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Interaction of nitrogen supply and water relations in plantation *Eucalyptus globulus*

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Introduction

Eucalyptus globulus produces a large canopy area during the early years of establishment, retains foliage even in adverse environmental conditions and maintains turgor at low leaf relative water contents (White *et al.*, 1996). These characteristics confer competitive advantage over other species in its natural habitat, enabling it to rapidly utilise resources in favourable conditions. However, these strategies also render it vulnerable during prolonged soil water deficits in environments of high evaporative demand (White *et al.*, 1996), such as in south-west Australia.

Leaf area is the dominant factor determining transpirational water loss. Modifying leaf area and retention through manipulation of fertiliser application provides an option for tree management where water deficits can impact on tree survival in some years. Nitrogen has particular potential for regulation of canopy size because there is a strong leaf area response to nitrogen and it is often deficient for tree growth in Western Australia, even on soils with a fertiliser history such as ex-farm sites.

Nitrogen affects plant growth directly, principally in two ways - by influencing leaf area and by affecting photosynthetic capacity. Improved nitrogen nutrition results in greater proportional allocation to above-ground biomass (Fabião *et al.*, 1995). Leaves respond to increased nitrogen availability by greater partitioning of nitrogen to the photosynthetic apparatus relative to other leaf components(Lambers *et al.*, 1998).

Improved nitrogen status resulting in greater leaf area for light interception and a greater capacity for carbon assimilation per unit leaf area potentially leads to a greater subsequent biomass production. However, in seasonally dry environments the potential for greater yield must be considered in the context of increased transpiration due to greater leaf area. Thus, the development of a nitrogen application prescription involves a trade-off between maximising productivity and minimising the risk of drought death.

An experiment investigating the physiological responses of plantation *E. globulus* to different levels of nitrogen application is being conducted south of Nannup, Western Australia. The initial objective of the project is to quantify the influence of nitrogen supply on carbon assimilation rates, and nitrogen and water use efficiencies at the leaf scale.

Methodology

Treatments were imposed on 2 year old trees planted at 1200 stems/ha on ex-pasture sites (Fig. 1). DAP had been applied at establishment. Basal (P, K, Mg, Mn, Cu and Zn) fertiliser was applied in September 1998. Nitrogen treatments consisted of 0, 45 and 250 kg N/ha annually as split applications (spring and autumn) in 3 replicate blocks. Initial measurements have only been made at Scott River.

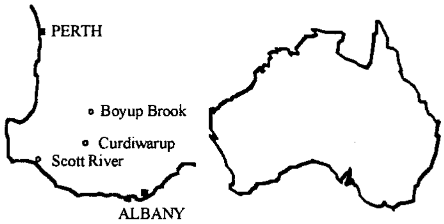

Figure 1. Location of study site.

Measurements consisted of carbon assimilation rate and transpiration rate using a PP Systems CIRAS-1 portable infrared gas analysis system. Instantaneous transpiration efficiency (TE) was defined as the ratio of carbon assimilation rate (μmol CO_2 m^{-2} s^{-1}) and transpiration rate (mmol H_2O m^{-2} s^{-1}), measured simultaneously at saturating light (arbitrarily, greater than 800 μmol/m^2/s). Foliar N was determined by modified Kjeldahl digestion, followed by colorimetric analysis (Shedley *et al.*, 1995).

Results

The foliar nitrogen concentration and carbon assimilation rate of leaves located at 3/4 of the total canopy height during the actively growing period of spring were significantly greater ($p < 0.05$) for the highest nitrogen treatment (Fig. 2). Instantaneous transpiration efficiency increased with nitrogen application, but only at the highest level of applied nitrogen (Fig. 2). The effect of remobilisation of nitrogen to the upper canopy is evident in the zero nitrogen treatment, whereas nitrogen was not remobilised to the same extent when nitrogen supply was greater (Fig. 3).

