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Original Article

Mineral Substances in Foliar Tissue of European Beech

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Abstract

Mineral substance concentration was studied in foliar 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 leaves but it was registered element surplus in some cases. Macro nutrient content of foliar samples is optimal, except K and partially the P content. The findings are similar with other studies based on foliar macro nutrient content for European beech.

Keywords: European beech, mineral substance, foliar tissue.

1. Introduction

European beech is a well distributed forest species in Romania. It is adapted to a wide range of site conditions. Investigation on foliar mineral content could serve with information about air-pollution status of the region [8, 9]. Trees are receiving the micro- and macro- nutrients from air, water and soil. Especially soil influences the mineral uptake of trees through root systems [15].

Minerals play an important role in plant metabolism while nutrient deficiencies could cause growth reductions, chlorosis, necrosis and susceptibility to diseases [5]. Every part of the tree has different mineral element content but it is demonstrated that leaves has the highest mineral content compared with other tree organs [1, 2, 3, 6, 7, 11].

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The aim of this paper is to present a survey on the chemical composition of foliar tissue in different European beech stands from the Romanian Carpathians.

2. Material and Method

The research was carried out in four adult beech stands (Table 1). Foliar samples were collected manually from four trees per site. The results are average values of individual measurement and they are expressed in mg g^{-1} for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and in g 100g $^{-1}$ for carbon (C).

Samples were frozen at -20 ^{0}C until analysis and were dried at 40 ^{0}C one week before grounding the material. Plant material of 0.1 g was digested in 5 cm^3 concentrated HNO_3 on high pressure in Microwave Digestion System (MDS 2000). Determination of Ca, Mg and K concentration in the obtained digested solution was carried out with Atomic Absorption Flame Emission Spectrophotometer (Shimadzu AA6601F).

Table 1. Stand characteristics of studied sites.

No.	Site	Sample	Location	Elevation (m a.s.l.)	Annual precipitation (mm)	Mean annual temperature (°C)	Soil
1	Răștolița	Leaves	N46°56´ E24°59`	530	950-1200	7	Eutric Cambisol
2	Lăpușna		N46°46` E25°11`	1050	1100-1250	5	Andic dystric Cambisol
3	Câmpu Cetății		N46°42´ E25°40`	565	750-950	7.6	Eutric Cambisol
4	Făgetul Clujului		N46°43´ E23°35´	615	590-663	8	Luvisol

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.

Concentration of P was determined spectrophotometrically in diluted solution on 660 nm. C and N were determinate by CHNS-O Analysis on EA3000 Elemental Analyser. From the grounded dried plant material 2-6 mg 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.

For statistical analysis R Statistical Program was used. The measurements were taken in Ecology Laboratory of Hungarian Forest Research Institute.

The obtained mineral content values and element ratios in leaves were compared with limits of mineral element in foliage (Table 2) and limits of element ratios in foliage (Table 6) defined for European beech by Stefan et. al. [13].

3. Results and discussions

Foliar analysis in European beech leaves (Table 3), showed low N content variation between the sites. Foliar concentrations of N were highest at Răștolița and Lăpușna showing a surplus in N content (N surplus >25 mg g^{-1}, [13]). Foliar concentration of P showed low variation between the sites, although a slightly surplus in foliar P concentration were recorded at Răștolița and Câmpul Cetății, according to Stefan et al. [13] (P surplus >1.7 mg g^{-1}).

There was non-significant differences in foliar K concentration between the sites, in all populations were recorded optimal foliar K concentration (optimal K 5-10 mg g^{-1}).

Foliar concentration of Ca showed non-significant differences between the sites, although highest Ca concentration was recorded at Câmpu Cetății without to exceed the optimum Ca content interval 3-10 mg g^{-1}. Foliar concentration of Mg showed non-significant differences between the sites, although supra-optimum foliar Mg concentration was registered at Câmpu Cetății, Făgetul Clujului and Lăpușna. According to our results, there were non-significant differences in macro element content in foliar tissue between the studied stands. Analysis of foliar carbon content showed non-significant differences in carbon content, while foliar carbon concentration was the highest at Răștolița (Table 2).

Table 2. Classification of the macronutrient content in foliage for *Fagus sylvatica*, according to Stefan et al. [13]

Class Limit	N	P	K	Ca	Mg
Deficit	≤18	≤1	≤5	≤4	≤1
Optimum	18-25	1-1.7	5-10	4-8	1-1.5
Supra-optimum	>25	>1.7	>10	>8	>1.5

We found mutual correlation with *r* higher or equal to ±0.5 in beech leaves for N-P and Mg-Ca element pairs (Table 4). In beech leaves nitrogen showed significant correlation with phosphorus (Fig. 1) and it was found also a significant correlation between magnesium and calcium concentration (Fig. 2). Results of linear regression model are presented in Table 5. To investigate possible element limitations, element ratios were analyzed for N versus P, K, Ca, Mg; K versus Ca, Mg; Ca versus Mg (Table 7). Nutrient ratios can show if tree nutrition is unbalanced (Table 6). Based on the evaluation of foliar results presented in table 7 it can be affirmed that tree nutrition was harmonious in all studied sites, according to element ratio limits specified by Stefan et al. [13].

Table 3. Nutrient concentration in foliage of *Fagus sylvatica*.

