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NUTRITION STATUS ASSESSMENT IN THE SOIL – PLANT SYSTEM

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Abstract. The coefficients of biological accumulation of K, Ca, Mg, Fe, Na, Mn, Cu, and Zn were determined. *Pinus nigra* was used as an edificator of vegetation. The results were interpreted in relation to the site hydrothermal regime. Zinc and potassium have maximum accumulation intensity – over 50, followed by Fe, Mn and Cu – between 6 and 50, and minimum values were observed for calcium, sodium and magnesium – up to 6. The variation limits of the accumulation coefficient of *Pinus nigra* might be used as a database for comparison with other regions.

Keywords: accumulation, mineral nutrition elements, *Pinus nigra*, soil-plant system.

AIMS AND BACKGROUND

The coefficient of accumulation as a ratio between the content of a given element in plants and its content in the soil has been proposed by Perelman in 1975[1]. Using data of own investigations and data presented by other authors, he determines coefficients of biological assimilation of various chemical elements, differentiating them according to their degree of accumulation in plants. Brooks[2] discusses the possibility to apply the accumulation coefficients for localization of ores and mineral deposits. There are large scale studies in this field. In connection with the investigation of forests status in Europe and evaluation of the contribution of pollution as a cause for their declined status and the realization of the International Cooperative Program " Assessment and Monitoring of the Effect of Polluted Air on Forest Ecosystems" (ICP-Forests-ECE), large scale observations are carried out aiming to establish a relation between wood plants and environmental conditions[3]. In spite of the abundant information concerning the chemical peculiarities of the environment, the recently established dependences, including intensity of accumulation of various elements in wood plants, are still insufficient.

The aim of the present study is to establish the biological accumulation of mineral nutrition elements in needle-shaped *Pinus nigra* leaves depending on soil fertility and the hydrothermal conditions.

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EXPERIMENTAL

The investigations were carried out in *Pinus nigra* cultures within the lower forest belt (zone) (600-700 m a.s.l.), aged between 33 and 40 years, bonitet II. The southerly exposure dominates. The plantations differ in soil type, soil-forming rocks and hydrothermal conditions. The studied area has a different level of air pollution. Main source is the lead-zinc factory in Kardzhali. Sample plot 1 (SP1) is at 2 km to the south from Kardzhali, sample plot 2 (SP2) – 5 km to south-west and sample plot 3 (SP3) – 12 km to the north. The dominating wind directions are north and north-east.

The results of leaves analyses used in this investigation have been published[4]. Their evaluation is based on the criteria according to ICP-Forests-ECE[5].

The mobile forms of elements in the soil are used for calculation of the coefficient of biological accumulation. The macroelements were determined in a $BaCl_2$-extract and the microelements – in NH_4NO_3-extract. In this way is achieved a clear definition of entries of water-soluble and exchangeable adsorbable forms in the solution. This characterises with an acceptable precision the amounts of elements' forms, present in soil, which can be assimilated by the plants.

The average annual course of soil moisture was determined by the method of Budiko, based on a common solution of the equations of heat balance of moisturised active surface and water balance of soil[6,7]. The dynamics of climate related soil humidity was elucidated by taking into account the rainfalls and the possible evaporation for decades as well as the soil-hydrologic indices – field capacity (FC), capillary moisture-retaining capacity (CMRC) and wilting point (WP). The coefficient of biological accumulation is determined as a ratio between the content of a given element in 1 and 2 years old needles and its content in soil.

The sample plots of needles and soil were collected in the beginning of August. The growth of the dominating tree is established by stem analysis. The statistical treatment of data was performed by means of Statistica 7-program.

RESULTS AND DISCUSSION

The analysis of the amounts of nutrition elements in SP1 shows that the nitrogen content is within a range considered as normal[1]. In the rest of the sample plots it is minimum. All elements are in normal limits[1] except iron – its quantity in 1 and 2 years old needles in SP1 and in 2 years old needles in SP2 is insufficient. The black pine in SP2 is best supplied with potassium, which means that there occurs a more intensive photosynthesis resulting in a higher productivity. The variation limits of the ratios between the nutrition elements show that in SP2 they may be considered as normal. In SP1 were observed deviations for N/Mg, Ca/Mg and K/Mg.

The investigated *Pinus nigra* plantations are situated on different soil types. In SP1 and SP2 there are Hromic Luvisols (zonal soil type) and SP3 – Regosols

(intrazonal soil type). The soil-forming rocks are marls (SP2), talc-chlorite schists (SP1) and conglomerates (SP3).

