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BIOELEMENT CONTENTS IN THE PLANTING STOCK TISSUES OF NORWAY SPRUCE (*PICEA ABIES* /L./ KARST.) AND EUROPEAN BEECH (*FAGUS SYLVATICA* L.) AFTER EXCESSIVE N AND MG FERTILIZATION

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Abstract

PALÁTOVÁ, E., MAUER, O., LIBUS, J.: *Bioelement contents in the planting stock tissues of Norway spruce (Picea abies /L./ Karst.) and European beech (Fagus sylvatica L.) after excessive N and Mg fertilization*. Acta univ. agric. et silvic. Mendel. Brun., 2008, LVI, No. 1, pp. 259–266

The paper informs of N, P, K, Ca and Mg-contents in the selected organs (tissues) of 4-year old Norway spruce (*Picea abies* /L./ Karst.) and 3-year old European beech (*Fagus sylvatica* L.) transplants after two years of Mg fertilization (100 kg $Mg.ha^{-1}.year^{-1}$) in the form of magnesium sulphate, and N fertilization (100 kg $N.ha^{-1}.year^{-1}$) in the form of ammonium sulphate. Analyses of buds, needles/leaves, bark and wood of above-ground part, fine roots (≤ 1 mm) and small-diameter roots (> 1 mm) showed that the greatest amounts of uptaken nutrients are in both tree species stored in assimilatory organs and in buds. The increased supply of nitrogen showed most in small-diameter roots (spruce), and in root-wood, and wood of stem and branches (beech). The two species responded to the increased supply of magnesium by increasing the bioelement content in root-wood and in fine roots. The increase of Mg-content in leaves occurred only in the second year of the fertilization.

European beech, Norway spruce, transplants, nutrition, needles, buds, wood, roots, nitrogen, magnesium

Adequate supply of nutrients and water in suitable conditions is a basic prerequisite for growth, development and vitality of tree species. One-sidedly high supply of an element may lead to unbalanced nutrition if other nutrients are not available at sufficient amounts. Unequal nutrition is considered by many authors one of reasons to the worsened health condition of forest trees (DIJK and ROELOFS, 1988; GEBAUER and SCHULZE, 1988). Damage to forest stands has been recently put into relation with increased nitrogen depositions and with a reduced content of basic cations namely Mg in the soil environment due to both natural and anthropogenic acidification.

Nitrogen is a basic building stone of aminoacids, nucleic acids, proteins and enzymes. Therefore it is key of importance in the metabolism of plants and cannot be substituted by any other element. Nitrogen deficiency manifests in the changed colour of assimilatory organs, in the decreased production of proteins and in the retarded growth. Increased nitrogen uptake supports vegetative growth, inducing enlargement of assimilatory area and rich green colouration of leaves (BERGMANN, 1983). High content of nitrogen is usually connected with the accumulation of organically fixed soluble nitrogen. This means that a great amount of nitrogen – in spite of being uptaken- cannot be converted into proteinic nitrogen (HEINSDORF, 1991). Nitrogen affects carbon distribution within the plant, synthesis of antibodies and sugar reserves (VOGT et al., 1993). It has an important place among nutrients with respect to its influence on the development of fine roots. Negative relation between soil nitrogen supply and biomass of fine roots was described by many authors

(TÖLLE, 1967; HEINSDORF, 1976; VOGT et al., 1990 and others).

Magnesium intervenes into a range of metabolic processes of plants, too. Its role is important in chlorophyll in which it is fixed in the porphyrin core. According to RYANT et al. (2004), as much as 15–20% of total Mg in the plant is fixed in chlorophyll. Mg deficiency results not only in the reduced content of chlorophyll and carotenoids but also in the changed activity of some enzymes, affecting the retranslocation of assimilates most likely through the collapse of sieve-tubes in the phloem. The result is a reduced growth of roots while the growth of above-ground part remains unchanged (FINK, 1992). It is also an excessively high Mg concentration in the soil that may impair the Ca and Mg balance in the plant. According to BERGMANN and NEUBERT (1976) and ZELENÝ (1993), high Mg concentrations in the soil do harm namely roots due to Ca deficiency.