	Foliar nutrient concetrations							
mg g^{-1}	**Răștolița**		**Lăpușna**		**Câmpu Cetății**		**Făgetul Clujului**	
	Mean ± sd	Range (min-max)	Mean ± sd	Range (min-max)	Mean ± sd	Range (min-max)	Mean ± sd	Range (min-max)
N	26,7±2,21	25,2-28,2	25,9±3,74	23,3-28,6	24,9±2,54	23,1-26,7	22,8±2,24	19,8-24,8
P	1,81±0,05	1,77-1,85	1,49±0,38	1,21-1,76	1,72±0,04	1,69-1,75	1,41±0,42	0,98-1,99
K	7,36±1,18	6,52-8,20	7,79±0,08	7,73-7,85	10,7±0,14	10,6-10,8	9,06±0,51	8,47-9,49
Ca	5,58±2,14	3,56-7,59	6,67±1,67	5,48-7,85	7,47±1,25	6,58-8,36	6,81±1,13	5,59-8,08
Mg	1,34±0,56	0,94-1,74	1,69±0,09	1,63-1,76	1,86±0,48	1,51-2,20	1,74±0,26	1,44-2,06
g/100g	Mean ± sd		Mean ± sd		Mean ± sd		Mean ± sd	
C	47,05±0,07		46,55±0,63		46,95±0,21		46,47±0,45	

Table 4. Pearson correlation between elements in foliage of European beech. Bold marked correlations are significant

	Foliar tissue				
Element	**N**	**P**	**K**	**Ca**	**Mg**
N	-				
P	**0,762**	-			
K	-0,295	0,056	-		
Ca	0,294	0,248	0,210	-	
Mg	-0,039	0,123	0,351	**0,618**	-

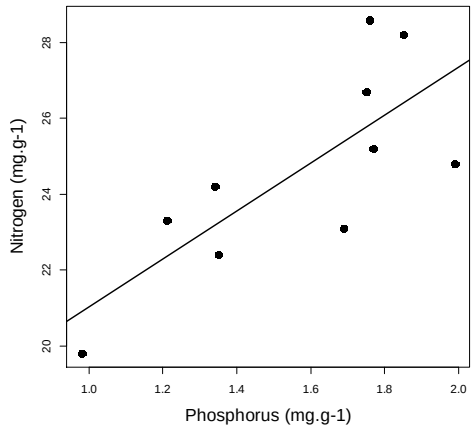

Figure 1. Correlation between P and N in leaves

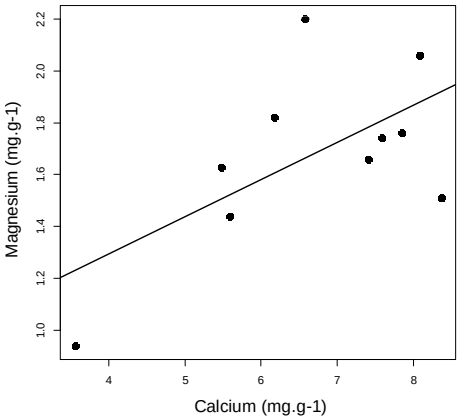

Figure 2. Correlation between Mg and Ca content in foliage

Table 5. Linear regression model for the correlated element pairs

	Estimated Coeficient	Standard error of the Coef. Estimate	t-value	Significance level	Linear regression model
Intercept P	14,714 6.32	1,897 0,064	4,851 3,332	p<0,01** p<0,05*	N=14,714+6,32P
Intercept Mg	2,193 2,670	2,048 1,199	1,071 2,226	p=0,315 p=0,05*	Ca=2,193+2,67Mg

Table 6. Classification of nutrient ratios limits in foliage of *Fagus sylvatica*, after Stefan et al. [13]

Ratio limit	**N/P**	**N/K**	**N/Ca**	**N/Mg**	**K/Ca**	**K/Mg**	**Ca/Mg**
Lower range	<10.6	<1.8	<2.3	<12	<0.63	<3.33	<3.67
Harmonious range	10.6-25	1.8-5	2.3-6.3	12-25	0.63-2.5	3.33-10	3.67-8
Upper range	>25	>5	>6.3	>25	>2.5	>10	>8

Table 7. Ratio of element in foliage of European Beech in study sites

Element ratio	Foliage			
	Răștolița	Lăpușna	Câmpu Cetății	Făgetul Clujului
N/P	14,74±0,71	17,75±2,12	14,46±,12	16,82±3,26
N/K	3,69±0,88	3,32±0,44	2,32±0,26	2,51±0,17
N/Ca	5,39±2,37	3,94±0,43	3,35±0,22	3,41±0,65
N/Mg	21,50±7,49	15,27±1,38	14,09±5,07	13,20±1,68
K/Ca	1,58±1,02	1,20±0,29	1,45±0,26	1,35±0,20
K/Mg	6,23±3,51	4,60±0,19	5,96±1,49	5,24±0,52
Ca/Mg	4,07±0,40	3,91±0,77	4,26±1,79	3,91±0,43

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 and it shows quite stable intervals in the case of one species [5, 6, 8, 10]. Mineral content in foliar tissue is similar between the stands. It was found N and P surplus at Răștolița. N and Mg surplus was found at Lăpușna, while at Cămpul Cetății a sligthly P, K and Mg surplus was registered. At Făgetul Clujului site only in Mg content were registered surplus. Otherwise insufficient P concentration, associated with increased N concentration, can induce a higher sensitivity to parasite infestations, low temperatures and water stress [2, 3, 4]. Non-significant differences were found in foliar N concentration along a European transect from North Sweden to central Italy. K, Ca, and Mg contents were in optimum intervals in the sites. Oneață et al. [11] revealed deficiencies for N, K and Ca content in Fundata monitoring plot for beech in 2009.

4. Conclusion

For the evaluation of nutrient supply in foliage in the case of N, P, K and Mg were recorded supra-optimal values in foliage of beech what could be explain by the characteristics of different soil types. The calculated nutrient ratios in the studied sites are situated in the harmonious range indicating harmonious tree nutrition beyond of some supra-optimal nutrient values.

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