In Table 1 are shown data for the content of mobile forms of macro- and microelements. The sum of basic elements is evaluated (according to Ref. 8) as very high in SP2, high – in SP3 and high to medium – in SP1. The macroelement exhibiting highest value in all three objects was the exchangeable calcium. The variation of its content in the separate sample plots is genetically conditioned by the presence or absence of a carbonate soil-forming rock, which determines the soil solution acidity. Taking into account the values of the exchangeable calcium and pH we can obtain a proportional correlation ($R = 0.63$). For the rest of elements these dependences are less expressed. For example, for the exchangeable magnesium the correlation coefficient is $R = 0.42$.

Table 1. Content of mobile forms

Depth (cm)	pH H_2O	K	Ca	Mg	Fe	Mn	Na	Cu	Zn	Pb
						(mg/kg)				
					SP 1					
0-5	6.22	90.06	2113.33	1120.00	4.46	101.84	6.13	0.27	3.03	0.82
5-29	6.82	59.82	1770.00	1440.00	4.46	18.98	6.90	0.23	0.18	0.80
29-68	6.73	69.99	1790.00	2050.00	4.46	12.93	8.28	0.20	0.15	0.93
68-88	7.07	30.00	1590.00	1660.00	5.40	38.40	26.20	0.23	0.20	0.75
88-102	8.65	50.05	1560.00	1690.00	4.46	10.73	5.75	0.18	0.18	0.75
					SP 2					
0-5	7.21	113.30	6500.00	226.67	5.63	28.41	14.26	0.40	1.05	1.88
5-27	7.76	120.04	7970.00	250.00	5.30	15.13	22.08	0.30	0.45	1.60
27-68	7.31	120.04	8270.00	250.00	6.14	1.38	24.84	0.20	0.35	1.90
68-93	6.67	90.00	6820.00	200.00	5.80	1.40	31.40	0.28	0.23	1.75
					SP 3					
0-5	6.07	180.07	3856.67	463.33	5.16	106.50	13.29	0.26	1.33	1.11
5-29	6.13	90.00	3970.00	510.00	5.60	14.80	24.00	0.30	0.38	1.38
29-78	6.16	90.00	5080.00	770.00	5.60	21.00	33.40	0.35	0.65	1.68

The quantities of mobile forms of the investigated elements were found to vary in general within limits typical for non-polluted soils. The profile distribution of mobile forms shows maximum in the layer 0-5 cm where the acidic conditions contribute to a higher mobility of elements.

The hydrothermal data show that the average duration of the vegetation season in SP1 is 212 days, FC is 815 mm and is exhausted in the first decade of July, the moisturising coefficient is 0.35 (Figs 1-3). The average duration of the vegetation season in SP2 is 195 days, during 97 days in the beginning of the vegetation season the moisture content is optimal and is exhausted in the third decade of July, the moisturising coefficient is 0.53 and FC – 615 mm, respectively. The average duration of the vegetation season in SP3 is 201 days, the optimum moisturising lasts 60 days. FC (322 mm) is exhausted in the third decade of June, the moisturising coefficient is 0.32.

