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Original Article

Mineral Substances in Stem Wood Tissue of European Beech (*Fagus sylvatica* L.)

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Abstract

Mineral substance concentration was studied in stem wood tissue of European beech in different populations. Elemental analysis and atomic absorption spectrophotometry (AAS) techniques were applied for quantitative determination of mineral elements. The results indicate similar macro nutrient content in wood samples, except Ca. Comparisons with similar studies on European beech stem wood macro nutrient content provided similar values.

Keywords: *Fagus sylvatica L.*, mineral substance, stem wood tissue

1. Introduction

European beech is adapted to a wide range of soil types and site conditions but has its ecological optimum on well-drained, moderately fertile soil with pH 5.2 - 6.8.

The concentration level of minerals in trees depends on several factors. Trees are receiving the micro- and macro- nutrients from air, water and soil. The quantity of mineral elements in wood depends on the species, age, tree section and growth condition, especially forest soil influences the mineral uptake of trees through root systems [12, 18]. Minerals play an important role in trees metabolism and could influence the increase in timber volume substantially. Several investigation on mineral budget of European beech wood tissue have been carried out [2, 3, 5, 7, 8, 9, 10, 13].

Investigation on stem wood mineral content shows that 80 % of inorganic content is made up by potassium, calcium and magnesium while half of this quantity was made up by calcium. The variation of stem wood mineral content could be explained by seasonal changes [6] and water consumption too [1]. The mobility of mineral elements also could have influence on the trees mineral budget. Mobile nutrients like N, P, K, Cl, Mg, Mo are able to move from older plant parts to younger ones to supplement deficiencies while immobile elements like B, Ca, Cu, Fe, Mn, Ni, S, Zn are not able at all or to move quick [18].

The aim of this paper is to present a survey on the chemical composition of stem wood in different *Fagus sylvatica* L. stands from the Romanian Carpathians.

2. Material and Method

The research was carried out in four adult beech stands (Table 1). For stem wood nutrient analysis five trees have been sampled in each

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studied stand. 15 cm long, wood tissue samples were taken from the trunk with an increment borer at 1.3 m height.

Samples were frozen at -20 ^{0}C until analysis and were dried at 40 ^{0}C one week before grounding the material to wood meal. From plant material 0,1 g was digested in 5 cm^3 concentrated HNO_3 on high pressure in Microwave Digestion System (MDS 2000).

Wood samples were analyzed without bark. Carbon (C) and nitrogen (N) were determinate by CHNS-O Analysis on EA3000 Elemental Analyser. 2-6 mg of dried plant material were packed in stannic capsule and burned on 1000 °C while C and N concentration in gas was measured by special detector and compared with standard samples. Phosphorus (P) was determined spectrophotometrically.

Table 1. Stand characteristics of studied sites

No.	Site	Sample	Location	Elevation (m a.s.l.)	Mena annual precipitation (mm)	Mean annual temperature (°C)	Soil
1	Feldru	Stem wood	N47°30` E24°45	1200	1000-1330	5	Dystric Cambisol
2	Sovata		N46°38` E25°07	850	800-1100	8	Eutric Cambisol
3	Braşov		N45°30` E25°51	1000	900-1150	7.7	Eutric Cambisol
4	Ciucea		N46°59` E22°55	620	800-900	8	Eutric Cambisol

Concentration of P was measured in diluted solutions on 660 nm. To the determinations of calcium (Ca), magnesium (Mg) and potassium (K) concentration in samples was used Atomic Absorption Flame Emission Spectrophotometer (Shimadzu AA6601F).

Concentration of Ca, Mg and K was measured in 10 ml digested solution. Mg concentration was measured on 285.2 nm, Ca on 422.7 nm and K on 766.5 nm.

The results are average values of individual measurement and they are expressed in mg g^{-1} for N, P, K, Ca and Mg in g 100g $^{-1}$ for C. For statistical analysis R Statistical Program was used. The measurements were taken in Ecology Laboratory of Hungarian Forest Research Institute.

3. Results and discussions

In European beech wood tissue (Table 2), N concentration showed almost significant difference between the stands (Kruskal-Wallis chi-squared = 7.27, df = 3, p = 0.063), although higher average N concentration was recorded in Feldru. Stem wood P content was almost equal in each stand, with lower average P concentration in Ciucea. K concentration was similar in each stand, although highest average K content was measured at Ciucea.

