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ACCUMULATION OF ELEMENTS IN *CORNUS SANGUINEA* AND *LIGUSTRUM VULGARE* LIVING IN THE EDGE AND INTERIOR OF A FOREST *(QUERCETUM PETRAEAE-CERRIS)**

I. DISTRIBUTION OF ELEMENTS WITHIN SHRUBS

By

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Investigations have been carried out in the framework of MAB in Hungary in the model area and its surroundings (Síkfőkút Project, JAKUCS 1973, 1978) on five individuals each of *Cornus sanguinea* and *Ligustrum vulgare* shrubs, with respect to the changes in the concentration of certain elements (N, P, K, Ca, Mg, Fe, Mn, Zn, Cu, Na) by plant fractions (leaf, one-year old branch, stem, primary root, secondary root). Furthermore the utilization of elements within the plant and the plant fractions which can be taken up through the root systems in contact with the soil was also studied.

Samples from 3 areas were analysed: from the sessile-turkey-oak forest of closed canopy from the northern edge of the forest adjacent to agricultural areas, and from shrubhedges surrounded by treeless agricultural areas.

It was established that always the physiologically most active parts of the plants, that is, the leaves and the root-hairs contain the elements in the highest concentration of macroelements (N, P, K, Ca and Mg) occurs in the leaf, while the microelements (Fe, Mn, Zn and Cu) accumulate large amount primarily in the root-hairs. The stem and the primary root do not differ significantly with respect to most elements. Likewise the one-year old branches and the primary roots have nearly the same role in the accumulation of elements. Of the two shrub species, *Ligustrum vulgare* contains all the elements — with the exception of Ca and Mg — in higher concentrations than *Cornus sanguinea.* In the leaf, one-year-old branch and primary root fraction of shrubs, the concentration-factor of all the elements is high. A high degree of in-plant accumulation is characteristic of N, Fe and K (10^0—10^3). In spite of the high Ca-concentration in the soil, the Ca-utilization of shrubs is unsatisfactory, the concentration of Ca is of 10^{-1}—10^0.

Introduction

Nutrient uptake and element accumulation as well as a knowledge of soil-plant relationship are important part features of the "Síkfőkút Project" complex ecological investigations in Hungary. The total element contents and changes in element concentrations of the annual phytoproduction of trees, shrubs and herbs of the oak forest have already been analysed in several papers (MÉSZÁROS 1977, 1979; ANTAL 1978, JACSÓ 1978, PAPP, B. 1982, MÉSZÁROS 1982).

In this paper the experimental results are presented which were through a detailed analysis of two selected dominant shrub species *Cornus sanguinea* and *Ligustrum vulgare.* Our examinations had a double twofold purpose, namely to ascertain in detail the distribu-

* "Síkfőkút Project" No. 65.

Table 1

Means and standard error of means of pH, organic matter

		pH		Organic matter %	Total-N %	NH_4-N+NO_3-N
		KCl	dest. w.			
Ligustrum vulgare						
Oak forest	$\bar{x}$	5.00	5.72	7.29	0.34	40.48
	s	0.3448	0.3977	0.5400	0.0228	3.7860
Forest edge	$\bar{x}$	6.04	6.69	6.45	0.36	51.95
	s	0.3764	0.4210	1.2877	0.0743	15.5914
Shrub hedge	$\bar{x}$	6.69	7.05	4.17	0.28	23.40
	s	0.0573	0.1373	1.2084	0.0374	3.7440
Cornus sanguinea						
Oak forest	$\bar{x}$	5.17	5.93	6.25	0.28	41.64
	s	1.0730	0.8940	2.0549	0.1075	9.7965
Forest edge	$\bar{x}$	6.09	6.71	7.66	0.35	58.04
	s	0.2181	0.1541	1.0843	0.0526	11.1684
Shrub hedge	$\bar{x}$	6.88	7.14	3.57	0.23	22.16
	s	0.0939	0.1293	1.7961	0.0771	7.9224

tion of elements in the plant and the utilization of the available element supply within the shrub from the soil; furthermore we were looking for differences in the element concentration in individuals of the same two shrub species whether living in forests, forest edges and by the side of uninterrupted forest cover, in shrub hedges that have survived among agricultural areas. It is stressed by several authors that a forest edge forming between a forest and the treeless area adjacent to it, being also structurally different from the forest, is of vital importance for the long-term survival and functional stability of the forest, because it bars and wards off the unfavourable effects reaching the forest from outside (Jakucs 1968, 1972; Wales 1972; Ranney 1977, etc.).

In Part I of the study the element concentrations in the various fractions of the shrubs, and the utilization of the available element supply of the soil within the shrub will be presented. The assessment of the results from the viewpoint of the woodland margin will be given in Part II of the study.

The research area and the sampling sites

The examinations were carried out in the research area and its surroundings called Síkfőkút Project, lying in the hill region of the North Hungarian Central mountain ranges (Jakucs 1973, 1978). One of the sampling sites was the interior of the sessile-turkeyoak forest with an enclosed canopy, which is a homogeneous 75 years-old stand of sprout origin; there has been no forestry activity in it for about 25 years. Several studies give descriptions of the forest and the structural indices of the shrub species occurring in the forest (Jakucs, Horváth, Kárász 1975; Kárász 1976; Kárász 1982).

and element concentrations in the soil of root zone

K	Ca	Mg	Fe	Mn	Cu	Zn	Na
mg. kg^{-1}							
153.76	2851.30	517.26	10.61	1407.30	0.74	14.56	8.24
14.9328	495.0221	46.1537	4.3500	122.7537	0.1274	1.3680	0.1807
303.22	4355.04	440.76	9.21	1356.50	0.81	16.86	8.94
72.9811	312.8056	40.7770	1.6228	114.060	0.1701	4.8222	2.3351
115.52	4478.80	317.52	0.60	76.63	0.35	1.50	10.43
62.5512	1016.1694	201.6343	0.8603	62.5833	0.2134	2.7103	5.5592
147.96	3024.86	531.28	12.04	1205.70	0.84	10.12	8.21
16.4649	1545.4207	120.5162	8.1584	306.1389	0.3367	4.4909	2.2328
253.24	4287.54	469.78	8.47	1290.30	0.97	12.28	9.29
32.2047	500.4027	42.9151	1.5967	174.5185	0.3516	3.3423	1.2561
75.60	4917.52	205.44	0.30	34.08	0.24	0.26	8.03
26.4971	88.0903	83.1473	0.1476	29.8900	0.0731	0.0217	1.0304

In the northern edge of the turkey-oak-forest which is connected with a vineyardarea, a closed forest margin has developed. This was our second sampling site. The shrub hedge, lying 500 m from the margin of the turkey oak-forest and surrounded by agricultural areas to the north, strongly exploited by man, was the third sampling site.

