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DYNAMICS OF MACROELEMENTS IN THE LEAVES OF TREE SPECIES GROWING IN PISMENOVO ARBORETUM DURING THE GROWING SEASON

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Abstract

The study took place in the period 2008–2012 in Pismenovo arboretum, situated in the peripheral sub-region of Strandzha Mountain (South-Eastern Bulgaria). Nitrogen and macroelement contents were examined in the leaves of 21–25-year-old specimen belonging to the following species: *Pinus nigra* Arn. ssp. *austriaca* Höss, *Pinus nigra* Arn. ssp. *laricio* Poiret, *Cedrus deodara* Loud., *C. atlantica* Manetti, *C. libani* A. Rich., *Cupressus sempervirens* L., *Quercus petraea* (Matt.) Liebl. (3 provenances), *Q. robur* L. (4 provenances), *Q. pubescens* Willd., *Q. rubra* L., *Q. suber* L., *Q. harwissiana* Stev., *Q. frainetto* Ten., *Fagus sylvatica* L., *F. orientalis* Lipsky and *Tilia tomentosa* Moench. Nitrogen content in the leaves of most deciduous species was the highest in May, maintaining comparatively high values in June and gradually lowering in the next months until the end of growing period. P_2O_5 content had its maximum value in the summer months, keeping relatively high values until the end of the growing period. K concentration in the leaves of most species was highest in August. Ca and Mg content gradually increased from the beginning to end of the growing period. N, P and K content in the coniferous species was significantly lower as compared to the one in the leaves of the deciduous species, which makes the latter ones more tolerant to soil fertility. Of conifers, the lowest concentration of these substances was recorded in the needles of the Atlas cedar. In deciduous species the highest content was measured in *Tilia tomentosa* and *Quercus hartwissiana* and the lowest one – in the leaves of the Cork oak. There were also differences among the provenances within a species. In Cedar needles, Ca and Mg concentration is 2 times higher, compared to that one in the needles of Black pine and *Pinus nigra* Arn. spp. *laricio*. It is obviously a characteristic biological particularity. The differences should be considered when modelling nutrient circulation in forest stands and when evaluating the long-term sustainability of forest management.

Key words: calcium, coniferous species, deciduous species, magnesium, nitrogen, phosphate, potassium.

Introduction

Nitrogen and other macroelements content and dynamics in the leaves of the tree species are of a great importance for the highlighting of the elements cycling in the forest ecosystems where the purpose is to optimize their productivity, sustainability, conservation and regeneration of species diversity.

The seasonal dynamics of the concentration of macroelements in the leaves of

tree species varies as it is dependent on their accessibility in the soil, climatic factors, age of the leaves and trees, phase of development during the growing season etc. (Bauer et al. 1997, Lukina 1996, Lukina et al. 2000, Lukyanets 1980, Yurukova and Bondev 1990). It is also known that the chemical composition of the plants is influenced by genetic factors, as well; and the plasticity of nitrogen, phosphorus and potassium content in the photosynthetic organs can be utilized in the selection of genotypes of desired characteristics (Bridgen 1988). Some authors clarify the relationship between air pollution and concentration of elements in needles and leaves of the tree species (Mankovská et al. 2004, Szaro et al. 2002).

The objective of the proposed work comprises the conducting of prolonged studies on N, P, K, Ca and Mg content and the highlighting of the particularities in the seasonal dynamics of the above mentioned elements in the leaves of some tree species.

Objects and Methods

That examination of macroelements content and dynamics in the leaves has been going on for more than 10 years (Broshtilova and Broshtilov 2009). The study points to the results obtained within the period 2008–2012. Pismenovo arboretum is located in the peripheral sub-region of Strandzha Mountain, on the territory of the State Forestry Tsarevo (Sector 12[5]). Each of the species is planted on an area of 500 m^2, 25 × 20 m size, with separating paths of 4 m each. The saplings are planted in rows at the inter-distance of 2 m and intra-distance of 1 m.

