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Temporal variation of the total nitrogen concentration in aereal organs of nitrogen fixing and non fixing riparian species

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Abstract. Changes in nitrogen concentration was determinated in samples of *Alnus glutinosa*, *Elaeagnus angustifolia*, *Populus* x *canadiensis* and *Ailanthus altissima* leaves, petioles and branches periodically during a year. Maximum nitrogen percentage was found in diazotrophic species (*Alnus* and *Elaeagnus*) and the nitrogen retranslocation form branches was higher (2.5 times) in no fixing species.

Resumen. *Variación temporal de la concentración total de nitrógeno en órganos aéreos de especies riparias fijadoras y no fijadoras de nitrógeno.* Se estudian los cambios en la concentración de nitrógeno en *Alnus glutinosa*, *Elaeagnus angustifolia*, *Populus* x *canadiensis* y *Ailanthus altissima*, en hojas, peciolos y tallos periódicamente durante un año. El porcentaje máximo de nitrógeno se encuentra en las especies diazotrofas (*Alnus* y *Elaeagnus*) y la retraslocación de dicho elemento desde los tallos es superior (2.5) veces) en las plantas no actinorrizas.

Introduction

The low availability of nitrogen limits the development of many plants (Larcher 1976), and so plants have mechanisms to optimize the use of this nutrient.

In this way, many diazotrophic plants (like *Alnus glutinosa* [L.] Gaernt. and *Elaeagnus angustifolia* L.) tend to lack synchronous leaf fall and retain green foliage until early winter (Hightshoe 1978). The fact that the leaves remain green suggests that they may retain organic nutrients, especially nitrogenous compounds, up to the time of leaf fall. Most winter-deciduous trees translocate a large percentage of their total nitrogen back into nearby twigs and branches before leaf fall in autumn. Silvester (1977) pointed out that falling leaves of different species of *Alnus* contain between 2.17% and 2.82% of nitrogen.

Retranslocated nitrogen in twigs and branches of winter-deciduous trees is readily available for foliar growth the following spring, and is usually found in high concentrations during spring (Tromp 1970). Leaf nitrogen conservation is important because in some instances, leaves may have more than 40%

of the total nitrogen content in broadleaved trees (Kramer & Kozolowski 1979). However *Alnus* and *Elaeagnus* are able to fix atmospheric nitrogen via root-nodule symbiosis with actinomicetes of the genus *Frankia* (Becking 1970). Thus, these plants benefit less from mechanisms of nitrogen conservation and there is probably less selection pressure to develop an efficient mean of doing so. By contrast different non nitrogen fixing plants have lower content in nitrogen as *Betula, Corylus, Tilia* (with levels of nitrogen between 0.63% and 1.30%) or conifers as *Pinus* sp., *Picea* sp. and *Tsuga* sp. (0.49% and 0.79%).

The information about nitrogen seasonal variations in aereal organs of diazotrophic plants is scarce, contrasting with studies of non diazotrophic plants (Dawson & Funk 1981).

The objetive of this study was to determine the variation of nitrogen concentration in leaf, petiole and branches of two diazotrophic trees [*Alnus glutinosa* (L.) Gaernt., *Elaeagnus angustifolia* L. and two other non diazotrophic species [*Populus* x *Canadiensis* Moench. I-214 and *Ailanthus altissima* (Miller) Swingle] and to asses the importance of the retranslocation mechanisms in the two types of plants.

Materials and methods

The samples of leaves, branches and petioles, were collected randomly from trees of the species studied every two months during a year. For each species and sample, leaves, branches and petioles of different size and in differents parts of the trees were collected. The sampled trees were 12-15 years old. After collection, all samples were dried at 55°C until constant weight. They were then triturated and sieved with a 0.2 mm diameter mesh, and the nitrogen concentrations were determinated by a microKjeldahl procedure B (Nelson & Sommers 1973): 200 mg of dry sample was digested with 7 ml of concentrated H_2SO_4 and 4g of catalyst (K_2SO_4: $CuSo_4 \cdot 5H_2O$/30:1) keeping the mixture at 500°C for 1 hour. The ammonium produced was measured by a specific electrode ORION 95-10-00 connected to a mV/pH-meter CRISON digit 501.

The results obtained were subjected to analysis of variance, bidirectional with three factors of variation and three replics —ANOVA— (Sokal & Rohlf 1981). Differing treatments were recognized by multiple comparision employing the Fisher Least Significant Difference —LSD— procedure (Steel & Torrie 1980).