The soil in the sampling sites is brown forest soil with clay illuviation (KOVÁCS 1978).

Sampling methods

The five cases of *Cornus sanguinea* and *Ligustrum vulgare* predominant in all three sampling sites, were chosen randomly, on September 29, 1977. Three kinds of samples were taken from the shoot system of all the selected shrubs: — leaf samples consisting of 150 leaves; — one-year-old branch sample containing 20 branches of 15—20 cm length and less than 2 mm in diameter; — stem sample, containing 5 pieces of 10 cm length each.

After digging individuals two kinds of root samples were taken: primary root samples, containing 5 primary root pieces of 10 cm length each, and so-called root-hair samples containing root branches of less than 1 mm dia. The fractions taken in this way were treated separately. Also, the soil samples were collected from under the shrubs in direct contact with the roots were collected.

Chemical analysis of the samples

We used KJELDAHL's method to determine the N-content in plant samples while for P the molybdate blue method; and the concentration of K, Ca, Mg, Fe, Mn, Zn, Cu and Na was determined on a UNICAM SP 1900 type atomic-absorption spectrophotometer.

Table 2

Means and standard error of means of macro- and microelement concentrations and comparison of mean values in the fractions of Ligustrum vulgare of oak forest (n = 5)

Fraction		$\bar{x}$	s	One-year-old branch	Stem	Primary root	Root-hair
				SD5%			
Leaf	N %	2.389	0.1896	0.256***	0.215***	0.239***	0.250***
	P %	0.301	0.0325	0.037***	0.039***	0.042***	0.044***
	K %	2.173	0.2489	0.291***	0.311***	0.317***	0.321***
	Ca %	0.863	0.0644	0.074***	0.083***	0.083***	0.122***
	Mg %	0.295	0.0504	0.064**	0.064***	0.064***	0.067**
	Fe mg kg^{-1}	309.00	69.7522	86.52**	89.22**	89.46+	258.21***
	Mn mg kg^{-1}	300.06	49.4471	62.58***	62.48***	55.63***	NS
	Cu mg kg^{-1}	6.00	1.3177	NS	1.67*	NS	3.37***
	Zn mg kg^{-1}	56.12	21.1588	NS	26.81*	26.66*	NS
	Na mg kg^{-1}	104.65	18.8607	31.30***	29.44***	26.50*	121.73***
	ash %	10.12	0.3030	0.45***	0.34***	0.62***	0.71***
One-year-old branch	N %	1.260	0.0765	—	0.118***	0.100***	0.104*
	P %	0.183	0.0132	—	0.017***	0.016***	0.018***
	K %	1.259	0.1312	—	0.164***	0.148***	0.236*
	Ca %	0.202	0.0318	—	0.039**	0.039**	NS
	Mg %	0.110	0.0083	—	0.012***	0.014***	0.018***
	Fe mg kg^{-1}	164.25	46.3517	—	61.33**	62.46*	249.95***
	Mn mg kg^{-1}	66.29	9.4029	—	13.42***	24.09*	58.01***
	Cu mg kg^{-1}	7.40	2.0627	—	2.59*	NS	3.75***
	Zn mg kg^{-1}	47.51	7.8564	—	9.17***	8.87***	NS
	Na mg kg^{-1}	53.70	23.7120	—	NS	NS	123.03***
	ash %	4.12	0.3152	—	0.36***	0.63***	0.72***
Stem	N %	0.557	0.0844	—	—	0.108*	0.109***
	P %	0.043	0.0047	—	—	0.009***	0.017***
	K %	0.284	0.0178	—	—	0.075**	0.234**
	Ca %	0.119	0.0195	—	—	NS	0.125*
	Mg %	0.044	0.0070	—	—	0.012**	0.022***
	Fe mg kg^{-1}	58.45	16.8844	—	—	43.73***	244.12***
	Mn mg kg^{-1}	34.85	8.9689	—	—	23.91***	57.90***
	Cu mg kg^{-1}	4.03	0.2699	—	—	2.01*	3.72***
	Zn mg kg^{-1}	25.46	4.1390	—	—	NS	8.80**
	Na mg kg^{-1}	38.23	21.3638	—	—	28.46*	122.37***
	ash %	1.24	0.1390	—	—	0.67**	0.79***

Primary root	N %	0.701	0.0250	—	—	—	0.086***
	P %	0.069	0.0088	—	—	—	0.019***
	K %	0.447	0.0571	—	—	—	0.242**
	Ca %	0.134	0.0214	—	—	—	NS
	Mg %	0.068	0.0094	—	—	—	0.018***
	Fe mg kg^{-1}	227.25	38.8153	—	—	—	247.96***
	Mn mg kg^{-1}	99.82	21.3357	—	—	—	52.10***
	Cu mg kg^{-1}	6.93	1.5942	—	—	—	3.49***
	Zn mg kg^{-1}	22.41	3.4719	—	—	—	8.49**
	Na mg kg^{-1}	75.32	17.3861	—	—	—	121.39***
	ash %	2.51	0.5187	—	—	—	0.83***
Root-hair	N %	1.128	0.0641	—	—	—	—
	P %	0.119	0.0119	—	—	—	—
	K %	0.947	0.1861	—	—	—	—
	Ca %	0.245	0.0987	—	—	—	—
	Mg %	0.163	0.0160	—	—	—	—
	Fe mg kg^{-1}	1143.46	195.6275	—	—	—	—
	Mn mg kg^{-1}	332.70	45.6988	—	—	—	—
	Cu mg kg^{-1}	20.12	2.9803	—	—	—	—
	Zn mg kg^{-1}	40.33	7.4436	—	—	—	—
	Na mg kg^{-1}	621.69	96.0781	—	—	—	—
	ash %	5.86	0.6190	—	—	—	—

Table 3

Means and standard error of means of macro- and microelement concentrations and comparison of mean values in the fractions of Ligustrum vulgare of a turkey oak-forest edge (n = 5)

