaf N allocation. However, lack of information about how these physiological characteristics in N-fixing trees could be affected by soil N deficiency and the difference between N-fixing and non-N-fixing trees.

Objectives: To understand the effects of soil N deficiency on PNUE, photosynthetic capacity, leaf N allocation, and g_m of N-fixing and non-N-fixing trees in subtropical China; and explore the different plant metabolism response modes between the tree species under soil N deficiency.

Materials and Methods

In this study, we chose seedlings of two N-fixing (*Dalbergia odorifera* and *Erythrophleum fordii*) and two non-N-fixing (*Castanopsis hystrix* and *Betula alnoides*) trees and conducted a pot experiment with three levels of soil N treatments (high nitrogen, set as Control; medium nitrogen, MN; and low nitrogen, LN). We investigated PNUE, photosynthetic capacity, leaf N allocation and g_m to CO_2 of the seedling leaves that were exposed to different soil N treatments.

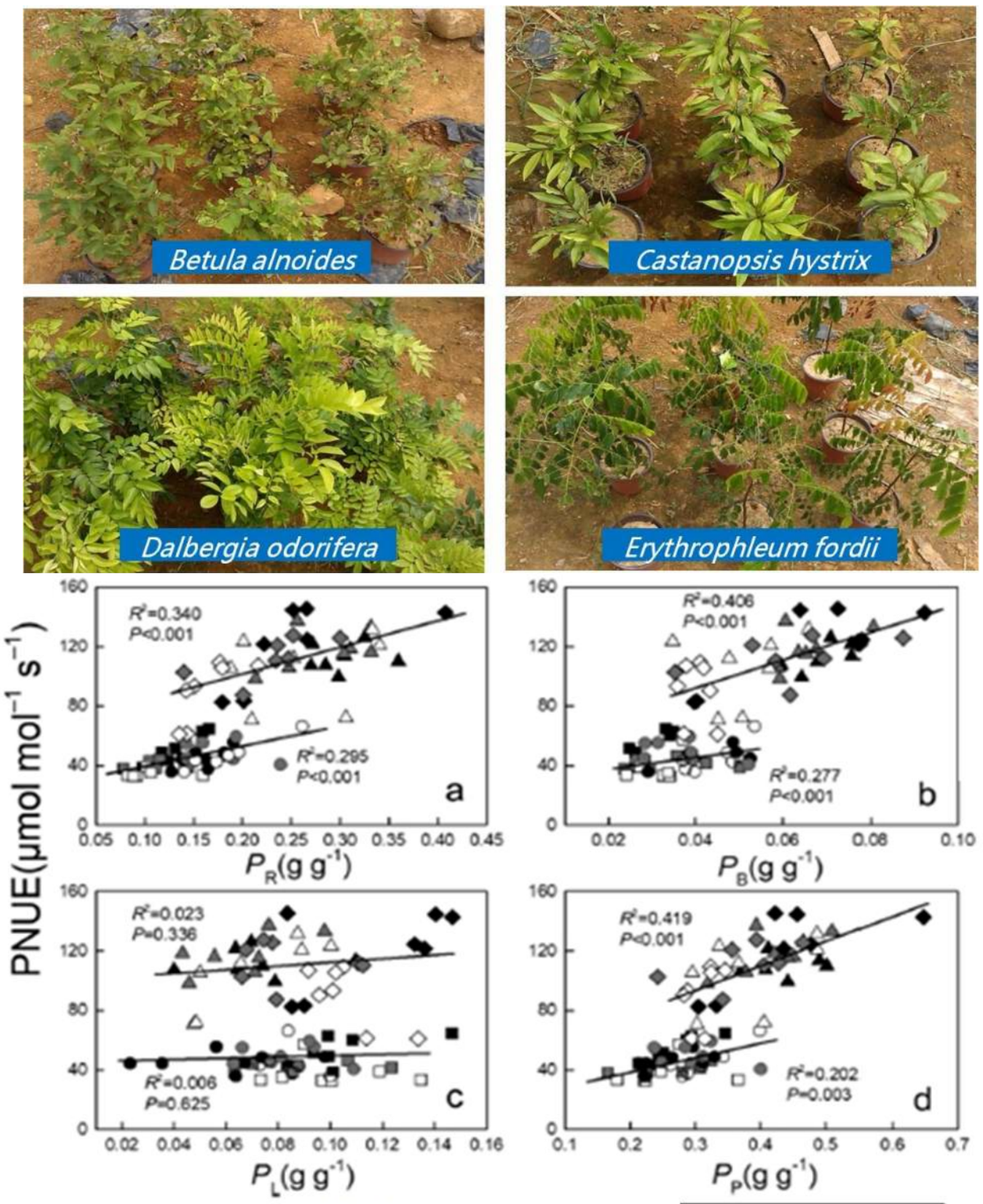

Figure 1. Regression analysis of nitrogen (N) allocation proportions in the photosynthetic system (P_P), light harvesting components (P_L), Rubisco (P_R), and bioenergetics (P_B) with the photosynthetic N use efficiency (PNUE) in the seedling leaves of the four tree species after exposure to different soil N treatments.