Results and discussion

The variation of nitrogen concentration in leaves, petioles and branches of the species studied is shown in Fig. 1. The method of random sampling of leaves, branches and petioles was employed because the content in nitrogen in aereal

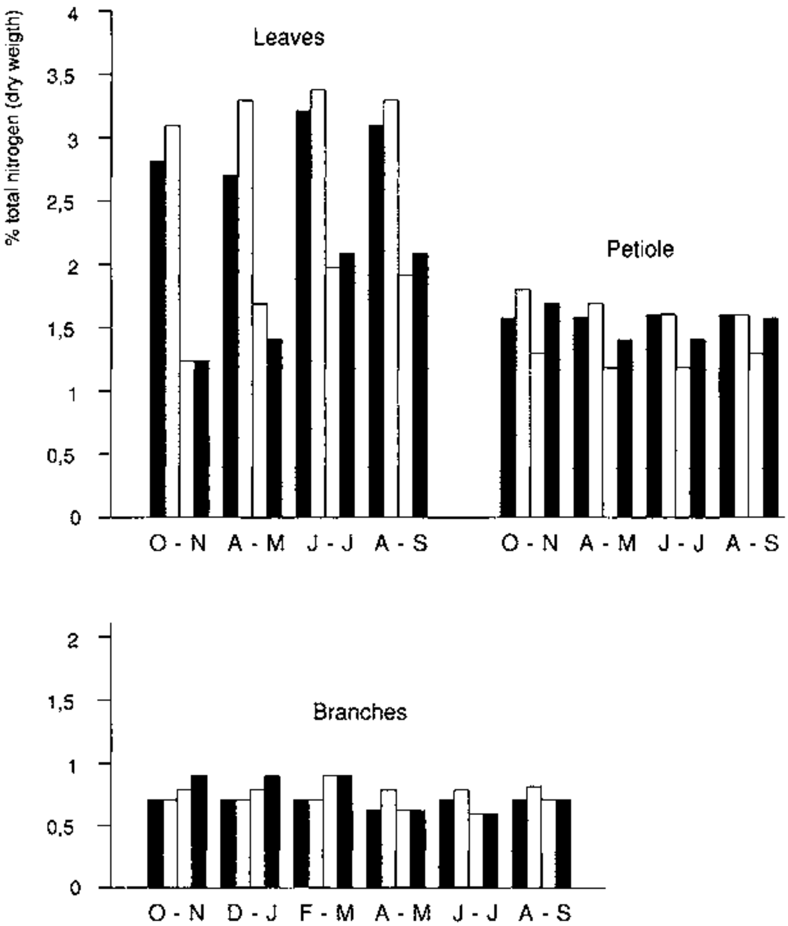

Figure 1. Nitrogen percentaje (dry weigth) in aereal organs. Months are represented by its first letter. (■)Alnus, (□) Elaeagnus, (□) Populus, (■)Ailanthus.

organs is independent of the size or position of those on the tree (Dawson & Funk, 1981).

Table 1 shows the average values of the nitrogen concentration in the differents organs and species studied. Table 2 shows the signification of ANOVAs and LSD carried out with the arithmetic mean of three replics. The leaves of diazotrophic plants show an average N value of 3.23% in *Elaeagnus* and 2.93% in *Alnus*. Sivester (1977) and Bocock (1964) obtained similar results (around 3%N) in different species of *Alnus*. These values are significantly higher than in non diazotrophic species (1.81% in *Populus* and 1.90% in *Ailanthus*). The percentage of nitrogen found in the petiole of diazotrophic plants was signi-

Table 1. Average values ± standard error of three replics of the nitrogen concentration (% dry weigth) in different organs of the species studied.