Fraction		$\bar{x}$	s	One-year-old branch	Stem	Primary root	Root-hair
				SD5%			
Leaf	N %	1.892	0.2933	0.360***	0.375***	0.370***	0.353***
	P %	0.251	0.0857	0.099*	0.108**	0.111*	0.111+
	K %	1.464	0.6020	NS	0.751**	0.751*	NS
	Ca %	0.981	0.1842	0.231***	0.231***	0.231***	0.208***
	Mg %	0.273	0.0429	0.053***	0.053***	0.058***	0.056*
	Fe mg kg^{-1}	250.48	76.3752	95.35*	89.69**	107.57*	710.73**
	Mn mg kg^{-1}	259.75	84.5405	107.69**	105.45**	105.95**	109.05+
	Cu mg kg^{-1}	5.66	2.2729	3.60**	NS	NS	5.92***
	Zn mg kg^{-1}	39.65	20.0810	NS	25.88+	NS	NS
	Na mg kg^{-1}	100.62	25.9192	NS	30.19**	33.81**	136.27***
	ash %	9.21	0.3422	0.56***	0.44***	0.41***	1.88*
One-year-old branch	N %	1.103	0.1873	—	0.247**	0.242**	NS
	P %	0.136	0.0439	—	0.056*	0.051*	NS
	K %	1.081	0.2165	—	0.275***	0.278**	NS
	Ca %	0.160	0.0138	—	0.030**	0.028**	NS
	Mg %	0.106	0.0061	—	0.007***	0.025*	0.022***
	Fe mg kg^{-1}	140.32	51.8284	—	NS	NS	707.30**
	Mn mg kg^{-1}	56.04	18.8457	—	24.94*	NS	31.03***
	Cu mg kg^{-1}	12.17	2.6432	—	3.32**	3.42**	6.08***
	Zn mg kg^{-1}	47.94	11.7981	—	13.44**	14.85**	NS
	Na mg kg^{-1}	91.61	36.5988	—	48.50*	43.08*	116.33***
	ash %	3.50	0.4173	—	0.53***	0.48***	1.90**
Stem	N %	0.430	0.0702	—	—	0.092**	0.196***
	P %	0.069	0.0117	—	—	NS	0.028***
	K %	0.219	0.0464	—	—	0.074**	0.375**
	Ca %	0.105	0.0269	—	—	NS	0.108*
	Mg %	0.038	0.0028	—	—	0.022*	0.019***
	Fe mg kg^{-1}	118.12	41.2841	—	—	NS	706.23**
	Mn mg kg^{-1}	21.65	6.8825	—	—	13.15***	30.32***
	Cu mg kg^{-1}	4.27	0.3996	—	—	NS	6.56***
	Zn mg kg^{-1}	19.56	5.4818	—	—	NS	8.15***
	Na mg kg^{-1}	36.61	13.5000	—	—	NS	133.46***
	ash %	1.16	0.0864	—	—	0.22***	1.83***

Primary root	N %	0.630	0.0555	—	—	—	0.231**
	P %	0.085	0.0213	—	—	—	0.032**
	K %	0.354	0.0555	—	—	—	0.378**
	Ca %	0.119	0.0237	—	—	—	0.108*
	Mg %	0.066	0.0181	—	—	—	0.025***
	Fe mg kg^{-1}	123.57	70.7827	—	—	—	709.84**
	Mn mg kg^{-1}	52.25	10.7180	—	—	—	26.58***
	Cu mg kg^{-1}	5.88	1.9944	—	—	—	6.99***
	Zn mg kg^{-1}	22.22	1.8715	—	—	—	7.42***
	Na mg kg^{-1}	39.61	19.9814	—	—	—	134.71***
	ash %	1.87	0.1935	—	—	—	1.85**
Root-hair	N %	1.099	0.1765	—	—	—	—
	P %	0.147	0.0230	—	—	—	—
	K %	1.096	0.2980	—	—	—	—
	Ca %	0.231	0.0831	—	—	—	—
	Mg %	0.182	0.0159	—	—	—	—
	Fe mg kg^{-1}	1434.15	566.5459	—	—	—	—
	Mn mg kg^{-1}	175.52	23.3937	—	—	—	—
	Cu mg kg^{-1}	31.49	5.2599	—	—	—	—
	Zn mg kg^{-1}	51.18	5.6680	—	—	—	—
	Na mg kg^{-1}	613.23	106.4959	—	—	—	—
	ash %	6.94	1.4710	—	—	—	—

Table 4

Means and standard error of means of macro- and microelement concentrations and comparison of mean values in the fractions of Ligustrum vulgare of shrub-hedge (n = 5)

Fraction		$\bar{x}$	s	One-year-old branch	Stem	Primary root	Root-hair
				$SD_{5\%}$			
Leaf	N %	1.881	0.4670	0.606*	0.587**	0.587**	0.587*
	P %	0.322	0.0970	0.122*	0.122**	0.122**	0.122*
	K %	1.058	0.0769	NS	0.095***	0.102***	NS
	Ca %	1.278	0.1303	0.164***	0.164***	0.164***	0.178***
	Mg %	0.271	0.0617	0.078**	0.078**	0.078**	0.083*
	Fe mg kg^{-1}	222.54	43.2194	60.31**	58.12***	57.11*	573.01**
	Mn mg kg^{-1}	244.17	41.5278	53.65***	51.77***	53.05***	65.09***
	Cu mg kg^{-1}	8.14	2.0786	5.37*	3.24*	NS	24.00**
	Zn mg kg^{-1}	75.34	14.3944	20.03**	18.24**	18.35**	20.62**
	Na mg kg^{-1}	56.93	8.5062	40.39**	18.95**	NS	420.27*
	ash %	10.87	1.1114	1.62***	1.39***	1.41***	1.70**
One-year-old branch	N %	1.075	0.1405	—	0.162***	0.162***	NS
	P %	0.135	0.0150	—	0.018***	0.018***	0.018+
	K %	1.071	0.1480	—	0.195***	0.200***	NS
	Ca %	0.179	0.0114	—	NS	0.028+	0.078*
	Mg %	0.100	0.0139	—	0.017***	0.017**	0.028***
	Fe mg kg^{-1}	132.74	22.0282	—	29.26**	NS	571.14***
	Mn mg kg^{-1}	43.32	11.7340	—	15.08**	15.80*	42.23*
	Cu mg kg^{-1}	13.14	3.7881	—	5.10**	4.48**	24.33*
	Zn mg kg^{-1}	44.69	7.2301	—	9.66**	8.19***	NS
	Na mg kg^{-1}	135.73	31.3521	—	34.93***	35.73***	421.94+
	ash %	3.88	0.6878	—	0.87**	0.90**	1.74***
Stem	N %	0.508	0.0697	—	—	NS	0.099***
	P %	0.075	0.0092	—	—	0.014+	0.014***
	K %	0.282	0.0492	—	—	0.081*	0.166***
	Ca %	0.147	0.0236	—	—	NS	0.081*
	Mg %	0.030	0.0041	—	—	0.006***	0.031***
	Fe mg kg^{-1}	86.27	17.8083	—	—	24.43**	570.81***
	Mn mg kg^{-1}	17.22	3.0881	—	—	NS	41.46**
	Cu mg kg^{-1}	4.58	1.5728	—	—	NS	24.01**
	Zn mg kg^{-1}	22.01	2.8449	—	—	NS	11.01**
	Na mg kg^{-1}	29.14	12.6495	—	—	19.97+	420.53*
	ash %	1.36	0.1195	—	—	0.27**	1.54***