The nutrition of trees is usually assessed on the basis of element contents in the assimilatory apparatus, which are related to the reference values of various scales for optimum/deficiency contents of individual elements in annual needles or leaves (BERGMANN, 1983; CAPE et al., 1990; GUSSONE et al., 1991). Data on element contents in other organs or tissues are very scarce and were gained in connexion with studying the reasons of Norway spruce decline (OREN et al., 1988; OSONUBI et al., 1988).

The work aims at providing additional data on the organs (tissues) of Norway spruce and European beech transplants, in which the bioelements of nitrogen and magnesium are stored after their increased amounts supplied into the soil.

MATERIAL AND METHODS

The experiment was established with Norway spruce (*Picea abies* /L./ Karst.) 2+0 seedlings and European beech (*Fagus sylvatica* L.) 1+0 seedlings planted into 10-litre plastic containers filled with 9 kg of soil and 2 kg of drainage material at the bottom. A dish to catch seeping irrigation water which was returned back to prevent washout of supplied nutrients was placed under each container.

Contents of available nutrients in the soil for trial establishment were measured in leaches by using the Mehlich III solution. Phosphorus was determined spectrophotometrically as the phosphomolybden blue, potassium by atomic emission spectrophotometry, calcium and magnesium by the method of flame atomic absorption spectrophotometry (ZBÍRAL, 2002). A comparison with the values of available nutrients on natural forest sites indicated (VAVŘÍČEK, 2001) soil of average acidity (pH/KCl = 4.7), low phosphorus content (11 $mg.kg^{-1}$), average potassium content (68 $mg.kg^{-1}$), average magnesium content (53 $mg.kg^{-1}$) and average calcium content (447 $mg.kg^{-1}$). In terms of physical properties the soil in question was sandy loam up to loamy sand of low humus content and lower sorption capacity.

The pot experiment had three variants for each tree species: Control (no fertilization), Nitrogen (100 kg $N.ha^{-1}.year^{-1}$) and Magnesium (100 kg $Mg.ha^{-1}.year^{-1}$). Nitrogen was supplied in the form of ammonium sulphate and magnesium was supplied in the form of magnesium sulphate. The total annual dose of fertilizers was all times split into six doses, which were supplied to soil in 2004 on 24 May, 7 June, 12 July, 28 July and 12 August, and in 2005 on 17 May, 30 May, 15 June, 5 July, 26 July and 11 August. Each variant included 25 plants at the beginning of the experiment which was commenced in the spring of 2004 and ended in the autumn of 2005.

Organs and tissues of Norway spruce and European beech seedlings resp. were analyzed prior to the establishment of the trial and at the end of the1st and 2nd growing periods. In the Norway spruce seedlings separate analyses were made of buds, the 1st and 2nd year of needles, bark and wood of above-ground part, fine roots (≤ 1 mm) and small-diameter roots (> 1 mm). In the European beech seedlings separate analyses were made of buds, bark and wood of above-ground part, root cortex, root-wood and fine roots. The analyses were implemented by standard procedures used in the accredited laboratory in Brno. All above mentioned organs (tissues) were measured for N, P, K, Ca and Mg-contents. Total nitrogen content was established from the mineralizate according to Kjeldahl on the Kjeltec AUTO 1030 Analyzer Tecator (ZBÍRAL, 1994). Plant material samples were mineralized by the wet method in sulphuric acid with the addition of hydrogen peroxide under the catalytic action of selenium. The contents of bioelements were detected by the AES-ICP method with using an optical emission spectrometer with the induction-fixed plasma (ZBÍRAL, 1994).

RESULTS

The comparison of N, P, K, Mg and Ca contents in annual spruce needles with their limit contents (BERGMANN, 1983) corroborated that the spruce seedlings used for the trial establishment were supplied with the optimum contents of all nutrients. The analyses of individual needle years, buds, bark and wood of above-ground part and roots (Tab. I) demonstrated that seedlings with the optimum nutrition exhibited at the beginning of the growing season the highest contents of studied bioelements in buds (N) and in the2nd needle year-class (P, K, Ca, Mg).

