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VARIABILITY IN MAGNESIUM CONCETRATION IN NEEDLES OF DIFFERENT DOUGLAS-FIR PROVENANCES

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Abstract

Magnesium concentration in the needles of Douglas-fir (*Pseudotsuga mensiesii* /Mirb./ Franco) was investigated in a provenance test under homogeneous site conditions (Ass. *Fagetum submontanum* Rud. on acid brown soil on gneiss) . The established quantities of magnesium in needles are indicative for different capabilities of certain Douglas-fir provenances to adopt this nutritive element from the soil. Significant differences among the examined provenances were found in mean height, mean diameter, tree volume and basal area. However, regression analysis revealed that there is no significant relation between magnesium concentration in needles of different Douglas-fir provenances and any of the examined forest stand parameters. Differences in mean height, mean diameter, tree volume and basal area are not the consequence of different capability of certain Douglas-fir provenances to adopt magnesium from the soil but are of genetic nature.

Key words: Douglas-fir, provenances, magnesium, foliar nutrion, stand height, stand diameter, Serbia.

Introduction

Douglas-fir (*Pseudotsuga menziesii* /Mirb./ Franco) is one of the most thriving coniferous species in its native range of North America and Canada (Brodie et al. 1987, Campbell 1979). As a fast growing species (Curtis et al. 1974), with the potential to produce high quality wood with wide usability it is regarded as an important component of the economy and wood industry (Cleary et al. 1978). It was introduced into Europe in 1827 and since then it has become the most prospective coniferous species introduced into plantations and mixed stands in Central Europe (Hermann 1987). The wide native range of the species implies the choice of a suitable provenance as a precondition for successful introduction (Campbell 1979, Hermann 1985).

One of the important elements of site suitability is the state of mineral foliar nutrition. If a plant is supposed to reach its optimum production determined by its genetic potential it needs to be adequately supplied with mineral nutrients.

Mineral nutrients have numerous physiological functions in a plant: forming of plant tissues, serving as catalysts of numerous reactions, osmoregulators, elements of buffer solutions, regulators of membrane permeability etc. For instance, Ca is a constituent of the cell wall, Mg of the chlorophyll molecule, S of proteins, P of phospholipids, nucleoproteids etc.

Magnesium ion (Mg^{2+}) is constituent of the chlorophyll molecule where it is placed in the centre of the chlorin ring. Magnesium also plays an important role in organic matter exchange by activating specific enzymes, which take part in photosynthesis and respiration (reactions which involve ATP-enzymes for carbon fixation). It participates in the metabolism of phosphorus and nitrogen and is important for the preservation of ribosome structure, as well as for the transport of products of photosynthesis and accumulation of reserve substances, particularly starch.

Magnesium participates in the process of neutralization of the surplus of organic acids by forming hardly soluble salts such as Mg-oxalate. It affects plant water regime through swelling of the protoplasmic colloids and improves the strength of the cell membrane by forming Mg-pectinate.

Material and Method

The object of the study is a Douglas-fir provenance test located in the Juhor mountain range in Central Serbia (Lavadinović et al. 2001, Lavadinović and Isajev 2003): Douglas-fir seedlings were produced in the nursery of the Institute of Forestry in Belgrade from seed imported from USA. The seed originated from 20 provenances, which differ in latitude, longitude and altitude and cover a part of the native range of the species (Table 1). The test was established in 1982 (seedling age 2+2) on a site classified as beech forest (*Fagetum moesiaca montanum* Jov. 1976) on acid brown soil (dystric cambisol) on gneiss.

The altitude of the site is 660–700 m a.s.l. on a southern slope. Each provenance was represented by 12 plants in each block with six replications, i.e. in total 72 trees per provenance. The site conditions in the entire test area were fairly uniform.

Stand parameters were measured at a stand age of 19 years. On the basis of these measurements the following values were calculated: mean diameter and mean height, basal area, tree volumes and volume increment of each Douglas-fir provenance.

Needle samples for foliar analysis were collected in the upper third part of sample trees of all provenances. Magnesium concentration in the needles was determined by the analysis of ash after dry ashing using the complexometric method.