Primary root	N %	0.557	0.0697	—	—	—	0.099***
	P %	0.087	0.0105	—	—	—	0.014***
	K %	0.364	0.0626	—	—	—	0.166***
	Ca %	0.152	0.0236	—	—	—	0.081*
	Mg %	0.052	0.0032	—	—	—	0.031***
	Fe mg kg^{-1}	123.77	15.5635	—	—	—	570.81***
	Mn mg kg^{-1}	22.67	9.8024	—	—	—	41.96**
	Cu mg kg^{-1}	5.85	2.1058	—	—	—	24.01**
	Zn mg kg^{-1}	19.76	3.2580	—	—	—	11.01**
	Na mg kg^{-1}	48.77	14.6140	—	—	—	420.53*
	ash %	1.78	0.2371	—	—	—	1.54***
Root-hair	N %	0.996	0.0653	—	—	—	—
	P %	0.151	0.0086	—	—	—	—
	K %	1.105	0.1491	—	—	—	—
	Ca %	0.267	0.0606	—	—	—	—
	Mg %	0.164	0.0237	—	—	—	—
	Fe mg kg^{-1}	1939.53	458.8612	—	—	—	—
	Mn mg kg^{-1}	95.53	31.8787	—	—	—	—
	Cu mg kg^{-1}	53.09	19.1944	—	—	—	—
	Zn mg kg^{-1}	41.95	8.2364	—	—	—	—
	Na mg kg^{-1}	521.13	337.9337	—	—	—	—
	ash %	7.51	1.2137	—	—	—	—

Table 5

Means and standard error of means of macro- and microelement concentrations and comparison of mean values in the fractions of Cornus sanguinea of oak forest (n = 5)

Fraction		$\bar{x}$	s	One-year-old branch	Stem	Primary root	Root-hair
				SD5%			
Leaf	N %	1.690	0.4124	0.545+	0.520**	0.517**	0.517+
	P %	0.210	0.0384	NS	0.050**	0.050**	0.046*
	K %	1.095	0.2520	0.284***	0.314**	0.320**	0.291**
	Ca %	1.271	0.1152	0.136***	0.129***	0.156***	0.284***
	Mg %	0.345	0.1033	0.136*	0.128**	0.131**	0.120*
	Fe mg kg^{-1}	291.58	66.8730	86.86**	88.56**	80.32**	396.24**
	Mn mg kg^{-1}	88.61	12.9324	16.72***	16.94***	15.45***	48.38***
	Cu mg kg^{-1}	4.18	0.9975	1.19+	1.35**	1.12***	9.67*
	Zn mg kg^{-1}	14.97	3.6842	NS	4.39**	4.19**	18.60*
	Na mg kg^{-1}	29.03	14.1592	15.58*	NS	25.41+	48.61**
	ash %	10.89	2.3926	3.03**	3.01**	3.07**	2.88*
One-year-old branch	N %	1.254	0.1482	—	0.166***	0.197***	NS
	P %	0.232	0.0316	—	0.042***	0.037***	0.039***
	K %	0.369	0.1088	—	0.139*	0.125*	NS
	Ca %	0.540	0.0657	—	0.083***	0.085***	NS
	Mg %	0.144	0.0368	—	0.047**	0.047+	0.067*
	Fe mg kg^{-1}	102.65	20.2140	—	32.84*	NS	388.23**
	Mn mg kg^{-1}	27.32	3.7064	—	5.86*	8.63**	45.87***
	Cu mg kg^{-1}	5.24	0.5671	—	1.05***	0.73***	9.62*
	Zn mg kg^{-1}	18.69	6.4854	—	8.49*	8.33*	15.69**
	Na mg kg^{-1}	48.23	5.2009	—	NS	NS	45.78**
	ash %	3.62	0.4682	—	0.60***	NS	1.87***
Stem	N %	0.526	0.0650	—	—	NS	0.081***
	P %	0.061	0.0110	—	—	0.018*	0.025***
	K %	0.146	0.0209	—	—	0.072*	0.158**
	Ca %	0.291	0.0482	—	—	NS	0.314+
	Mg %	0.040	0.0035	—	—	0.017***	0.067**
	Fe mg kg^{-1}	63.14	24.5326	—	—	48.18*	388.62**
	Mn mg kg^{-1}	20.45	4.2921	—	—	8.91***	45.94***
	Cu mg kg^{-1}	2.11	0.8485	—	—	NS	9.65*
	Zn mg kg^{-1}	5.89	2.1210	—	—	NS	17.28**
	Na mg kg^{-1}	37.21	14.0612	—	—	NS	48.57**
	ash %	2.08	0.3453	—	—	0.73*	1.83**

Primary root	N %	0.472	0.0536	—	—	—	0.072***
	P %	0.086	0.0142	—	—	—	0.025***
	K %	0.236	0.0541	—	—	—	0.143**
	Ca %	0.347	0.0500	—	—	—	0.317^{+}
	Mg %	0.103	0.0138	—	—	—	0.067**
	Fe mg kg^{-1}	119.49	39.6639	—	—	—	390.55**
	Mn mg kg^{-1}	42.12	23.6640	—	—	—	46.57***
	Cu mg kg^{-1}	1.70	0.4125	—	—	—	9.61*
	Zn mg kg^{-1}	5.94	1.6874	—	—	—	17.20**
	Na mg kg^{-1}	51.84	20.1074	—	—	—	43.00**
	ash %	3.12	0.6147	—	—	—	1.61***
Root hair	N %	1.233	0.0453	—	—	—	—
	P %	0.144	0.0215	—	—	—	—
	K %	0.465	0.1265	—	—	—	—
	Ca %	0.633	0.2489	—	—	—	—
	Mg %	0.222	0.0525	—	—	—	—
	Fe mg kg^{-1}	1222.11	311.6172	—	—	—	—
	Mn mg kg^{-1}	255.42	36.7040	—	—	—	—
	Cu mg kg^{-1}	15.20	7.7175	—	—	—	—
	Zn mg kg^{-1}	50.23	13.7315	—	—	—	—
	Na mg kg^{-1}	127.54	36.4488	—	—	—	—
	ash %	7.28	1.4322	—	—	—	—