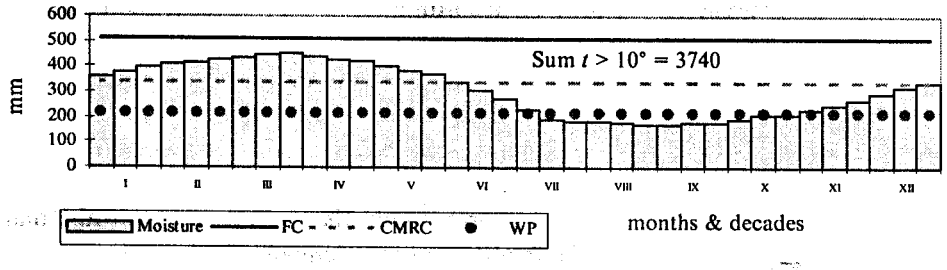

Fig. 1. Dynamics of soil moisture in SA1 K. Dere

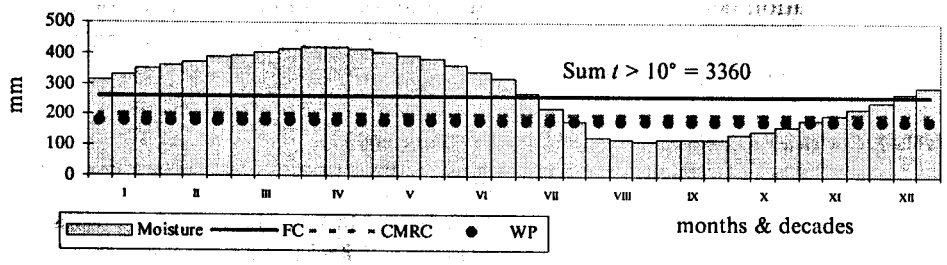

Fig. 2. Dynamics of soil moisture in SA2 Boino

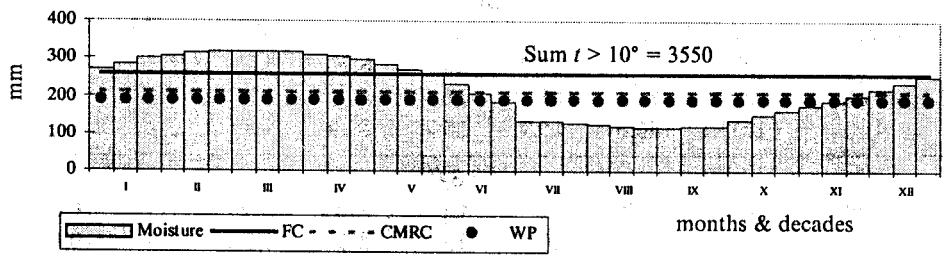

Fig. 3. Dynamics of soil moisture in SA3 Zheleznik

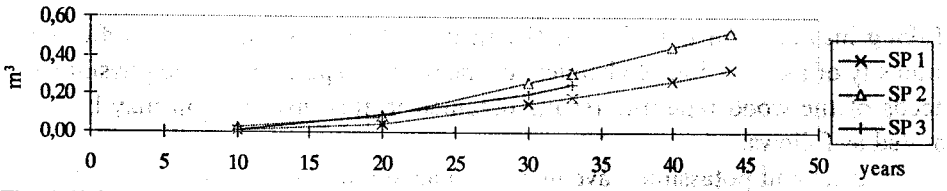

Fig. 4. Volumetric yield of the black pine

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The sample areas can be ordered according to the moisturising coefficient as follows: SP2 > SP3 > SP1.

The analysis of mineral nutrition of plants shows that under the existing soil and hydrothermal conditions the sum of chemical elements is maximum in 2 years old needles in SP2 (12 815 mg/kg) and minimal in 2 years old needles in SP1 (8500 mg/kg).

The established volumetric yield corresponds also to soil and hydrothermal conditions and to the content of mineral nutrition elements. The maximum yield was observed by the dominant tree in SP2, followed by SP3 and SP1 (Fig. 4).

The coefficients of biological accumulation are listed in Table 2. The established correlation between environmental conditions and growth of the dominant tree enables a more categorical evaluation of the coefficients in relation to elements and needles age (Table 2).

Table 2. Coefficients of biological accumulation in *Pinus nigra*

				SP 1				
1 year old	Zn >	K >	Cu >	Fe >	Mn >	Na >	Mg >	Ca
	266.8	95.1	35.6	14.1	4.8	3.8	0.97	0.83
2 years old	Zn >	K >	Cu >	Fe >	Mn >	Na >	Ca >	Mg
	347.7	85.7	26.7	24.8	7.9	6.3	1.43	0.97
				SP 2				
1 year old	Zn >	K >	Cu >	Mn >	Fe >	Mg >	Na >	Ca
	97.7	48.2	27.9	20.9	8.7	3.1	1.3	0.32
2 years old	Zn >	K >	Mn >	Fe >	Cu >	Mg >	Na >	Ca
	153.1	46.6	15.9	35.7	27.9	3.8	2.3	0.88
				SP 3				
1 year old	Zn >	K >	Fe >	Cu >	Mn >	Mg >	Na >	Ca
	68.9	55.8	20.1	13.4	8.2	1.9	1.3	0.66
2 years old	Zn >	K >	Fe >	Mn =	Cu >	Mg >	Na >	Ca
	59.6	52.8	25.4	8.2	1.3	1.8	1.3	0.88

CONCLUSIONS

Taking into account that the coefficient of biological accumulation reflects the intensity of assimilation of chemical elements corresponding to the physiological needs of the wood type, the results obtained in this investigation may be interpreted as follows:

1. Zinc and potassium have maximum accumulation intensity – over 50, followed by Fe, Mn and Cu – between 6 and 50, and minimum values were observed for calcium, sodium and magnesium – up to 6.

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2. There is an inversely proportional dependence between the accumulation coefficient of Ca, K, Mg, Na and Zn and their assimilable forms in the soil (R = 0.75, 0.93, 0.85, 0.99 and 0.84).

3. The variation limits of the accumulation coefficient of *Pinus nigra* might be used as a database for comparison with other regions.

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