Results

Average magnesium content in oven-dry needles of all the examined Douglas-fir provenances was 0.40% needles (Table 2, Fig. 1). The highest magnesium content (0.88%) was observed in the provenance with mark 30 (code Oregon 204-04), and the lowest one in the provenance marked 15 (code Washington 202-17). Standard deviation was 0.1617 and the coefficient of variation 40.87%. Magnesium content of provenance Oregon 204-04 significantly deviated from the average of all the examined provenances at the threshold of significance of 95%. Inter-provenance variability of magnesium content in Douglas-fir needles was not the consequence of different nutritive conditions of nutrition, because the provenances were grown under the same site conditions on the same type of soil, the same altitude and exposition. Stand conditions were also made uniform for all provenance groups of trees. The differences in the quantity of magnesium adopted by Douglas-fir trees are thus genetically preconditioned.

Table 1. Geographical co-ordinates of the tested Douglas-fir provenances.

Provenance	Our mark, No	Latitude, °N	Longitude, °E	Altitude, m asl
Oregon 205-15	1	43.7	123.0	750
Oregon 205-14	2	43.8	122.5	1200
Oregon 202-27	3	45.0	122.4	450
Oregon 205-38	4	45.0	121.0	600
Washington 204-07	9	49.0	119.0	1200
Oregon 205-13	10	43.8	122.5	1050
Oregon 205-18	11	44.2	122.2	600
Oregon 202-22	12	42.5	122.5	1200
Washington 202-17	15	47.6	121.7	600
Oregon 201-10	16	44.5	119.0	1350
Washington 201-06	17	49.0	120.0	750
Oregon 202-19	18	45.3	123.8	300
Oregon 205-11	20	45.0	123.0	150
New Mexico 202-04	22	32.9	105.7	2682
New Mexico 202-10	23	36.0	106.0	2667
Oregon 202-31	24	44.3	118.8	1500
Oregon 205-29	26	42.6	122.8	900
Oregon 205-08	27	42.7	122.5	1050
Oregon 204-04	30	45.0	121.5	900
Washington 205-17	31	47.7	123.0	300

Regression analysis (table 3) revealed no significant relationship between magnesium concentration in Douglas-fir needles and the mean diameter of provenances. Maximum mean diameter was recorded for provenance Oregon 202-27. Magnesium concentration in the needles of this provenance was 0.49%. The minimum mean diameter was found in provenance Washington 204-07 and magnesium content in the needles was 0.33%.

Regression analysis revealed that there was no significant relationship between magnesium concentration in needles and mean height of the Douglas fir provenances. The largest mean height (11.0 m) was found in provenance Washington 205-17 in which the magnesium concentration was 0.25%. The smallest

Table 2. Magnesium content in needles of various Douglas-fir provenances hand forest estimation elements.

Provenance	Our mark	Mg concentration in needles	Standard deviation of [Mg]	Aritmetic mean diameter	Aritmetic mean height	Basal area	Volume	Periodic volume increment (15-18 years)
	No	%		cm	m	$m^2 \cdot ha^{-1}$	$m^3 \cdot ha^{-1}$	$m^3 \cdot ha^{-1}$
Oregon 205-15	1	0.45	0.3370	14.8	10.8	35.8	179.5	20.1
Oregon 205-14	2	0.45	0.3370	14.6	10.2	34.9	174.7	22.2
Oregon 202-27	3	0.49	0.5844	15.5	10.6	39.3	201.0	35.1
Oregon 205-38	4	0.42	0.1515	15.0	10.3	38.8	187.8	26.3
Washington 204-07	9	0.33	-0.4051	6.8	4.8	8.7	30.9	3.3
Oregon 205-13	10	0.54	0.8936	14.5	10.3	34.4	170.4	26.4
Oregon 205-18	11	0.39	-0.0340	14.6	9.9	34.9	173.0	23.1
Oregon 202-22	12	0.22	-1.0853	15.1	10.0	37.3	181.2	28.0
Washington 202-17	15	0.10	-1.8275	14.8	10.4	35.8	177.4	27.9
Oregon 201-10	16	0.51	0.7081	10.9	7.2	19.4	86.2	9.4
Washington 201-06	17	0.45	0.3370	11.3	7.1	20.9	90.8	13.3
Oregon 202-19	18	0.19	-1.2709	15.0	10.7	36.8	186.3	27.7
Oregon 205-11	20	0.31	-0.5288	15.2	10.0	37.8	179.8	22.8
New Mexico 202-04	22	0.41	0.0897	11.5	7.7	21.6	102.8	16.5
New Mexico 202-10	23	0.40	0.0278	11.3	7.8	20.9	94.4	11.9
Oregon 202-31	24	0.47	0.4607	8.3	5.6	11.3	47.4	5.7
Oregon 205-29	26	0.34	-0.3432	15.1	10.1	37.3	183.5	21.1
Oregon 205-08	27	0.31	-0.5288	14.7	10.6	35.3	175.9	23.6
Oregon 204-04	30	0.88	2.9963	14.0	9.7	32.1	157.3	26.8
Washington 205-17	31	0.25	-0.8998	14.5	11.0	34.4	177.7	28.6
Average		0.40	0.0000	13.38	9.24	30.39	147.90	20.99
St deviation		0.1617		2.4927	1.8435	9.4953	51.5632	8.4290
V		40.87		18.64	19.95	31.25	34.86	40.16
Min		0.10		6.80	4.80	8.70	30.90	3.30
Max		0.88	2.9963	15.50	11.00	39.30	201.00	35.10