Fertilization with ammonium sulphate (var. Nitrogen) and magnesium sulphate (var. Magnesium) during the 1st growing season increased the content of both elements in organs (tissues) of the transplants (Tab. II). The content of nitrogen increased very markedly in the 1st and 2nd needle-years but the relatively greatest increase was recorded in small-diameter roots. After the second growing season in which the spruce transplants were supplied an increased amount of nitrogen, the element content in all monitored parts of the plants further increased with a relatively greatest increase being found in small-diameter roots and in the wood of above-ground part (Tab. III).

In the first year of the experiment the spruce transplants responded to the increased magnesium supply only by an increased content of this element in the wood of above-ground part and in fine roots. Only after the second year of Mg fertilization an increase of about 50% was recorded in the last needle-year. A much more pronounced (more than double) increase of its content was however recorded in fine roots, in small-diameter roots and in the wood of above-ground part (Tab. III).

The analysis of dormant beech seedlings at the beginning of the experiment revealed that the highest deposits of all macrobioelements were stored in fine roots (N, P, K, Mg). An exception was Ca that was in considerable amounts detected in the root cortex and in the bark of stem and branches (Tab. IV).

Nitrogen fertilization (var. Nitrogen) showed in an increased content of this element in all analyzed beech transplants – most in root-wood and in the wood of stem and branches while the increase of its content in leaves was considerably lower (Tab. V). After the second year of N fertilization, the bioelement content in root-wood as well as in the wood of stem and branches and in the root cortex of beech transplants further grew. The relative increase in leaves was less significant as compared with that recorded in root-wood (Tab. VI).

Towards the end of the first growing season the fertilization with magnesium showed in an increased content of this bioelement in fine roots and in the wood of roots with the increase of Mg content in leaves being relatively smaller similarly as in the case of nitrogen (Tab. V). The fertilization induced a significantly increase Mg-content in leaves only after the second year; however, a relatively comparable increase was recorded also in fine roots, root-wood and root cortex (Tab. VI).

I: *Bioelement contents in the dry matter of individual organs and tissues of Norway spruce seedlings at the beginning of the experiment (Spring 2004)*

Organ (tissue)	Bioelement content in dry matter				
	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Fine roots	0.98	0.19	0.44	0.71	0.11
Small-diameter roots	0.36	0.09	0.30	0.32	0.07
Bark of above-ground part	1.13	0.19	0.65	0.61	0.12
Wood of above-ground part	0.53	0.10	0.35	0.17	0.05
1st needle year-class	1.34	0.21	0.70	0.74	0.11
2nd needle year-class	1.31	0.43	0.88	1.27	0.20
Buds	2.12	0.36	0.78	0.56	0.15

II: *Bioelement contents in the dry matter of individual organs and tissues of Norway spruce transplants (Autumn 2004)*

Variant	Bioelement contents in dry matter														
	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium
Fine roots	1.07	1.64	1.03	0.10	0.10	0.09	0.09	0.61	0.60	0.32	0.27	0.24	0.09	0.05	0.12
Small-diam. roots	0.42	1.08	0.44	0.03	0.05	0.03	0.20	0.30	0.30	0.25	0.22	0.22	0.05	0.04	0.06
AGP* bark	0.81	1.31	0.72	0.06	0.07	0.05	0.45	0.56	0.62	0.60	0.59	0.65	0.09	0.09	0.11
AGP* wood	0.50	0.55	0.38	0.03	0.03	0.03	0.21	0.36	0.44	0.21	0.16	0.19	0.04	0.05	0.08
1st year needles	1.43	2.74	1.44	0.07	0.07	0.07	0.73	0.71	0.85	0.64	0.69	0.61	0.17	0.17	0.18
2nd year needles	1.21	2.29	1.13	0.08	0.07	0.07	0.71	0.75	1.04	0.95	0.91	1.00	0.16	0.14	0.16
Buds	1.34	1.62	1.23	0.16	0.17	0.14	0.60	1.03	1.02	0.33	0.37	0.40	0.13	0.12	0.13

*AGP – above-ground part

III: Bioelement contents in the dry matter of individual organs and tissues of Norway spruce transplants (Autumn 2005)