Table 2. Nutrient concentration in stem wood of *Fagus sylvatica*

Stem wood nutrient concetrations								
mg g^{-1}	Feldru		Sovata		Braşov		Ciucea	
	Mean ± sd	Range (min-max)	Mean ± sd	Range (min-max)	Mean ± sd	Range (min-max)	Mean ± sd	Range (min-max)
N	1,20±0,12	0,90-1,40	0,94±0,13	0,80-1,10	1,08±0,21	1,00-1,30	0,88±0,20	0,70-1,10
P	0,09±0,04	0,05-0,14	0,09±0,02	0,06-0,12	0,08±0,01	0,05-0,10	0,06±0,008	0,05-0,07
K	0,95±0,16	0,71-1,15	1,13±0,54	0,55-1,80	1,04±0,33	0,51-1,42	1,33±0,50	0,95-2,03
Ca	1,82±0,48	1,55-2,68	1,20±0,28	0,88-1,54	1,43±0,49	1,07-2,29	1,11±0,37	0,80-1,75
Mg	0,31±0,09	0,22-0,45	0,20±0,08	0,10-0,32	0,17±0,04	0,12-0,23	0,21±0,09	0,11-0,33

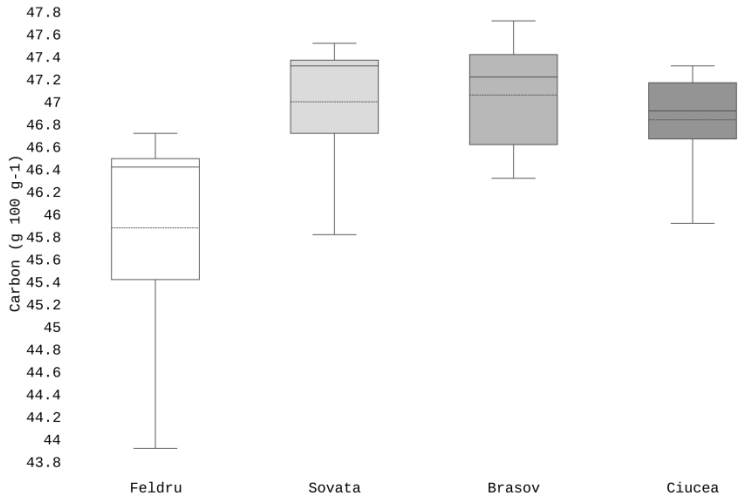

Figure 1. Mean carbon content in stem wood of European beech (--- average,─ median)

In each stand the mean K content was smaller compared to mean Ca content, exception at Ciucea.

There was a significant difference in Ca concentration between the four European beech stand (Kruskal-Wallis chi-squared =7.81, df=3, $p<0.05$*).

The highest Ca concentration was registered at Feldru. Stem wood Mg content showed similar, optimum values in each stand, although highest mean Mg content was recorded at Feldru. Analysis of carbon content in stem wood showed non-significant differences between the stands. Stem wood carbon content was the lowest in stand Feldru (Fig. 1) [19].It was found mutual correlation with *r* higher or equal to ±0.5 in beech stem wood for N-Ca and Mg-Ca element pairs (Table 3).

Significant correlation between nitrogen and calcium content in beech stem wood is presented in Fig. 2. It was found also a significant correlation between magnesium and calcium concentration (Fig. 3). Linear regression model is presented in Table 4.