The arboretum is situated on a slight slope terrain (1–2 °) at 70 m a.s.l., at north exposure. The soil is cinnamon-coloured, very deep, consolidated by an average to heavy sand-clay soil texture, gleying in its lower levels, due to winter over-moisturing. Considering its potential water resources, that kind of soil is characterized as fresh to humid. It has average stocks of humus and assimilable potassium and poor to average stocks of total nitrogen; there is a low acidic reaction in its root-inhabited layer. The assimilable phosphorus content is very low.

The content of macroelements is examined in the leaves of 20–25-year-old trees, as follows: Black pine (*Pinus nigra* var*. austriaca* Poiret)*, Pinus nigra* Arn ssp. *laricio* Poiret)*,* Deodar cedar (*Cedrus deodara* Loud.), *Atlas cedar* (*Cedrus atlantica* Manetti), Lebanon cedar (*Cedrus libani* Laws.), Common cypress (*Cupressus semepervirens* L.), Durmast oak (*Quercus petraea* Liebl.) – 3 provenances („Tsarevo", „Varbitsa" and „Varshets"), Common oak (*Quercus robur* L.) – 4 provenances („Vardim Island", „Village of Yulievo", district of Kazanlak, „Sofia" and "Slovenia")*,* Pubescens oak (*Quercus pubescens* Willd.), Red oak (*Quercus rubra* L.), Cork oak (*Quercus suber L.*), *Quercus hartwissiana* Stev., *Quercus frainetto* Ten., Common beech (*Fagus sylvatica* L.), Oriental beech (*Fagus orientalis* Lipsky), ansd Silver linden (*Tilia tomentosa* Moench).

Leaves of 6–7 model trees of average height and degree of development, from the light exposed side of the crown, are collected for analysis in the middle of each month, during the growing season (May-September). 2-year-old needles of the coniferous species are analyzed in that period. Samples are taken annually each month from May to September. The results presented are the average of five years. Nitrogen content in the needles is determined using Kjeldahl`s method, while the content of phosphorus was spectrophoto-

metrically detected, potassium – by the emission method and magnesium – by the complex metric one.

Results and Discussion

The coniferous species are of a significantly lower N concentration in their needles compared to that one in the leaves of the deciduous species (Fig. 1a,b). The average results, obtained within the examination period of N content in the coniferous species, show approximately 2 times lower N content therein, compared to that one in the broadleaved species. Similar data are reported about the differences in N concentration in Black pine needles and Oak leaves in the region of Strandzha Mountain (Pavlova et. al. 1995, 2000). Data about significantly lower N content in the needles of conifers compared to that in the leaves of deciduous is designated by other authors (Bauer et al. 1997, Hagen et al. 2004).

The highest N concentration is detected in Black pine needles, being by 7.4 % higher compared to that one in *Pinus nigra* Arn. ssp. *laricio*, and by 20.3 % higher, in comparison with that one in Atlas cedar leaves. There are no significant differences among the three Cedar species.

In the deciduous species, the highest N content is detected in the leaves of *Q. harwissiana*, followed by that one in Red oak and Silver linden leaves. The lowest is the concentration in Cork oak leaves (27 % lower, compared to that one in the leaves of *Q. hartwissiana*).