Variant	Bioelement contents in dry matter														
	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium
Fine roots	1.01	1.87	0.87	0.08	0.09	0.08	0.37	0.30	0.45	0.38	0.50	0.36	0.04	0.04	0.14
Small-diam. roots	0.45	1.08	0.40	0.03	0.04	0.04	0.19	0.16	0.22	0.25	0.37	0.26	0.03	0.04	0.07
AGP* bark	0.99	1.95	0.90	0.06	0.05	0.07	0.46	0.39	0.43	0.59	0.59	0.69	0.10	0.10	0.15
AGP* wood	0.41	0.89	0.41	0.04	0.03	0.04	0.26	0.22	0.40	0.20	0.26	0.18	0.05	0.05	0.12
1st year needles	1.98	3.33	1.73	0.09	0.08	0.08	0.56	0.59	0.51	0.80	0.71	0.66	0.13	0.13	0.20
2nd year needles	not measured														
Buds	1.51	1.24	1.34	0.14	0.15	0.15	0.71	1.01	0.74	0.31	0.40	0.27	0.09	0.20	0.15

*AGP – above-ground part

IV: *Bioelement contents in the dry matter of individual organs and tissues of European beech seedlings at the beginning of the experiment (Spring 2004)*

Organ (tissue)	Bioelement contents in dry matter				
	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Fine roots	1.74	0.23	0.70	0.60	0.19
Root-wood	1.32	0.15	0.27	0.10	0.14
Root cortex	1.19	0.10	0.60	2.45	0.15
Stem and branch wood	1.06	0.09	0.31	0.14	0.11
Stem and branch bark	1.31	0.10	0.46	2.55	0.15
Buds	1.24	0.16	0.41	0.55	0.12

V: *Bioelement contents in the dry matter of individual organs and tissues of European beech transplants (Autumn 2004)*

Variant	Bioelement contents in dry matter														
	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium
Fine roots	0.68	1.06	0.86	0.06	0.07	0.07	0.46	0.55	0.60	0.26	0.29	0.28	0.10	0.14	0.17
Root-wood	0.30	0.79	0.50	0.03	0.03	0.06	0.35	0.23	0.32	0.12	0.13	0.14	0.07	0.06	0.10
Root cortex	0.71	1.18	0.80	0.05	0.05	0.05	0.48	0.40	0.50	2.21	2.79	2.97	0.11	0.10	0.15
Stem and branch wood	0.48	1.16	0.36	0.05	0.09	0.05	0.28	0.22	0.27	0.33	0.33	0.28	0.05	0.07	0.07
Stem and branch bark	0.83	1.10	0.83	0.05	0.05	0.05	0.31	0.28	0.35	1.66	1.98	1.61	0.07	0.08	0.08
Buds	0.98	1.08	1.19	0.11	0.10	0.11	0.47	0.64	0.52	0.43	0.38	0.40	0.11	0.10	0.13
Leaves	1.44	2.12	1.58	0.09	0.09	0.09	0.44	0.52	0.47	1.23	1.15	1.20	0.20	0.19	0.23

VI: *Bioelement contents in the dry matter of individual organs and tissues of European beech transplants (Autumn 2005)*

Variant	Bioelement contents in dry matter														
	N (%)			P (%)			K (%)			Ca (%)			Mg (%)		
	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium	Control	Nitrogen	Magnesium
Fine roots	0.76	1.26	0.71	0.05	0.06	0.05	0.29	0.39	0.39	0.31	0.24	0.25	0.06	0.11	0.13
Root-wood	0.42	1.27	0.31	0.02	0.03	0.03	0.21	0.25	0.25	0.20	0.19	0.19	0.05	0.08	0.12
Root cortex	0.64	1.32	0.61	0.03	0.05	0.03	0.37	0.35	0.35	1.15	1.90	1.47	0.07	0.13	0.15
Stem and branch wood	0.26	0.59	0.27	0.02	0.02	0.03	0.22	0.29	0.23	0.23	0.20	0.19	0.05	0.07	0.10
Stem and branch bark	0.85	1.14	0.76	0.03	0.04	0.04	0.27	0.24	0.27	1.98	2.13	1.88	0.08	0.11	0.15
Buds	1.11	1.36	1.32	0.09	0.11	0.12	0.56	0.73	0.62	0.60	0.41	0.53	0.12	0.13	0.18
Leaves	1.31	2.24	1.40	0.06	0.07	0.06	0.45	0.47	0.56	0.70	0.76	1.00	0.13	0.19	0.30