	Alnus	Elæagnus	Populus	Ailanthus
Leaves				
O – N	2.8 ± 0.1	3.1 ± 0.3	1.5 ± 0.02	1.5 ± 0.04
A – M	2.7 ± 0.01	3.3 ± 0.01	1.7 ± 0.01	1.4 ± 0.6
J – J	3.2 ± 0.03	3.4 ± 0.01	2.0 ± 0.06	2.1 ± 0.1
A – S	3.1 ± 0.2	3.3 ± 0.03	1.9 +0.05	2.1 ± 0.04
Petiole				
O – N	1.6 ± 0.01	1.8 ± 0.02	1.3 ± 0.07	1.7 ± 0.06
A – M	1.6 ± 0.3	1.7 ± 0.01	1.2 ± 0.06	1.4 ± 0.03
J – J	1.6 ± 0.02	1.6 ± 0.01	1.2 ± 0.1	1.4 ± 0.03
A – S	1.6 ± 0.01	1.6 ± 0.2	1.3 ± 0.04	1.6 ± 0.01
Branches				
O – N	0.7 ± 0.03	0.7 ± 0.1	0.8 ± 0.01	0.9 ± 0.01
D – J	0.7 ± 0.02	0.7 ± 0.02	0.8 ± 0.03	0.9 ± 0.02
F – M	0.7 ± 0.04	0.7 ± 0.04	0.9 ± 0.02	0.9 ± 0.01
A – M	0.6 ± 0.6	0.8 ± 0.1	0.6 ± 0.02	0.6 ± 0.2
J – J	0.7 ± 0.6	0.8 ± 0.06	0.6 ± 0.02	0.6 ± 0.03
A – S	0.7 ± 0.6	0.8 ± 0.04	0.7 ± 0.2	0.7 ± 0.6

ficantly higher than in the others and was homogeneous during the year. This fact is in acordance with Singh & Coleman (1977): the petiole is just a transfer organ and is not implied in nitrogen storage. However the total nitrogen concentration in petiole clearly shows the retranslocation phenomenon, because in the non diazotrophic species, the samples collected before the leaves fall (O-N) have a significantly higher pecentage than the samples in the other season (table 2).

The branches of the studied species have similar total nitrogen values in spring and summer. During the end of autumm and winter the non fixing species have significantly higher nitrogen concentrations. This is caused by the retranslocation of this nutrient from the leaves. As fixing plants do not need to retranslocate the nitrogen from the leaves to the branches at the end of summer, this effect is not detected. Their diazotrophic capacity will replace the nitrogen lost in the leaves fall.

In general, the high fixing capacity is related to high nitrogen percentage in aereal organs (Pizelle 1975). Our results evidence that the majority of nitrogen fixed is placed in the leaves given the significant differences between summer (J-J, and A-S) and spring (A-M) or autumm (O-N) (table 2); by contrast such differences do not exist for other organs.

The nitrogen retranslocated in *Alnus* and *Elaeagnus* was approximately 10% (see table 1). Other authors obtained values around 20% in *A. glutinosa* studied in the Illinois mountains (Dawson & Funk 1981) or even 46% in *A. rubra* studied in the Colorado mountains (Cole et al. 1977). This difference could

Table 2. ANOVAs (p<0.01) and LSD (p<0.05) significations. Legend: A= Alnus, E= Elæagnus, P= Populus and Ai= Ailanthus.

		ANOVA df	F	p<
Leaves	Months	3	807.41	0.01
	Species	3	61.49	0.01
Petiole	Months	3	84.52	0.01
	Species	3	4.99	0.01
Branches	Months	3	12.79	0.01
	Species	3	9.26	0.01

	LSD Months	Species
Leaves	ON-AS, ON-JJ, ON-AM AM-AS, AM-JJ	A-Ai, A-P, A-E E-Ai, E-P, P-Ai
Petiole	ON-JJ, ON-AM, JJ-AS	AAi, A-P, A-E EAi, E-P, P-Ai
Branches	ON-AS, ON-JJ, ON-AM DJ-AS, DJ-JJ, DJ-AM FM-AS, FM-JJ, FM-AM AM-AS	A-Ai, A-P, E-Ai

be due to a higher fixing activity in the trees we studied, so nitrogen storage is not needed. Indeed, Granhall (1981) pointed out that there is a higher fixation activity in temperate climates. Nevertheless other authors (Salama & Warening 1979), claimed that the levels of cytokinins could also be implied in nitrogen levels. Obviously levels of this phytohormone must be in relation with senescence and retranslocation of nutrients.

The non actinorrizal species show a percentage of retranslocation around 25% (see table I). These results are lower than in *Betula, Populus, Salix* and *Sorbus* studied by Viro (1956) in cold climates (Finland) and similar to those reported by Kramer & Kozlowski (1979) in different deciduous species. Therefore, the retranslocation depends not only on the species but also on the soil, plant age (Loehwind 1951) and, mainly, on the temperature and photoperiode (Pate 1976), decreasing when the plant grows in temperate climates, such as the case of the species studied in the present paper.

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