Table 6

Means and standard error of means of macro- and microelement concentrations and comparison of mean values in the fractions of Cornus sanguinea of forest edge (n = 5)

Fraction		$\bar{x}$	s	One-year-old branch	Stem	Primary root	Root-hair
				SD5%			
Leaf	N %	1.808	0.2411	0.305*	0.273***	0.314***	0.314**
	P %	0.210	0.0613	NS	0.078**	0.074*	0.081+
	K %	1.096	0.1469	0.173***	0.186***	0.186***	0.256***
	Ca %	1.357	0.2104	0.275**	0.264***	0.272***	0.270**
	Mg %	0.390	0.0582	0.067***	0.072***	0.075***	0.072***
	Fe mg kg^{-1}	281.73	37.9798	51.07***	42.59***	51.57***	175.08***
	Mn mg kg^{-1}	82.12	29.2557	38.15*	37.02**	37.83*	74.63***
	Cu mg kg^{-1}	5.81	1.2481	1.42**	1.41+	1.68*	3.23***
	Zn mg kg^{-1}	29.16	5.3733	NS	6.77***	6.86***	18.57**
	Na mg kg^{-1}	31.72	12.8736	19.62**	17.14*	19.89**	106.87*
	ash %	14.18	2.1385	2.69***	2.67***	2.71***	2.47***
One-year-old branch	N %	1.442	0.1713	—	0.210***	0.194***	0.194***
	P %	0.241	0.0454	—	0.058**	0.060**	0.053**
	K %	0.519	0.0830	—	0.108***	0.111**	NS
	Ca %	0.724	0.0670	—	0.089***	0.095***	0.085*
	Mg %	0.172	0.0272	—	0.036***	0.032***	0.046*
	Fe mg kg^{-1}	124.19	31.6412	—	36.65**	NS	173.13***
	Mn mg kg^{-1}	27.08	9.2681	—	11.16*	NS	82.92**
	Cu mg kg^{-1}	2.82	0.5698	—	0.81**	0.79**	3.64***
	Zn mg kg^{-1}	35.31	6.5905	—	8.27***	8.34***	15.93***
	Na mg kg^{-1}	67.62	13.9581	—	NS	NS	107.08*
	ash %	4.49	0.3526	—	0.52***	0.55***	1.39*
Stem	N %	0.482	0.1079	—	—	NS	0.136***
	P %	0.073	0.0124	—	—	0.047+	0.028***
	K %	0.147	0.0238	—	—	0.042*	0.250*
	Ca %	0.286	0.0234	—	—	NS	0.055***
	Mg %	0.046	0.0085	—	—	0.018***	0.044***
	Fe mg kg^{-1}	63.92	16.0423	—	—	23.90**	169.77***
	Mn mg kg^{-1}	13.94	5.5461	—	—	10.37*	82.40**
	Cu mg kg^{-1}	4.52	0.5390	—	—	NS	3.63***
	Zn mg kg^{-1}	7.45	0.8721	—	—	NS	17.36***
	Na mg kg^{-1}	55.07	4.9364	—	—	NS	105.85*
	ash %	1.97	0.2226	—	—	0.47	1.35**

Primary root	N %	0.581	0.0770	—	—	—	0.111***
	P %	0.115	0.0361	—	—	—	NS
	K %	0.198	0.0319	—	—	—	0.250**
	Ca %	0.294	0.0623	—	—	—	0.083***
	Mg %	0.087	0.0167	—	—	—	0.042***
	Fe mg kg^{-1}	111.81	16.6723	—	—	—	141.19***
	Mn mg kg^{-1}	26.81	8.3723	—	—	—	82.77**
	Cu mg kg^{-1}	3.98	0.5182	—	—	—	3.63***
	Zn mg kg^{-1}	6.29	1.2420	—	—	—	17.40***
	Na mg kg^{-1}	63.82	14.3190	—	—	—	107.16*
	ash %	2.66	0.3984	—	—	—	1.41**
Root hair	N %	0.947	0.0755	—	—	—	—
	P %	0.134	0.0233	—	—	—	—
	K %	0.506	0.1995	—	—	—	—
	Ca %	0.612	0.0492	—	—	—	—
	Mg %	0.226	0.0356	—	—	—	—
	Fe mg kg^{-1}	1127.89	135.6095	—	—	—	—
	Mn mg kg^{-1}	255.41	66.0476	—	—	—	—
	Cu mg kg^{-1}	16.52	2.8714	—	—	—	—
	Zn mg kg^{-1}	77.99	13.9395	—	—	—	—
	Na mg kg^{-1}	198.07	84.9931	—	—	—	—
	ash %	6.11	1.0592	—	—	—	—

Table 7

Means and standard error of means of macro- and microelement concentrations and comparison of mean values in the fractions of Cornus sanguinea of shrub hedge (n = 5)

Fraction		$\bar{x}$	s	One-year-old branch	Stem	Primary root	Root-hair
				SD5%			
Leaf	N %	1.317	0.1449	NS	0.162***	0.222***	0.178***
	P %	0.206	0.0237	NS	0.028***	0.030***	0.030***
	K %	0.955	0.4488	NS	0.559*	0.564**	0.567+
	Ca %	1.603	0.1619	0.189***	0.180***	0.201***	0.214***
	Mg %	0.341	0.0523	0.060***	0.067***	0.067***	0.076**
	Fe mg kg^{-1}	265.03	29.6967	36.19***	37.48***	37.81***	193.34***
	Mn mg kg^{-1}	34.97	3.9555	4.47***	5.14***	6.13***	10.83***
	Cu mg kg^{-1}	5.41	1.1393	1.99**	1.27***	1.41+	31.96*
	Zn mg kg^{-1}	20.82	1.8161	NS	3.67***	2.90***	16.49**
	Na mg kg^{-1}	44.90	11.0304	29.41*	14.02*	NS	27.29+
	ash %	15.36	0.9902	1.34***	1.14***	1.35***	1.29***
One-year-old branch	N %	1.178	0.1607	—	0.214**	0.233***	0.192***
	P %	0.196	0.0216	—	0.025***	0.030***	0.028***
	K %	0.540	0.0654	—	0.076***	0.092***	0.109*
	Ca %	0.778	0.0845	—	0.112***	0.143***	0.106*
	Mg %	0.143	0.0242	—	0.028***	0.028***	NS
	Fe mg kg^{-1}	132.00	18.5810	—	28.85***	NS	191.18***
	Mn mg kg^{-1}	16.93	1.7395	—	2.18***	5.90*	12.25***
	Cu mg kg^{-1}	8.90	1.5487	—	2.01***	1.78***	31.99*
	Zn mg kg^{-1}	29.29	9.4735	—	12.38**	12.07***	16.73**
	Na mg kg^{-1}	81.33	26.2480	—	32.76**	34.37*	NS
	ash %	5.83	0.8296	—	0.99***	1.23***	1.16+
Stem	N %	0.526	0.0596	—	—	NS	0.116**
	P %	0.078	0.0117	—	—	NS	0.021***
	K %	0.223	0.0312	—	—	NS	0.108**
	Ca %	0.315	0.0673	—	—	NS	0.092***
	Mg %	0.033	0.0119	—	—	0.016*	0.067**
	Fe mg kg^{-1}	69.00	20.8448	—	—	27.10**	191.54***
	Mn mg kg^{-1}	5.79	1.2003	—	—	NS	12.15***
	Cu mg kg^{-1}	2.51	0.4668	—	—	0.92**	31.94*
	Zn mg kg^{-1}	6.81	3.0560	—	—	NS	16.77**
	Na mg kg^{-1}	24.73	2.3387	—	—	NS	29.98*
	ash %	2.24	0.4889	—	—	NS	0.93***