DISCUSSION

A precondition for the successful growth and good health condition of tree species is a sufficient supply of all basic bioelements. The supply depends on the content of available nutrients in the soil, which is above all predetermined by the character of soil-forming material but may change due to fertilization or anthropogenic deposition. Those processes may improve the nutrition status or they may conversely provoke imbalance of nutrients that would result in metabolic changes and even in growth disorders. The supply of individual nutrients to trees is determined from their contents in annual needles or foliage. Nevertheless, it is well known from literature that plants do not respond to fertilization with some elements immediately by increasing their contents in assimilatory organs. Therefore a question comes along whether the increased uptake of some nutrients can be detected before it shows in leaves or needles, and in what plant organs or tissues the elements accumulate at higher amounts.

Reason being the ever increasing depositions of nitrogen compounds, we studied the response of spruce and beech transplants on an increased amount of nitrogen which was supplied in the form of ammonium sulphate because according to some authors (AARNES et al., 1995) conifers prefer a reduced (ammonium) form of nitrogen. Moreover, supplying nitrogen in this form increases the probability of an earlier "saturation" of the plant with the bioelement. Magnesium is one of elements washed out from the soil in consequence of acidification and trees suffer from its deficiency. Acute symptoms of magnesium deficiency can be eliminated by fertilizers of different chemical fixation and solubility (HÜTTL and SCHAAF, 1997). Salts of $MgSO_4$ are soluble most and their application is therefore recommended if a Mg deficiency demonstrated by leaf analyses calls for a fast solution (HORN et al., 1987). In order to achieve a rapidly increased Mg uptake we used this type of fertilizer in our experiment.

Spruce transplants in our experiment responded to nitrogen fertilization by increasing the content of this element in all analyzed organs/tissues with the N content in needles being increased in the first year nearly to a double (from 1.43% to 2.74%) but a relatively higher increase of its content was recorded in small-diameter roots (from 0.42% to 1.08%, i.e. by 157%). In the following growing season the nitrogen fertilization increased the N content in needles to 3.33%; however, a relatively greater N-content increase was again found in small-diameter roots and in the wood of above-ground part. Similarly, the N-content in European beech leaves increased after the 1st and 2nd year of fertilization but a relatively greater part of the uptaken N was accumulated in root-wood and in the wood of stem and branches. The immediate increase of N-content in needles after the fertilization is not in compliance with data published for example by HOFFMANN et al. (1990) who found in a trial with pine in the first year only an insignificant increase of N-content in needles (from 1.4% to 1.5%) regardless of supplied N dose, and recorded an increase to 2.0% only in the third year. A similar dynamics of the gradually rising N-content in needles was described in pine also by KRAUSS (1965) and FIEDLER and HÖHNE (1965). A slowly increasing N-content in all needle year-classes after the repeated supply of ammonium sulphate at 100 kg $N.ha^{-1}.year^{-1}$ was observed in spruce also by NILSSON and WIKLUND (1994). The differences may result from the varied age of the analyzed experimental material as the authors analyzed needles originating from older stands.

The increased nitrogen uptake influenced the uptake of other bioelements. The variant with nitrogen fertilization showed a decreased phosphorus content after the second growing period, which corresponds with the findings of FIEDLER and HÖHNE (1965). The authors observed the nitrogen fertilization to have suppressed the phosphorus content in the first year, which however later increased in the course of the experiment. With respect to the end of our trial we could not confirm the trend but it can be expected that it would not have shown as the used soil had a very low P-content. Also, PAHLSSON and BALSBERG-PAHLSSON (1992) recorded a decreased P-content in the leaves of beech trees fertilized with nitrogen. Neither this finding was corroborated in our experiment. As compared with the nitrate nitrogen a high uptake of ammonium nitrogen suppressed the uptake of cations, namely Ca and Mg, its effect on them being antagonistic (LIU and HÜTTL, 1991). The ammonium form of nitrogen is suppressing also the potassium resorption and the N-fertilization induces a K-deficiency in needles (LUNDBERG and RAVNSBAEK, 1992). Although we cannot corroborate the finding (the K-content in needles did not change essentially after the two years of fertilization), a mild decrease was recorded of its content in other analyzed parts of transplants (with an exception of buds) – see Table III.

