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Comparative study of nitrogen assimilation in woodland species

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Introduction

Trees differ in their ability to assimilate nitrate in their leaves (Smirnoff *et al.*, 1984). In Australian rain forest trees a relatively high capacity for leaf nitrate assimilation is characteristic of pioneer species or species of open communities. Those of closed communities tend to have lower shoot:root nitrate reductase (NR) ratios (Stewart *et al.*, 1988). This study compares the level of leaf NR activity in several northern temperate tree species. The capacity for assimilation of foliar supplied nitrate is discussed.

Results and Discussion

Five tree species have been sampled throughout the 1988 season for leaf NR activity (for method see Smirnoff *et al.*, 1984). The climax species beech had the lowest level of NR (0.28 $\mu mol.h^{-1} \cdot g^{-1}$ fwt), while the pioneer species birch exhibited the highest activity (2.34). Of 3 conifers tested, Scots pine (1.76) was higher than either Sitka spruce (0.29) or Norway spruce (0.49).

In the case of Scots pine and birch a marked seasonal variation in leaf NR activity existed (Fig. 1). Pine had a relatively high leaf NR activity in the spring, which could be associated with a flush of soil nitrification and rising sap. Birch, however, showed a relatively low level for NR in buds and expanded leaves until near the onset of autumn. At this time, a 5-fold increase in activity had occurred. This phenomenon was noted in 1987 and at 2 other sites this year. Three possibilities seem likely: 1) stored nitrate within the leaf vacuole is being released with the onset of senescence; 2) the flux of nitrate from root to shoot is being increased; 3) the onset of senescence could have led to the removal of some form of end product inhibitor. The exact reason is as yet unclear, but measurement of leaf nitrate content gave only trace amounts (around 0.1–0.2 $\mu mol \cdot g^{-1}$ fwt) and so the first possibility seems unlikely. Either way, the peak in NR activity just prior to senescence would seem to be a useful means for a fast-growing deciduous species to assimilate nitrate into organic form and then use this to promote next year's leaf growth.

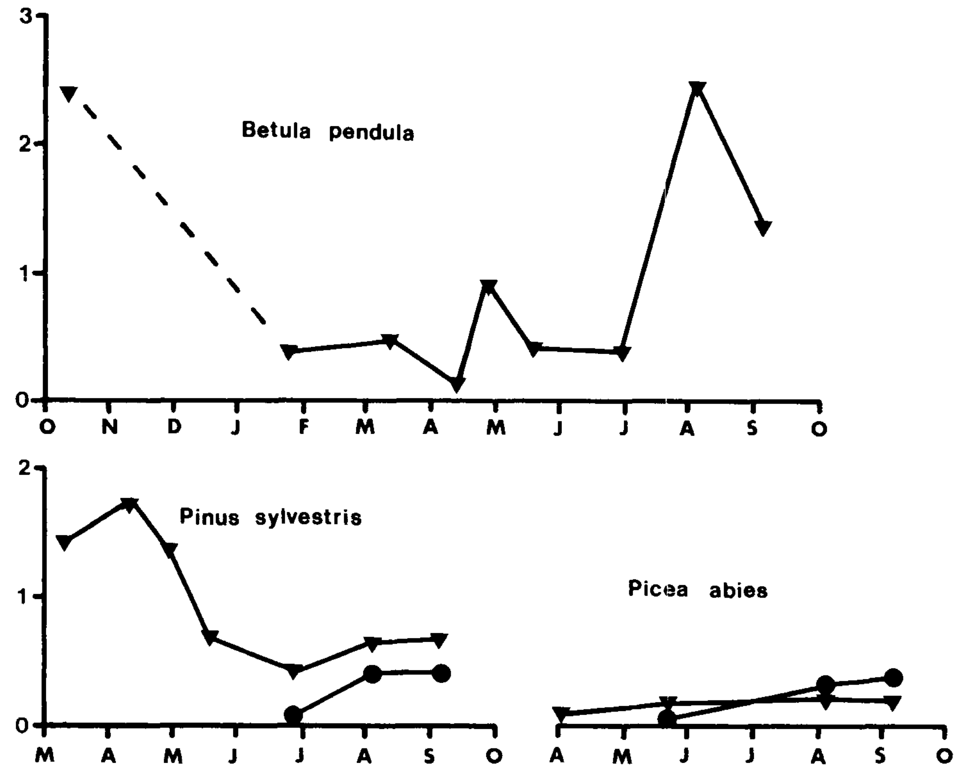

Fig. 1. Seasonal variation (1988) in nitrate reductase activity (μmol·h^{-1}·g^{-1} fwt) 1 yr old (▼) and current (●) needles in 3 conifer species. Values are the averages for 3 replicates.

Current needle development in Sitka spruce is earlier than that in Scots pine. The 1 yr old needles would seem to be net exporters whereas the current needles are net importers of nitrogen early on in development, especially in Scots pine (Fig. 1). Sitka spruce is predominantly a root assimilator of nitrate, but maintains a relatively low, yet constitutive capacity for shoot assimilation (Fig. 1 and Table I).

However, when the shoots are sprayed with nitrate the leaves do show an increase in NR activity. Poplar exhibits the type of response that could be considered typical of the nitrophilous pioneer behavior. It has both a high leaf and root capability for nitrate assimilation when the soil is fertilized. The foliar application has increased leaf NR activity when compared to the unfertilized control. With the growing concern over NO_x pollutants in the atmosphere, these different leaf responses may be important in defining how resistant to acid rain a particular tree species might be. A low capacity for leaf nitrogen assimilation may mean that a species would be unable to buffer itself against such aerial inputs. Table II shows that the pool of free amino acids is highest in those 2 species, pine and birch, with the higher leaf NR. Such pools might represent an important buffering capacity in relation to acid rain inputs (Raven, 1988).

Table I. Shoot and root NR activities in a 6 mo old pioneer species *Populus deltoides* and in 3 yr old *Picea sitchensis.*

Species	*Treatment*	*Shoot* ($\mu mol{\cdot}h^{-1}g^{-1}$ fwt)	*Root*
P. deltoides	control	0.187	0.607
	soil	2.131	1.451
	foliar	1.151	
P. sitchensis	control	0.364	0.244
	soil	0.280	0.621
	foliar	0.540	

Plants were grown in pots for 6 mo and then treated with an application of 3 mM KNO_3 to the soil or as a foliar spray. Assays were carried out 2 d after application and are the averages of 3 replicates.

Table II. Soluble amino acids in the leaves of 4 tree species collected from the field.

Amino acid	Fagus sylvatica *7.8.88*	Picea sitchensis *2.4.88*	Pinus sylvestris *2.4.88*	Betula pubescens *5.10.88*
Glu	577[a]	477	1 780	753
Asn	–	437	–	–
Ser	384	343	2 000	–
Gln	203	340	1 080	–
Gly	–	–	–	1 917
Arg	–	460	1 100	1 773
Ala	791	730	2 530	1 237
Gaba	–	–	–	1 622
Tyr	–	880	1 350	–

[a] All values are given in $nmol{\cdot}g^{-1}$ fwt.
Means of 3 replicates.

Certainly, of the broad leaf trees, it seems that recent reports for acid rain damage are becoming more common for the climax species beech, which seems to have a low leaf NR capacity.

Acknowledgment

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