Primary root	N %	0.475	0.1589	—	—	—	0.192*
	P %	0.089	0.0179	—	—	—	0.025**
	K %	0.188	0.0603	—	—	—	0.104**
	Ca %	0.263	0.1094	—	—	—	0.129***
	Mg %	0.054	0.0101	—	—	—	0.067**
	Fe mg kg^{-1}	124.89	15.9232	—	—	—	190.81***
	Mn mg kg^{-1}	7.93	4.4175	—	—	—	11.01***
	Cu mg kg^{-1}	4.21	0.7593	—	—	—	31.95**
	Zn mg kg^{-1}	4.77	2.1385	—	—	—	16.55**
	Na mg kg^{-1}	34.40	20.4350	—	—	—	32.56*
	ash %	2.91	0.8537	—	—	—	1.18***
Root-hair	N %	0.702	0.0949	—	—	—	—
	P %	0.127	0.0162	—	—	—	—
	K %	0.406	0.0811	—	—	—	—
	Ca %	0.649	0.0593	—	—	—	—
	Mg %	0.188	0.0519	—	—	—	—
	Fe mg kg^{-1}	1219.02	152.6443	—	—	—	—
	Mn mg kg^{-1}	65.92	9.7022	—	—	—	—
	Cu mg kg^{-1}	47.21	25.6827	—	—	—	—
	Zn mg kg^{-1}	55.54	13.1366	—	—	—	—
	Na mg kg^{-1}	67.73	24.0013	—	—	—	—
	ash %	6.98	0.7540	—	—	—	—

Table 8

The concentration factor of the elements (in plant) concentration

	Fraction	N	K	Ca
				Ligustrum vulgare
Oak forest	leaf	$5.90 \cdot 10^{2}$	$1.41 \cdot 10^{1}$	$3.03 \cdot 10^{0}$
	one-year-old branch	$3.11 \cdot 10^{2}$	$8.19 \cdot 10^{1}$	$7.08 \cdot 10^{-1}$
	stem	$1.73 \cdot 10^{2}$	$1.85 \cdot 10^{1}$	$4.17 \cdot 10^{-1}$
	primary root	$2.18 \cdot 10^{2}$	$2.91 \cdot 10^{1}$	$4.70 \cdot 10^{-1}$
	root-hair	$2.79 \cdot 10^{2}$	$6.16 \cdot 10^{1}$	$8.59 \cdot 10^{-1}$
Forest edge	leaf	$3.64 \cdot 10^{2}$	$4.83 \cdot 10^{1}$	$2.25 \cdot 10^{0}$
	one-year-old branch	$2.12 \cdot 10^{2}$	$3.57 \cdot 10^{1}$	$3.67 \cdot 10^{-1}$
	stem	$8.28 \cdot 10^{1}$	$7.22 \cdot 10^{0}$	$2.41 \cdot 10^{-1}$
	primary root	$1.21 \cdot 10^{2}$	$1.17 \cdot 10^{1}$	$2.71 \cdot 10^{-1}$
	root-hair	$2.12 \cdot 10^{2}$	$1.28 \cdot 10^{1}$	$5.30 \cdot 10^{-1}$
Shrub hedge	leaf	$8.04 \cdot 10^{2}$	$9.16 \cdot 10^{1}$	$2.85 \cdot 10^{0}$
	one-year-old branch	$4.59 \cdot 10^{2}$	$9.27 \cdot 10^{1}$	$4.00 \cdot 10^{-1}$
	stem	$2.17 \cdot 10^{2}$	$2.44 \cdot 10^{1}$	$3.28 \cdot 10^{-1}$
	primary root	$2.38 \cdot 10^{2}$	$3.15 \cdot 10^{1}$	$3.39 \cdot 10^{-1}$
	root-hair	$4.26 \cdot 10^{2}$	$9.57 \cdot 10^{1}$	$5.96 \cdot 10^{-1}$
				Cornus sanguinea
Oak forest	leaf	$4.06 \cdot 10^{2}$	$7.45 \cdot 10^{1}$	$4.20 \cdot 10^{0}$
	one-year-old branch	$3.01 \cdot 10^{2}$	$2.51 \cdot 10^{1}$	$1.79 \cdot 10^{0}$
	stem	$1.26 \cdot 10^{2}$	$9.94 \cdot 10^{0}$	$9.62 \cdot 10^{-1}$
	primary root	$1.13 \cdot 10^{2}$	$1.61 \cdot 10^{1}$	$1.15 \cdot 10^{0}$
	root-hair	$2.96 \cdot 10^{2}$	$3.17 \cdot 10^{1}$	$2.09 \cdot 10^{0}$
Forest edge	leaf	$3.10 \cdot 10^{2}$	$4.33 \cdot 10^{1}$	$3.17 \cdot 10^{0}$
	one-year-old branch	$2.47 \cdot 10^{2}$	$2.05 \cdot 10^{1}$	$1.69 \cdot 10^{0}$
	stem	$8.30 \cdot 10^{1}$	$5.81 \cdot 10^{0}$	$6.67 \cdot 10^{-1}$
	primary root	$1.00 \cdot 10^{2}$	$7.82 \cdot 10^{0}$	$6.86 \cdot 10^{-1}$
	root-hair	$1.63 \cdot 10^{2}$	$1.99 \cdot 10^{1}$	$1.43 \cdot 10^{0}$
Shrub edge	leaf	$5.94 \cdot 10^{2}$	$1.26 \cdot 10^{2}$	$3.26 \cdot 10^{0}$
	one-year-old branch	$5.32 \cdot 10^{2}$	$7.14 \cdot 10^{1}$	$1.58 \cdot 10^{0}$
	stem	$2.37 \cdot 10^{2}$	$2.95 \cdot 10^{1}$	$6.41 \cdot 10^{-1}$
	primary root	$2.14 \cdot 10^{2}$	$2.49 \cdot 10^{1}$	$5.35 \cdot 10^{-1}$
	root-hair	$3.17 \cdot 10^{2}$	$5.37 \cdot 10^{1}$	$1.32 \cdot 10^{0}$