Results

- N_{area} and N_{mass} were significant higher while PNUE was significantly lower in N-fixing than in non-N-fixing species under different N treatments. A_{max}', N_{mass}, and PNUE of *E. fordii* were less affected by soil N deficiency while that of other three species had a significant decrease under LN treatments.
- No significant change of g_m under LN for *E. fordii* while that of the other three species were significantly lower under LN treatments.
- V_{cmax} and J_{max} of non-N-fixing species were significantly lower under LN treatments. V_{cmax} and J_{max} of N-fixing species were significantly higher than that of non- N-fixing species under LN treatments.
- N allocation pattern of N-fixing species changed little, but there was a large change for non-N-fixing species under different N treatments. No significant change of P_{CW} for *E. fordii* while that for the other three species were significantly higher under LN treatments.
- P_R, P_B, and P_P showed a significant positive correlation with PNUE in these species (P < 0.01; Fig. 1a,b,d). No significant correlation was observed between P_L and PNUE in these trees (Fig. 1c). Significant positive relationships were observed between g_m and PNUE in these trees ($P \leq$ 0.001; Fig. 2). The changes in P_R, P_B, and g_m were important physiological factors influencing PNUE.

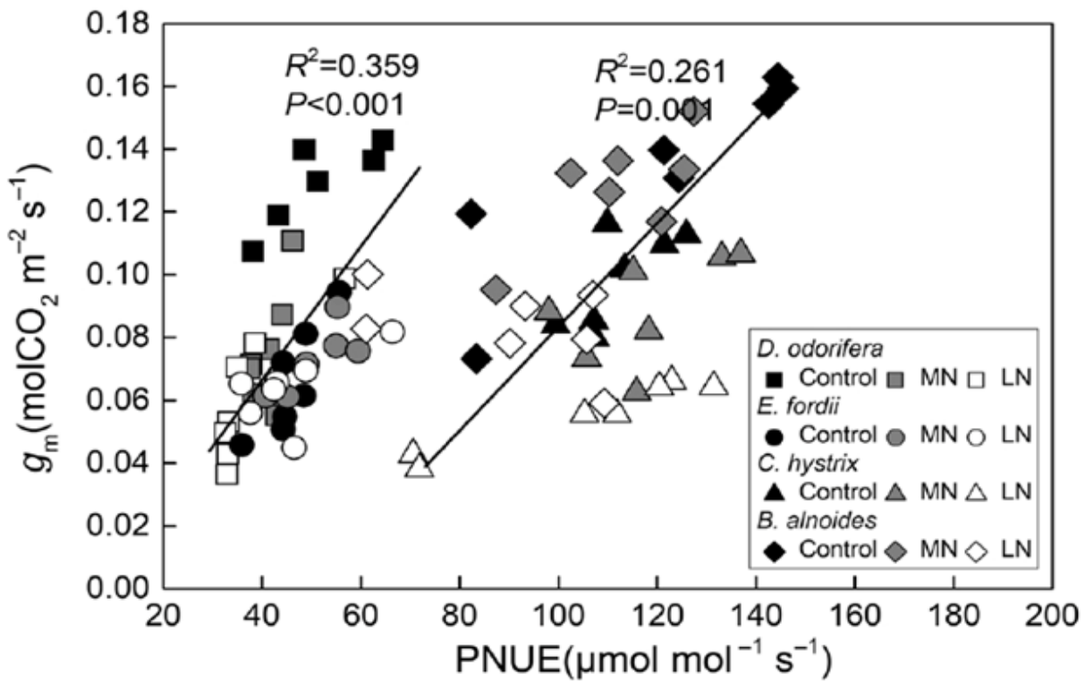

Figure 2. Regression analysis of g_m with PNUE in the seedling leaves of four tree species following exposure to different soil N treatments.

Conclusions

Soil N deficiency significantly decreased leaf N concentration and photosynthetic capacity in the two non-N-fixing trees, but it had less influence on these indices in the two N-fixing trees. The LN treatment had a lower g_m in *Dalbergia odorifera* and lower P_R, P_B and g_m in *Betula alnoides*, eventually resulting in their low PNUE. *D. odorifera*, *B. alnoides*, and *C. hystrix* seedlings showed improving P_{CW} and (or) LMA to adapt to a low-N soil environment.