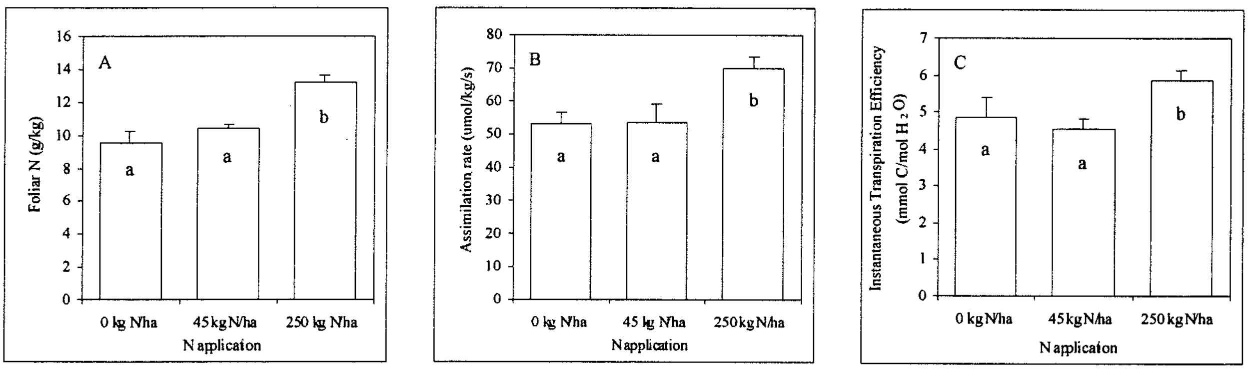

Figure 2. Effect of N application on leaf N concentration (A), light-saturated carbon assimilation rate (B) and instantaneous transpiration efficiency (C). Mean values of youngest mature leaf, Oct. 1999. Bars labelled with the same letters were not significantly different ($p<0.05$).

Discussion

Application of nitrogen to glasshouse-grown *E. globulus* seedlings has been reported to increase leaf nitrogen concentrations (eg. Sheriff, 1992; Shedley *et al.*, 1995) and carbon assimilation rates (eg. Sheriff and Nambiar, 1991). However, increased foliar concentration and photosynthetic capacity following nitrogen application are not always observed in the field (Pereira *et al.*, 1992). Increased nitrogen availability may only lead to an increase in leaf biomass, resulting in dilution of nitrogen within the whole plant, and an increase in shoot/root ratio. In this study, nitrogen application increased foliar nitrogen concentration and assimilation rate in 3 year-old plantation *E. globulus* (Fig. 2).

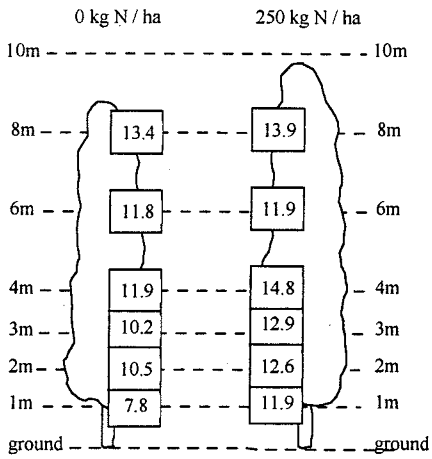

Figure 3. Effect of N application on distribution of N (g/kg) throughout the canopy (mean values of youngest mature leaf, July 1999).

An inevitable consequence of CO_2 uptake is the loss of water vapour via the stomata. Therefore factors which influence photosynthetic activity affect the efficiency of use of transpired water in assimilating carbon. Instantaneous transpiration efficiency improved with nitrogen application in plantation *E. globulus* trees, but only at the high level of applied nitrogen (Fig. 2).

Improved nitrogen status allows greater investment of foliar N in the assimilatory apparatus. Furthermore, the proportion of the canopy capable of higher rates of photosynthesis is greater because an adequate N supply means that N invested lower in the canopy need not be sacrificed to supply new growth (Fig. 3). Combined with a greater leaf area to intercept light, there is a greater potential for growth. However, leaf area is the dominant factor determining transpirational water loss. Does this render plantation *E. globulus* well-supplied with N vulnerable to tree deaths during prolonged soil water deficits in environments of high evaporative demand such as south-western Australia? This is the focus of the remainder of the study at Scott River, and at Boyup Brook and Curdiwarup (Fig. 1) where plantations experience greater water stress.

Acknowledgments

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