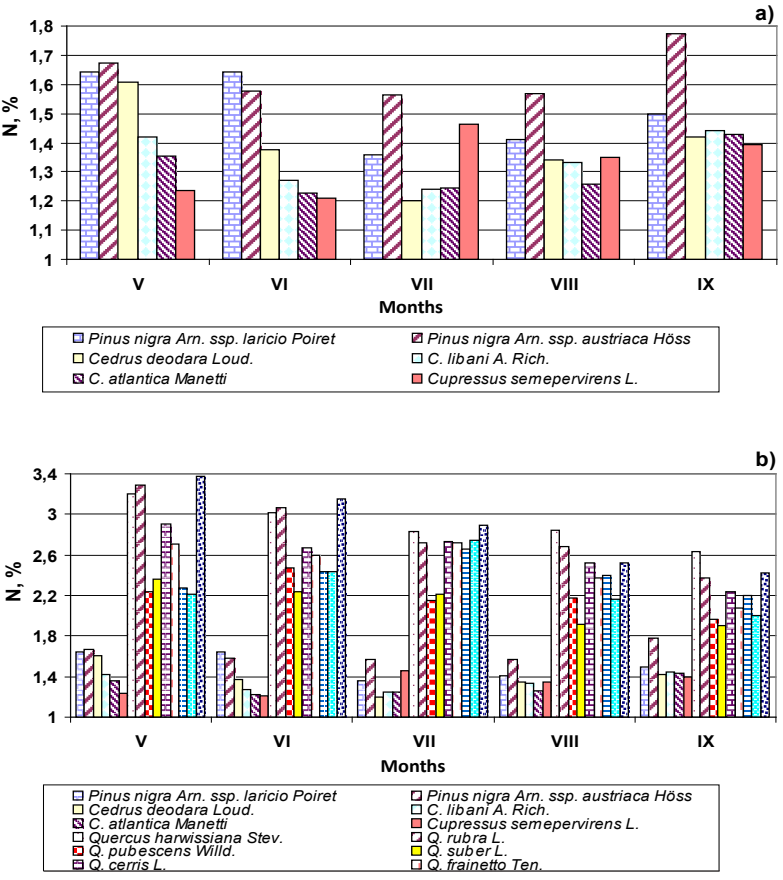

Fig. 1. Dynamics of nitrogen in the leaves of coniferous (a) and deciduous (b) species during the growing periods 2008–2012 (mean values).

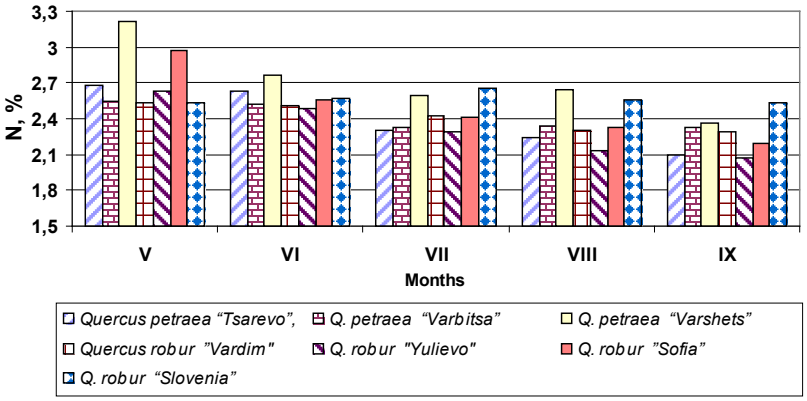

Fig. 2. Dynamics of nitrogen in the leaves of Durmast oak and Common oak provenances during the growing periods 2008–2012 (mean values).