in soil in the fractions of Ligustrum vulgare and Cornus sanguinea

Mg	Fe	Mn	Cu	Zn	Na
$5.70 \cdot 10^{0}$	$2.91 \cdot 10^{1}$	$2.13 \cdot 10^{-1}$	$8.11 \cdot 10^{0}$	$3.85 \cdot 10^{0}$	$1.27 \cdot 10^{0}$
$2.13 \cdot 10^{0}$	$1.55 \cdot 10^{1}$	$4.71 \cdot 10^{-2}$	$1.00 \cdot 10^{1}$	$3.26 \cdot 10^{0}$	$6.52 \cdot 10^{0}$
$8.51 \cdot 10^{-1}$	$5.51 \cdot 10^{0}$	$2.48 \cdot 10^{-2}$	$5.45 \cdot 10^{0}$	$1.75 \cdot 10^{0}$	$4.64 \cdot 10^{0}$
$1.32 \cdot 10^{0}$	$2.14 \cdot 10^{1}$	$7.09 \cdot 10^{-2}$	$9.37 \cdot 10^{0}$	$1.54 \cdot 10^{0}$	$9.14 \cdot 10^{0}$
$3.15 \cdot 10^{0}$	$1.08 \cdot 10^{2}$	$2.36 \cdot 10^{-1}$	$2.72 \cdot 10^{1}$	$2.77 \cdot 10^{0}$	$7.55 \cdot 10^{1}$
$6.19 \cdot 10^{0}$	$2.72 \cdot 10^{1}$	$1.92 \cdot 10^{-1}$	$6.99 \cdot 10^{0}$	$2.35 \cdot 10^{0}$	$1.13 \cdot 10^{1}$
$2.41 \cdot 10^{0}$	$1.52 \cdot 10^{1}$	$4.13 \cdot 10^{-2}$	$1.50 \cdot 10^{1}$	$2.84 \cdot 10^{0}$	$1.02 \cdot 10^{1}$
$8.62 \cdot 10^{-1}$	$1.28 \cdot 10^{1}$	$1.60 \cdot 10^{-2}$	$5.27 \cdot 10^{0}$	$1.16 \cdot 10^{0}$	$4.10 \cdot 10^{0}$
$1.50 \cdot 10^{0}$	$1.34 \cdot 10^{1}$	$3.85 \cdot 10^{-2}$	$7.26 \cdot 10^{0}$	$1.32 \cdot 10^{0}$	$4.43 \cdot 10^{0}$
$4.13 \cdot 10^{0}$	$1.56 \cdot 10^{2}$	$1.29 \cdot 10^{-1}$	$3.89 \cdot 10^{1}$	$3.04 \cdot 10^{0}$	$6.86 \cdot 10^{1}$
$8.54 \cdot 10^{0}$	$3.71 \cdot 10^{2}$	$3.19 \cdot 10^{0}$	$2.33 \cdot 10^{1}$	$5.02 \cdot 10^{1}$	$5.46 \cdot 10^{0}$
$3.14 \cdot 10^{0}$	$2.21 \cdot 10^{2}$	$5.65 \cdot 10^{-1}$	$3.75 \cdot 10^{1}$	$2.98 \cdot 10^{1}$	$1.30 \cdot 10^{1}$
$9.45 \cdot 10^{-1}$	$1.44 \cdot 10^{2}$	$2.25 \cdot 10^{-1}$	$1.31 \cdot 10^{1}$	$1.47 \cdot 10^{1}$	$2.79 \cdot 10^{0}$
$1.64 \cdot 10^{0}$	$2.06 \cdot 10^{2}$	$2.96 \cdot 10^{-1}$	$1.67 \cdot 10^{1}$	$1.32 \cdot 10^{1}$	$4.68 \cdot 10^{0}$
$5.17 \cdot 10^{0}$	$3.23 \cdot 10^{3}$	$1.25 \cdot 10^{0}$	$1.52 \cdot 10^{2}$	$2.80 \cdot 10^{1}$	$4.99 \cdot 10^{1}$
$6.49 \cdot 10^{0}$	$2.42 \cdot 10^{1}$	$7.35 \cdot 10^{-2}$	$4.98 \cdot 10^{0}$	$1.48 \cdot 10^{0}$	$3.53 \cdot 10^{0}$
$2.71 \cdot 10^{0}$	$8.53 \cdot 10^{0}$	$2.27 \cdot 10^{-2}$	$6.24 \cdot 10^{0}$	$1.85 \cdot 10^{0}$	$5.88 \cdot 10^{0}$
$7.53 \cdot 10^{-1}$	$5.24 \cdot 10^{0}$	$1.70 \cdot 10^{-2}$	$2.51 \cdot 10^{0}$	$5.82 \cdot 10^{-1}$	$4.53 \cdot 10^{0}$
$1.94 \cdot 10^{0}$	$9.92 \cdot 10^{0}$	$3.49 \cdot 10^{-2}$	$2.02 \cdot 10^{0}$	$5.87 \cdot 10^{-1}$	$6.31 \cdot 10^{0}$
$4.18 \cdot 10^{0}$	$1.02 \cdot 10^{2}$	$2.12 \cdot 10^{-1}$	$1.81 \cdot 10^{1}$	$4.96 \cdot 10^{0}$	$1.55 \cdot 10^{1}$
$8.30 \cdot 10^{0}$	$3.33 \cdot 10^{1}$	$6.36 \cdot 10^{-2}$	$5.99 \cdot 10^{0}$	$2.38 \cdot 10^{0}$	$3.41 \cdot 10^{0}$
$3.66 \cdot 10^{0}$	$1.47 \cdot 10^{1}$	$2.10 \cdot 10^{-2}$	$2.91 \cdot 10^{0}$	$2.88 \cdot 10^{0}$	$7.28 \cdot 10^{0}$
$9.79 \cdot 10^{-1}$	$7.55 \cdot 10^{0}$	$1.08 \cdot 10^{-2}$	$4.66 \cdot 10^{0}$	$6.07 \cdot 10^{-1}$	$5.93 \cdot 10^{0}$
$1.85 \cdot 10^{0}$	$1.32 \cdot 10^{1}$	$2.08 \cdot 10^{-2}$	$4.10 \cdot 10^{0}$	$5.12 \cdot 10^{-1}$	$6.87 \cdot 10^{0}$
$4.81 \cdot 10^{0}$	$1.33 \cdot 10^{2}$	$1.98 \cdot 10^{-1}$	$1.70 \cdot 10^{1}$	$6.35 \cdot 10^{0}$	$2.13 \cdot 10^{1}$
$1.66 \cdot 10^{1}$	$8.83 \cdot 10^{2}$	$1.03 \cdot 10^{0}$	$2.25 \cdot 10^{1}$	$8.01 \cdot 10^{1}$	$5.59 \cdot 10^{0}$
$6.96 \cdot 10^{0}$	$4.40 \cdot 10^{2}$	$4.97 \cdot 10^{-1}$	$3.71 \cdot 10^{1}$	$1.13 \cdot 10^{2}$	$1.01 \cdot 10^{1}$
$1.61 \cdot 10^{0}$	$2.30 \cdot 10^{2}$	$1.70 \cdot 10^{-1}$	$1.05 \cdot 10^{1}$	$2.62 \cdot 10^{1}$	$3.08 \cdot 10^{0}$
$2.63 \cdot 10^{0}$	$4.16 \cdot 10^{2}$	$2.33 \cdot 10^{-1}$	$1.75 \cdot 10^{1}$	$1.84 \cdot 10^{1}$	$4.28 \cdot 10^{0}$
$9.15 \cdot 10^{0}$	$4.06 \cdot 10^{3}$	$1.93 \cdot 10^{0}$	$1.97 \cdot 10^{2}$	$2.14 \cdot 10^{2}$	$8.43 \cdot 10^{0}$

