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The effects of water, nutrient availability and their interaction on the growth, morphology and physiology of two poplar species

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ABSTRACT

We exposed cuttings of two poplar species, *Populus cathayana* Rehder and *Populus przewalskii* Maximowicz, from Sect. *Tacamahaca* Spach to two watering regimes (well-watered and water-stressed conditions) and to two nutrient regimes (with or without fertilization) in a greenhouse to determine how fertilization affects the growth, morphology and physiology of poplars under different water conditions. Under stress conditions, changes in early growth and dry matter allocation, and decrease in gas exchange and the related functions are usually observed. Moreover, the measurement of carbon isotope composition ($\delta^{13}C$) provides an integrated measurement of water use efficiency. And abscisic acid (ABA) is a phytohormone which plays a prominent role in various physiological and biochemical processes related to environmental stresses. So we determine these characteristics and related parameters, and our results showed the following: (1) Fertilization promoted the growth of poplars under well-watered conditions, while under water-stressed conditions its effect on growth was negative. (2) Fertilization increased $\delta^{13}C$, total N concentration, chlorophyll a/b and intrinsic efficiency of photosystem II (Fv/Fm) but decreased relative water content of leaves, stomatal conductance, transpiration rate and C/N ratio under both well-watered and water-stressed conditions. (3) Fertilization appeared to increase net photosynthesis rate and decrease ABA content under well-watered conditions, while it decreased net photosynthesis rate and increased ABA content under water-stressed conditions. Moreover, compared to *P. cathayana,* collected from a lower altitude region, *P. przewalskii,* collected from a high-altitude region, has a slower growth rate and stronger adaptability to drought stress, which perhaps resulted from its chronic adaptability to the low water availability of high-altitude region; but to the nutrient stress, there was no difference between the two species.

1. Introduction

The growth rate of plants mainly depends on the availability of water and nutrients in their habitat (Tilman, 1997). The theory of the stress-resistance syndrome predicts that plants adapted to low-resource environments (e.g., infertile, dry or saline soils) grow slowly even when provided with an optimal supply of resources, because they divert resources to functions other than growth, mainly to defense or storage (Chapin, 1980). On the other hand, plants adapted to high-resource environments will respond phenotypically to environmental resources (e.g., water and nitrogen) by increasing allocation to resource-acquiring functions (Chapin, 1991). Inter-specific differences in such responses to different environments may reflect local, climatic adaptation. Numerous studies have shown that fertilization is most effective when trees are not water-stressed, and that irrigation is most effective when nutrients are not scarce (Sands and Mulligan, 1990). Graciano et al. (2005) have concluded that drought-tolerance strategies are altered by fertilization in woody plants.

Although soil water contents are high and precipitation is often abundant at high altitudes, trees may still suffer from drought stress induced by frozen and unavailable soil water or damaged foliage. James et al. (1994) have hypothesized that trees at high altitudes are typically water-stressed, and the water stress is caused by damage to the cuticule of the trees due to wind and ice blasting during win-

Abbreviations: A, net photosynthesis rate; ABA, abscisic acid; ANOVA, analysis of variance; Chl, chlorophyll; C%, carbon proportional concentration; *E*, transpiration rate; ELISA, enzyme-linked immunosorbent assay; F, fertilization treatments; FC, field capacity; Fm, maximum fluorescence yield of photosystem II; Fo, minimum fluorescence yield of photosystem II; Fs, foliage area/stem cross-sectional area ratio; Fv/Fm, maximum quantum efficiency of photosystem II; g_s, stomatal conductance; N%, nitrogen proportional concentration; PAR, photosynthetically active radiation; Pc, *Populus cathayana*; Pp, *Populus przewalskii*; Rf, root mass/foliage area ratio; Rs, root/shoot ratio; RWC, relative water content; S, species; Sla, specific leaf area; W, watering regimes; WUE, water use efficiency; $\delta^{13}C$, carbon isotope composition.

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