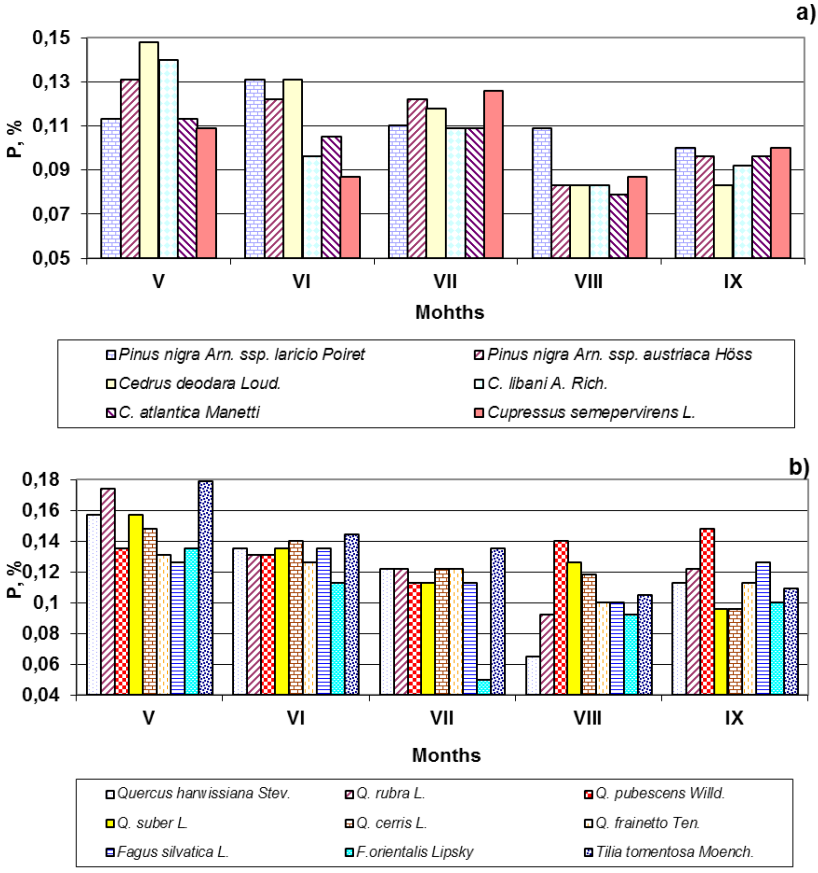

Fig. 3. Dynamics of P in the leaves of coniferous (a) and deciduous (b) species during the growing periods 2008–2012 (mean values).

There are differences among the single provenances within the species of Common and Sessile oak (Fig. 2). The average results within the period show that N content in the leaves of Common oak ("Yulievo" provenance) is lower by10 %, compared to that one in the leaves of the trees of "Slovenia" provenance. N content in the leaves of Durmast oak trees ("Tsarevo" provenance) is by 22 % lower, compared to that one in the leaves of the trees of „Varshets" provenance. According to some authors, a higher N content can be considered as an indicator of a better growth, vitality and adaptability of the

trees from the respective origin (Lukyanets 1980, Patlai and Boiko 1978).

N content in the leaves of most deciduous species is the highest in May, keeping relatively high values in June and gradually dropping later on, during the vegetation period and maintaining relatively high values even in September (Fig. 1b). In Pubescens oak leaves, the maximum concentration of N is detected in June, while in Common oak leaves ("Slovenia" provenance) and Common and Oriental beech its maximum is in July.

No outlined seasonal dynamics is observed in the coniferous species during the growing season, regardless of a certain trend to N concentration increase from May to June and to its drop in October (Fig. 1a).

In most of the species, the content of P is the maximum in the beginning of the growing season and its high values are being also kept in June and July (Fig. 3a,b). According to Yanovich (1965), the concentration of phosphorus in the leaves is uneven during the growing period and it reaches its maximum in summer months: probably, that is due to a higher energy need in the same period characterized by the soil moisture exhaustion (Yanovich 1965).

No substantial differences are found out in Black pine and *Pinus nigra* Arn. ssp. *laricio* regards to the average concentrations of P in the needles. The concentration of P in Deodar cedar needles is slightly higher, compared to that one of the

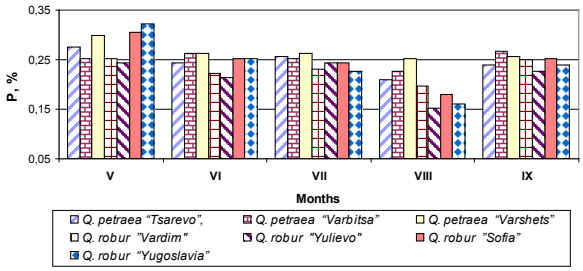

Fig. 4. Dynamics of P in the leaves of Durmast oak and Common oak provenances during the growing periods 2008–2012 (mean values).