mean height (4.8 m) was found in provenance Washington 204-07, which also has the smallest mean diameter.

The largest basal area was found in the provenance Oregon 202-27, which had also the largest mean diameter, and the

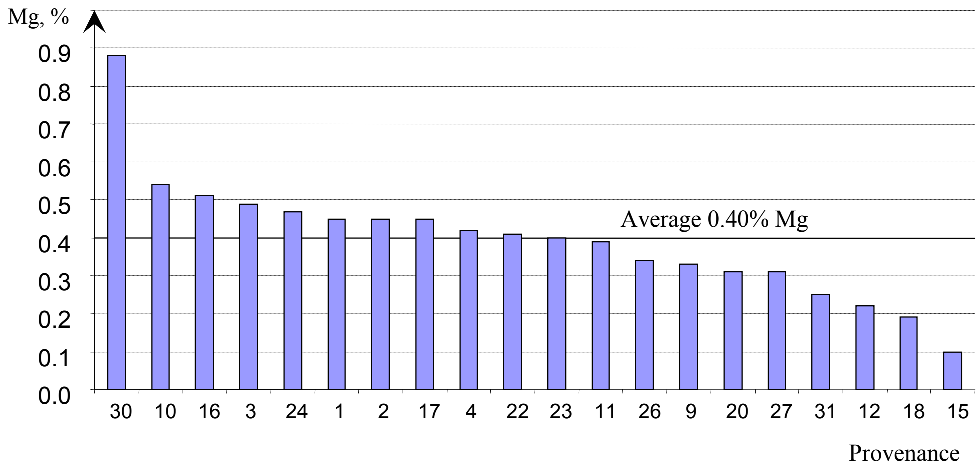

Fig. 1. Inter-provenance variability of magnesium concentration in Douglas-fir needles.

smallest in the provenance Washington 204-07 with the smallest stem diameter. Inter-provenance variability of magnesium concentration in needles had no impact on the inter-variability of stand basal area, which is derived from stand diameter.

Tree volume was also derived from diameter and height. No relation between stand tree volume and magnesium concentration in needles was found.

The statistical analysis showed that inter-provenance variability of magnesium concentration in needles has no impact on the volume increment of Douglas-fir. The highest volume increment on the examined site was recorded in prov-

Table 3. Regression analysis.

Forest stand parameter	Regression equation	Degrees of freedom n-1	Coefficient of determination, r^2
Mean diameter	d = -2.2624 Mg + 14.27	19	0.0215 ns*
Mean height	h = -1.9263 Mg + 10.002	19	0.0285 ns
Basal area	G = -10.321 Mg + 34.467	19	0.0309 ns
Volume	V = -56.264 Mg + 170.15	19	0.0311 ns
Periodic volume increment (15-18 years)	Iv = -56.264 Mg + 170.15	19	0.311 ns

* Not significant at 0.05 probability level

enance Oregon 202-27 and the lowest one - in provenance Washington 204-07.

Conclusion

Based on the examinations carried out as a part of a test of the 19-year-old Douglas-fir provenance on a beech site (*Fagetum moesiaca montanum* Jov. 1976) on acid brown soil (dystric cambisol) on gneiss, it can be concluded that inter-provenance variability of magnesium concentration in Douglas-fir needles is genetically preconditioned and is not a consequence of different conditions of nutrition with this element.

Inter-provenance variability of magnesium content in Douglas-fir needles is not the cause of inter-provenance variability of the examined forest stand parameters (mean diameter, mean heights, basal area, volume and volume increment). Like in the case of magnesium concentration in needles, differences in the examined forest estimation elements among certain provenances are genetically preconditioned.

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