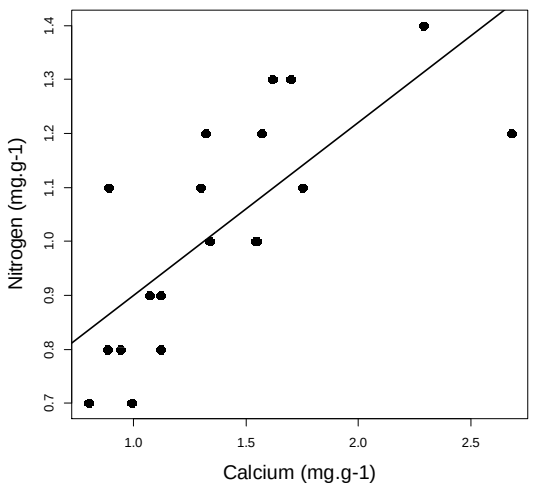

Figure 2. Correlation between Ca and N in stem wood

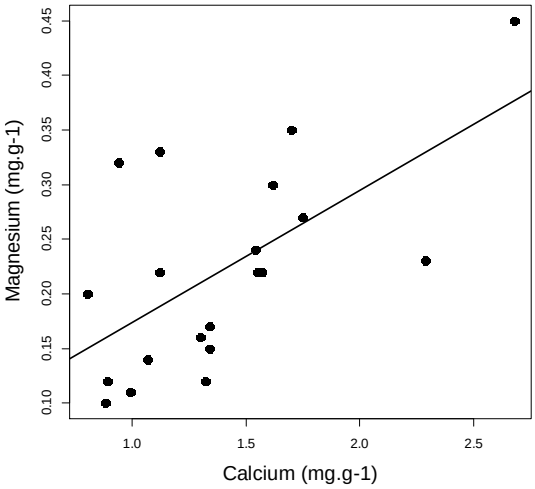

Figure 3. Correlation between Mg and Ca content in stem wood

To investigate possible element limitations, element ratios were analyzed for P, K, Ca and Mg versus N, Ca and Mg versus K and Ca versus Mg (Table 5).

Nutrient ratios can show if tree nutrition is unbalanced. Stem wood element ratio is presented informatively in tab. 5, while no ratio limits were found for stem wood nutrient content.

Table 3. Pearson correlation between elements in stem wood of *Fagus sylvatica*. Bold marked correlations are significant.

	Stem wood tissue				
Element	N	P	K	Ca	Mg
N	-				
P	0.252	-			
K	-0.180	0.096	-		
Ca	**0.743**	0.427	0.040	-	
Mg	0.304	0.353	0.407	**0.616**	-

Table 4. Linear regression model for the correlated element pairs

	Estimated Coeficient	Standard error of the Coef. Estimate	t-value	Significance level	Linear regression model
Intercept	0.580	0.099	5.851	p<0.001***	N=0.58+0.319Ca
Ca	0.319	0.067	4.722	p<0.001***	
Intercept	0.694	0.226	3.065	p<0.01**	Ca=0.694+3.15Mg
Mg	3.150	0.947	3.325	p<0.01**	

Table 5. Ratio of element in stem wood of European Beech in study sites

Element ratio	**Stem wood**			
	Feldru	Sovata	Brasov	Ciucea
N/P	15.76±7.23	11.57±3.12	15.17±5.78	15.53±4.67
N/K	1.30±0.31	1.02±0.48	1.19±0.68	0.71±0.26
N/Ca	0.68±0.14	0.80±0.10	0.78±0.11	0.83±0.24
N/Mg	4.14±1.03	5.48±2.18	6.65±2.12	5.10±2.68
K/Ca	0.54±0.14	0.97±0.56	0.79±0.37	1.19±0.20
K/Mg	3.36±1.31	5.64±1.21	6.09±1.51	6.89±1.83
Ca/Mg	6.07±1.00	6.83±2.34	8.52±2.28	6.05±2.34

Nutrient analysis on wood tissue reflects the macro nutrient accumulation in long time. It is demonstrated that mineral element concentration in plant tissue depends on its availability in soil.

In our study all stands has Cambisol as main soil type, which might explain from one hand the obtained similar results. On the other hand our measurements were taken on one species and it is demonstrated that mineral content is unique for every species apart [7, 8, 9, 11].

Similar content of C, N, P, K and Mg is revealed between the studied stands in stem wood tissues but we obtained significant difference between the sites in Ca content. The significant difference in Ca content could be explained with the different soil subtype. The highest Ca, Mg and N concentration was registered at Feldru. The measured mineral concentration could explain by the characteristics of Dystric Cambisol.

These soils are well supplied with total nitrogen, weak-moderate supplied with phosphorus and are poor in assimilable potassium. The highest P and K concentration was registered at Ciucea.

The measured values could explain by the characteristic of Eutric Cambisol which in terms of available phosphorus and potassium is middle supplied [14].

Stand composition could influence also the nutrient supply because in mixed stands the coexisting species could change soil reaction and indirectly influence the nutrient supply. At Braşov and Sovata we have pure European beech stands. We have a mixed European beech stand with *Quercus petreae* and *Carpinus betulus* at Ciucea and a mixed stand with *Picea abies*, *Abies alba* and *Acer pseudoplatanus* at Feldru.

Berger et al. [4] showed that acidification caused by spruce in mixed stands mobilizes cations and could increase Ca stem wood concentrations in European beech.

The contents of N, P, K, Ca and Mg in stem wood tissue correspond to the results published by

Hagen-Thorn et al. [8], and similar results were published by Penninckx et al. [15], Srámek et al. [17], and Meerts [11], for macro nutrient concentration in beech wood.

4. Conclusions

This stdudy has shown similarities in micronutrient concentration between forests growing on the same main soil type.

These similarities could be explained by similar soil reaction, similar stand age and stand structure.

These mineral content values must be considered when defining optimum levels in biomass of European beech and could be used for environmental monitoring.

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