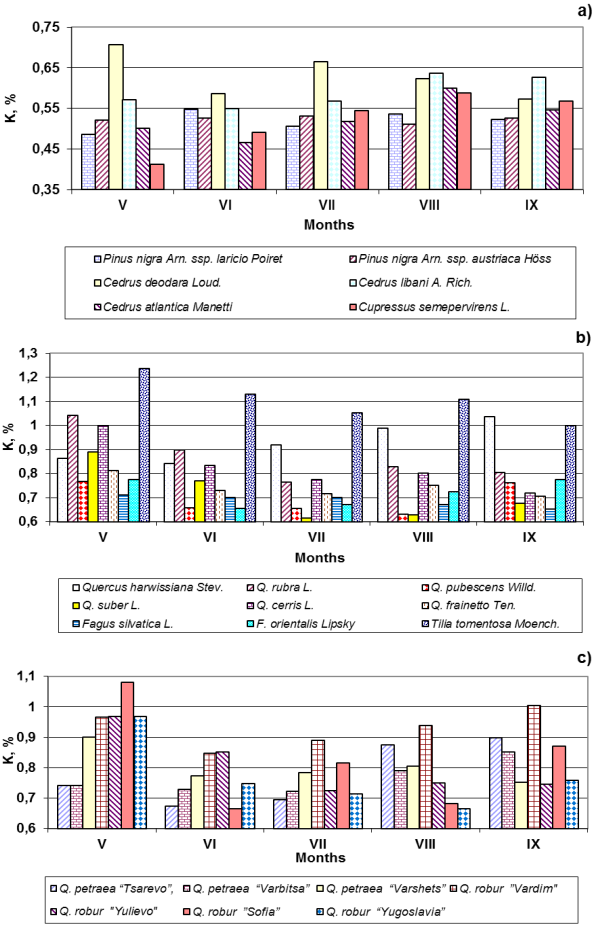

Fig. 5. Dynamics of K the leaves of coniferous (a) and deciduous (b) species and oak provenances (c) during the growing periods 2008–2012 (mean values).