The analysis of the soil samples covered the following characteristics; pH, organic matter, total-N, $NH_4 + NO_3$, 0.1 n hydrochloric acid soluble K, Ca, Mg, Fe, Mn, Cu, Zn, Na (ratio of soil to solvent was 1 : 5).

The mean and standard error of the mean of the element concentrations of soil in contact with the roots of two shrubs are summarized in Table 1.

The element concentration mean values and the standard error of data for the *Ligustrum vulgare* fractions are contained in Tables 2, 3, and 4, and those of *Cornus sanguinea* fractions in Tables 5, 6 and 7.

The element concentrations in the various fractions of the shrubs, and to the estimate the level of significance of differences in the means. The *t* test was used to compare (SVÁB 1973). These data are given in Tables 2—7.

Results

The distribution of elements within shrubs

The concentration of all the elements in the root system of the two shrub species is significantly higher in the root-hairs than in the primary ones, while in their shoot system concentration increases as follows: stem — one year-old branches — leaves order (Tables 2—7).

The stem and primary root do not significantly differ with regard to most of the elements.

The maximum macroelement accumulation is to be found in the leaves.

In both species, the macroelement content of the leaves significantly differ from those of the primary root fractions.

There is a relatively high concentration of macroelements in the one year-old branches and the root-hairs, besides the leaves. The N, P and K content of the one year old branches mostly does not differ significantly from that of the root-hairs and it shows a great similarity also to that of the leaves.

The two shrub species essentially differ in their accumulation of K and Ca *Cornus sanguinea* takes up and utilizes Ca to a greater extent than K, thus the ratio of potassium and Ca concentration in its fractions is below 1, and the fluctuation of this among the fractions is small (0.5—0.9). On the other hand, in the fractions of *Ligustrum vulgare*, which accumulates K in a high concentration, the ratio K : Ca is higher than 1 and changes among the fractions in a higher proportion. The ratio K : Ca is low in the fractions stem and primary root (2—3), as well as leaf (1—2), while in the one-year-old branches it is very high (6—7). The K : Ca ratio in the root-hairs approaches that of the one-year-old branches (4—5).

Similar to potassium, there is also a higher concentration of magnesium in the fractions of *Cornus sanguinea* (Table 1).

In contrast with the macroelements, the accumulation of the microelements (Fe, Mn, Zn and Cu) is higher in the fractions of *Ligustrum vulgare* (Tables 2, 3 and 4).

In the individuals of both shrub species the microelements — but mainly Fe — have their concentration maximum in the root-hairs, but —

compared with the primary root fractions — they can be found in a much higher concentration also in the leaves and the one-year-old branches.

The two shrub species are different also from the viewpoint of microelement distribution within the plant. *Cornus sanguinea* accumulates the microelements taken up from the soil in its root-hairs (Tables 5, 6 and 7), from there their transportation towards the leaf is minimal thus the root hairs differ significantly from all the fractions. The distribution of microelements (mainly Mn, Zn and Cu) in the individuals of *Ligustrum vulgare* is more balanced; the accumulation in the one-year-old branches and in the leaves is of an identical value or surpassing that in the root-hairs.

Of the four microelements, the concentration of Fe is especially high in the root-hairs (above 1000 ppm), it surpasses the Fe-content of the leaves several times (200—300 ppm). Shrubs in their prefer Fe to Mn being present in the soil at a higher concentration (Table 1). Owing to a higher Mn uptake, a smaller Fe : Mn ratio is characteristic of the individuals of *Ligustrum vulgare*.

Nutrient utilization in shrubs

It appears from the values expressing the nutrient utilization (element concentration in plant: concentration in soil; see Table 8), that the concentration of elements in plants is decidedly influenced by the activity and selectivity of the plant. In relation to concentration factors, a differentiation in groups of macro- and microelements is difficult because the concentration factor of certain microelements, and it can even be higher than that. In the leaf fractions, one-year-old branch and root-hair of the two shrub species examined, the concentration factor values were high in relation to all the elements.

A high accumulation in the plant is characteristic of N, Fe and K; the concentration factor of N is of a 10^2 order of magnitude in all the fractions; that of Fe is 10^0—10^3; that of potassium varies between orders of magnitude 10^0—10^2, depending on the fraction. In the case of Zn, Cu, Na and Mg, accumulation is smaller by one order of magnitude (10^0—10^1).

In spite of the high concentration in the soil (Table 1), the utilization of Ca is unsatisfactory, the concentration factor values are of 10^0 and 10^{-1} order of magnitude. Of the microelements, Mn is contained in the soil, at the highest concentration, still it is utilized in the plant at the lowest value (10^{-2}—10^{-1} order of magnitude).

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