The level of magnesium nutrition is assessed by the bioelement content in needles. Analyses of other tissues were made seldom and at all times in connection with the decline of spruce trees related to imbalanced mineral nutrition. Having compared the healthy spruce trees and the spruce trees exhibiting damage symptoms ZÖTTL (1985) detected Mg-content differences between the youngest needles of healthy and damaged trees while the Mg-contents in fine roots did not show the differences. More detailed analyses of the respective tissues and organs in damaged and healthy spruce trees were made by OREN et al. (1988) who concluded that the Mg-content is subject to fluctuation during the growing season and that greatest variances between healthy and damaged trees occur in needles and branches, and less in stem bark while the Mg-contents in stem wood and in fine roots do not differ. If the Mg-contents in plant organs and tissues analyzed by us are compared with the data reported by OREN et al. (1988) for healthy trees, they are very similar except for needles in which we found a higher content. In our experiment the Mg-content in needles of the 1st and 2nd year-class remained nearly unchanged after the 1st year of fertilization while HORN et al. (1987) detected after $MgSO_4$ application a Mg-content in needles of the last year-class increased by 65% as compared with the unfertilized control. In our experiment, however, an expressive Mg-content increase occurred in fine roots, small-diameter roots and in the wood of above-ground part. This might have been caused by a good Mg supply to our transplants (0.13% Mg in annual needles), which suggests that the Mg reserve in the plant is likely to exceed the actual requirement.

The obtained results indicate that an increased nitrogen uptake or an excessive magnesium fertilization show particularly in roots and in the wood of above-ground part. The use of the analyses of these organs or tissues for the detection of incipient deposition is however much more labourious than the sampling of needles or leaves and their use is connected with some methodological problems, too. Furthermore, it would call for a scale of the sufficient content that may differ for young and mature trees.

SUMMARY

The assessment of tree species nutrition status dwells on the contents of individual bioelements in annual needles or leaves which were to be compared with the scales of optimal bioelement contents published by various authors. In some cases, the tree species did not respond to the supply of nutrients through fertilization or to the anthropogenic deposition by an immediate increase of the bioelement in their assimilatory apparatus. The goal of this work was therefore to find out what organs or tissues of Norway spruce (*Picea abies* /L./ Karst.) and European beech (*Fagus sylvatica* L.) preferrably deposit nitrogen and magnesium uptaken by the plant.

Norway spruce seedlings aged 2 years and 1-year old seedlings of European beech planted into containers filled with soil from the forest stand were fertilized 2 years with nitrogen (100 kg $N.ha^{-1}.year^{-1}$) in the form of ammonium sulphate or with magnesium (100 kg $Mg.ha^{-1}.year^{-1}$) in the form of magnesium sulphate. The total annual fertilization dose was broken down to 6 parts to be supplied into the soil at regular intervals from mid-May to mid-August. The N, P, K, Ca and Mg contents in buds, needles or leaves, bark and wood of above-ground part, fine roots (roots up to a diameter of 1 mm) and low-diameter roots (roots of a diameter larger than 1 mm) were measured at the beginning of the experiment and at the end of the first and the second growing period.

Results revealed by the analyses are as follows:

- The highest amounts of Mg, P, K and Ca recorded in 2-year dormant spruce seedlings with an optimum supply of nutrients were stored in the 2nd needle year-class. The highest N content was recorded in buds.
- The highest N, P, K and Mg-contents recorded in 1-year dormant (leafless) beech seedlings were in fine roots. The highest Ca content was found in the bark of stem and branches.
- Fertilization of Norway spruce transplants with nitrogen induced after two years an increased N-content in small-diameter roots (by 140%) and in the wood of above-ground part (by 117%) while the bioelement content in needles was only 68% as compared with the control.
- Fertilization of Norway spruce transplants with magnesium increased after two years the bioelement content most in fine roots (by 250%), small-diameter roots (by 130%) and in the wood of above-ground part (by 140%) as compared with the control.
- Fertilization of European beech transplants with nitrogen induced an increased bioelement content in root-wood (by 200%) and in the wood of stem and branches (by 120%) with the increase in leaves being ca. 70% as compared with the control.