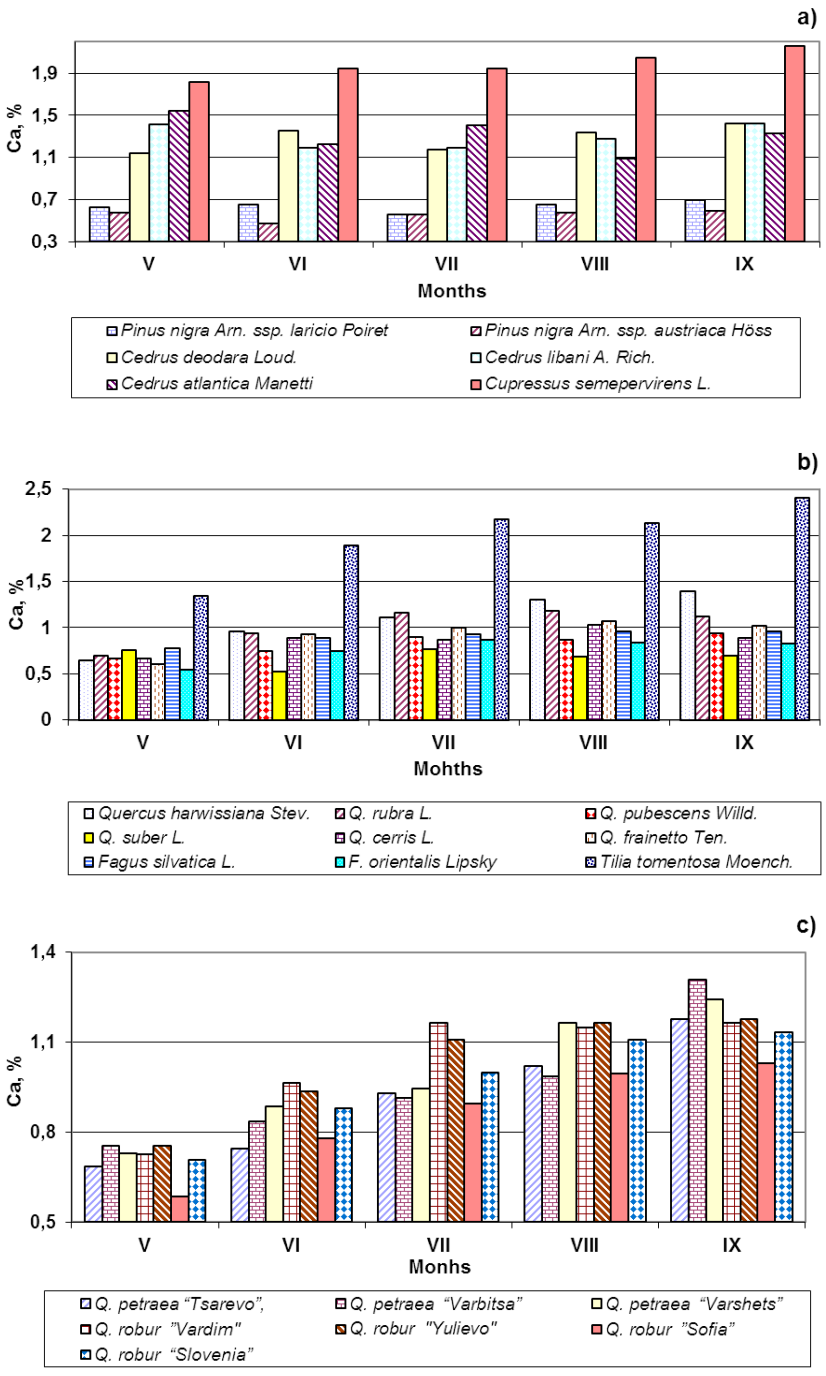

Fig. 6. Dynamics of Ca in the leaves of coniferous (a) and deciduous (b) species and oak provenances (c) during the growing periods 2008–2012 (mean values).

other two Cedar species. The lowest P concentration is detected in Common cypress leaves.

The highest P concentration is detected in Silver linden leaves and in Durmast oak ones ("Varshets" provenance), while the lowest P concentration is in Common oak ("Yulievo" provenance) leaves and Oriental beech ones (Fig. 4).

The differences in P concentration are not great among the single species and origins. According to Pavlova et al. (1995, 2000), there are similar average P concentrations in Sessile oak leaves within the same region.

K con-

centration in the needles of the coniferous species evidences a slight in crease from May to June, with the exception of K concentration in Deodar cedar needles, which is the highest in the beginning of the growing season (Fig. 5a).

In most of the deciduous species, K concentration in the leaves is the highest in the beginning of the growing period, dropping in June and keeping the same values up to the end of the growing season (Fig. 5b).

During that same period, as previously mentioned, regarding N and P content, the average results, obtained in the deciduous species, show that the highest concentration of K is detected in Silver linden leaves, while the lowest one is in Cork oak and Common beech ones. There is a difference of 37.6 %.

In the coniferous species, the lowest K content is detected in Atlas cedar needles: by 17.1 % lower, compared to that one in Deodar cedar leaves. No significant difference exists between Black pine and *Pinus nigra* Arn. spp. *laricio* regarding K concentration in their needles (Fig. 5a).

The differences in K concentration are not great among the origins (Fig. 5c).

Ca and Mg contents in the growing season is characterized by a flu-

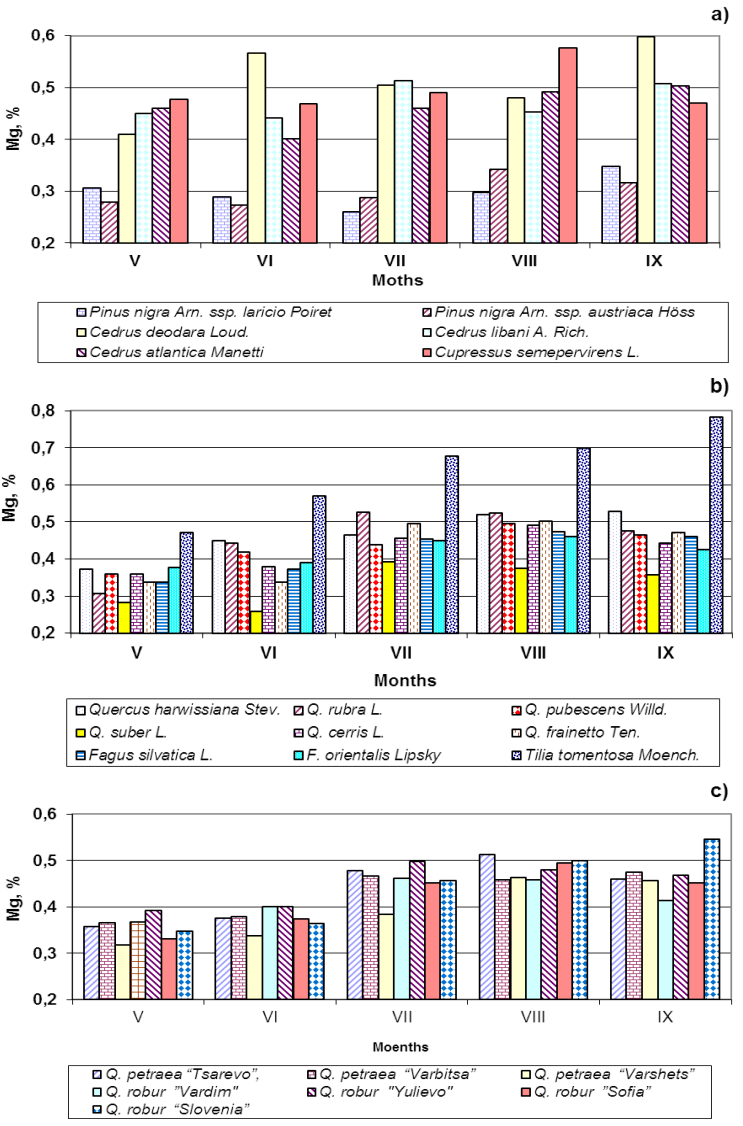

Fig. 7. Dynamics of Mg in the leaves of coniferous (a) and deciduous (b) species and oak provenances (c) during the growing periods 2008–2012 (mean values).

ent increase from the beginning up to the end, more evidently outlined in the deciduous species (Fig. 6a,b,c and 7a,b,c).

The average results show that a very high Ca concentration in Cedars and Common cypress leaves is characteristic in that same season, nearly 2 times higher, compared to that one in Black pine needles (Fig. 6a). It is obviously a characteristic biological particularity.

Ca concentration in silver linden leaves is significantly higher in comparison with that one of the other species, nearly 3 times higher than the concentration in Cork oak leaves (Fig. 6b).

In Cedar needles, Ca and Mg concentration is 1.7 times higher, compared to that one in the needles of Black pine and *Pinus nigra* Arn. spp. *laricio*.

In the deciduous species, Mg concentration is the highest again in Silver linden leaves and the lowest in Cork oak leaves (Fig. 7b).

No significant differences exist in Ca and Mg concentration among the single provenances (Fig. 7c).

Conclusions

Nitrogen content in the leaves of most deciduous species was the highest in May, maintaining comparatively high values in June and gradually lowering in the next months until the end of growing period. P content had its maximum value in the summer months, keeping relatively high values until the end of the growing period. K concentration in the leaves of most species was the highest in August. Ca and Mg content gradually increased from the beginning to the end of the growing period.

N, P and K content in the coniferous species was significantly lower as compared to the one in the leaves of the deciduous species, which makes the latter ones more tolerant to soil fertility.

Of conifers, the lowest concentration of these elements was recorded in the needles of the Atlas cedar. In deciduous species the highest content was measured in *Tilia tomentosa* and *Quercus hartwissiana* and the lowest one – in the leaves of the Cork oak. There were also differences among the provenances within a species.

In Cedar needles, Ca and Mg concentration is 2 times higher, compared to that one in the needles of Black pine and *Pinus nigra* Arn. spp. *laricio*. It is obviously a characteristic biological particularity.

The differences should be considered when modelling nutrient circulation in forest stands and when evaluating the long-term sustainability of forest management.

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