- Fertilization of European beech transplants with magnesium increased the bioelement content in root-wood (by 140%), in leaves (by 130%) and in fine roots (by 117%) as compared with the control.

Results from the analyses of roots, root-wood and above-ground part wood can provide an information about an incipient saturation of the plant with nitrogen or excessive fertilization with magnesium earlier than those from the analyses of leaves. Considering its labouriousness and the absence of the knowledge about the level of N- and Mg-contents in these parts of the plant, the procedure cannot be however so far recommended for practical use.

SOUHRN

Obsah vybraných biogenních prvků v pletivech sazenic smrku ztepilého (*Picea abies* /L./ Karst.) a buku lesního (*Fagus sylvatica* L.) po hnojení dusíkem a hořčíkem

Při posuzování stavu výživy dřevin se vychází z obsahů jednotlivých prvků v jednoletých jehlicích nebo listech, které se srovnávají se stupnicemi optimálního obsahu prvků, zveřejněných různými autory. Na dodávku živin hnojením nebo v důsledku antropogenní depozice dřeviny v některých případech nereagují bezprostředně zvýšením obsahu prvku v asimilačních orgánech. Cílem práce bylo proto zjistit, ve kterých orgánech nebo pletivech smrku ztepilého (*Picea abies* /L./ Karst.) a buku lesního (*Fagus sylvatica* L.) se ukládá přednostně dusík a hořčík přijatý rostlinou.
Dvouleté semenáčky smrku a jednoleté semenáčky buku, které byly vysázeny do nádob naplněných zeminou z lesního porostu, byly dva roky hnojeny dusíkem (100 kg N.ha^{-1}.rok^{-1}) ve formě síranu amonného nebo hořčíkem (100 kg Mg.ha^{-1}.rok^{-1}) ve formě síranu hořečnatého. Celková roční dávka hnojiv byla rozpočítána na šest dílů, které byly do půdy dodávány v pravidelných intervalech od poloviny května do poloviny srpna. Na počátku experimentu a na konci první a druhé vegetační periody byl zjišťován obsah N, P, K, Ca a Mg v pupenech, jehlicích, resp. listech, kůře a dřevě nadzemní části, jemných kořenech (kořeny do průměru 1 mm) a slabých kořenech (kořeny o průměru větším než 1 mm). Z analýz vyplynulo, že:

- ve dvouletých dormantních semenáčcích smrku optimálně zásobených živinami bylo největší množství Mg, P, K a Ca uloženo v jehlicích druhého ročníku, největší obsah N byl zjištěn v pupenech,
- v jednoletých dormantních (bezlistých) semenáčcích buku byl zjištěn nejvyšší obsah N, P, K a Mg v jemných kořenech, nejvyšší obsah Ca byl zjištěn v kůře kmínku a větví,
- hnojení smrkových sazenic dusíkem vyvolalo po dvou letech zvýšení obsahu N ve slabých kořenech (o 140 %) a dřevě nadzemní části (o 117 %), zatímco nárůst jeho obsahu v jehlicích činil pouze 68 % oproti kontrole,
- hnojení smrkových sazenic hořčíkem zvýšilo po dvou letech jeho obsah nejvíce v jemných kořenech (o 250 %), slabých kořenech (o 130 %) a dřevě nadzemní částí (o 140 %) oproti kontrole,
- hnojení bukových sazenic dusíkem vyvolalo nárůst jeho obsahu ve dřevě kořenů (o 200 %) a dřevě kmínku a větví (o 120 %), nárůst v listech byl pouze cca 70 % oproti kontrole,
- hnojení bukových sazenic hořčíkem zvýšilo jeho obsah ve dřevě kořenů (o 140 %), v listech (o 130 %) a jemných kořenech (o 117 %) oproti kontrole.

Výsledky analýz kořenů, resp. dřeva kořenů a dřeva nadzemní části mohou informovat o počínajícím nasycování rostliny dusíkem nebo hořčíkem dříve než analýza listů. Vzhledem k vysoké pracnosti a absenci znalosti optimálního obsahu N a Mg v těchto částech rostliny nelze však zatím postup doporučit k praktickému využití.

buk lesní, smrk ztepilý, sazenice, výživa, jehlice, pupeny, dřevo, kořeny, dusík, hořčík

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