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Soil Genesis

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INFLUENCE OF PINE AND SPRUCE ADMIXTURE IN EUROPEAN BEECH STAND ON SOME PROPERTIES OF ORGANIC AND HUMIC HORIZONS OF DYSTRIC ARENOSOLS AND THE INTENSITY OF BIOLOGICAL TURNOVER

Abstract. The aim of the study has been to assess the influence of Scots pine *(Pinus sylvestris* L.) and Norway spruce *(Picea abies)* admixture in European beech *(Fagus sylvatica)* stand on some properties of organic and humic horizons of Dystric Arenosols and the intensity of biological turnover. The studies were conducted in northern Poland in Łysomice Forest Subdistrict (Forest District Leśny Dwór, Regional Directorate of State Forest Szczecinek). Significant differences in some properties of examined soil horizons were noticed between the stands. About 3-times higher stocks of organic matter in ectohumus were found in beech-pine and about 2-times in beech-spruce in relation to pure beech stand. Higher stocks of soil organic matter recorded in beech-pine and beech-spruce stands may result from the influx of coniferous litter and reduction of the intensity of biological turnover. The stocks of organic matter in A horizons were slightly higher in beech stand. Lower values of pH in O and A horizons were found in mixed stand in relation to pure beech. The concentration of nitrogen was comparable in both stands. It can be assumed that spatial variability of the stocks of nitrogen was strongly related to spatial diversity of soil organic matter stocks.

Mixed pine-beech and spruce-beech forests commonly occur in central and middle Europe [8]. In the area of Pomerania these are often age-differentiated beech stands with an admixture of over hundred-year-old pine, spruce or, rarely, larch. Beech, as natural component of the stands, was replaced by coniferous species in past centuries as a result of silviculture. At present, we witness the regeneration of beech in the stands and progressive decline of coniferous species.

Opinions about the impact of beech on soil properties are different despite many results of studies which were conducted on the topic. The studies of Chodzicki [6] from the beginning of the 20th century on the influence of beech admixture in pine stands on soil properties showed different influence of beech

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on the properties of different soil types. Its admixture on podzolized soils increased soil pH, whereas on Cambisols it decreased. According to the author, the admixture of beech in pine stands led to the reduction of the intensity of podzolization by increasing (in relation to pine) of the intensity of biological turnover of iron, which promotes the immobilization of the element in topsoil. Also, according to other authors, [1] beech influences podzolization in soils much less than the coniferous species. Berger *et al.* [4] proved that the admixture of beech in coniferous stands resulted in the increase of nutrient stocks in the soil and the increase of soil pH.

Comparative studies of leachates from organic and humic horizons of Dystric Arenosols carried out in the area of Pomerania showed that the admixture of pine in beech stand increases acidification of the leachates and leads to the increase of dissolved organic carbon, iron and aluminum concentration. This indicates higher intensity of the process of podzolization in mixed stand in relation to pure beech [16].

In relation to other broadleaved tree species, in general, beech causes stronger acidification of the soil, especially in humic horizon [2, 13]. It is the effect of the small intensity of biological turnover of base cations. Presented examples of the studies show that beech is intermediate between other broadleaved and coniferous species in terms of the nature of impact on soil properties.

The aim of the study was the assessment of the influence of Scots pine *(Pinus sylvestris* L.) and Norway spruce *(Picea abies)* admixture in European beech *(Fagus sylvatica)* stand on the stocks of soil organic matter and some properties of organic and humic horizons of Dystric Arenosols and the intensity of biological turnover.

MATERIALS AND METHODS

The studies were conducted in northern Poland in the Łysomice Forest Subdistrict (Forest District Leśny Dwór, Regional Directorate of State Forest Szczecinek). Two 40x40 m plots have been located in neighboring forest divisions. The first plot was located in 120-year-old beech stand with an admixture of 90-year-old trees (forest division 148a), the second in mixed beech-pine-spruce stand (forest division 147a), where 66% was 70–110-year-old beech, 19% 110-year-old pine and 15% 70–110-year-old spruce. Selected features of the tree-stands are presented in Table 1. The forest habitat type was mixed fresh forest and the soil was Dystric Arenosol.

The studies were conducted during the spring of 2007 and included mapping of the location of trees in the plots, measurement of its diameter and soil sampling. Soil samples were collected from 41 points regularly spaced in each plot. Ol and Ofh horizons were sampled using ring sampler of diameter 20 cm.

TABLE 1. SELECTED PARAMETERS OF TREE-STANDS

Tree-stand component	Age (years)	Precentage (%)	Mean diameter (cm)	High (m)	Yield class
Beech stand					
European beech	90–120	100	43.3	25–29	II
Mixed stand					
European beech	70–110	66	33.7	21–27	II. III
Scots pine	110	19	48.0	27	II
Norway spruce	70–110	15	39.9	22–28	II. III

Samples from A horizon were taken as monoliths and volumetric samples using l00 cm^3 steel rings. In each point thickness of A horizon was measured in five replications. On the basis of tree canopies coverage, the plot in mixed stand was divided on patches - pure beech, beech-pine and beech-spruce. Sampling points have been assigned to the particular patches.

Soil samples were dried to constant mass (mineral samples in temperature 105°C, organic samples in 65°C) and weighted. Samples of A horizon were removed of skeleton fraction using a mesh of 2 mm, samples of O horizon were homogenized in laboratory mill. The following properties were analyzed: soil organic matter (SOM) content as weight loss in ignition in 550°C, soil total organic carbon (TOC) content by Tiurin method for mineral samples and Alten's method for organic samples, total nitrogen (TN) by Kjeldahl's method, pH potentiometrically in H_2O and 1 M dm^{-3} solution of KC1. Bulk density of A horizon was determined using l00 cm^3 steel rings. Stocks of SOM, TOC and TN were calculated for O and A horizons.

Mean values of pH as well as content and stocks of SOM, TOC and TN and standard deviations were calculated for Ol, Ofh and A horizons of the soils in beech and particular patches in mixed stand. Means were compared with *T-test* Student.

Based on SOM stocks in ectohumus and plant litter-fall production during 2007–2009 [15], the rate of biological turnover intensity [3] was calculated for beech and mixed stands.

Four soil profiles (one in beech and three in mixed stand) were done, soils described, sampled and analyzed. Bulk density was determined with l00 crn^3 steel rings, texture by mixed sieve and pipette methods, pH potentiometrically in H_2O and 1 M dm^{-3} solution of KC1, TOC content by Tiurin method for mineral samples and Alten's method for organic samples, TN content by Kjeldahl's method.

RESULTS

Soil Characteristics

Dystric Arenosols of examined stands were formed of quaternary sands with sandy-loam inter-beddings in parent material (Table 2). Bulk density of the soils was 0.97–1.35 $g.cm^{-3}$ in AEs horizons and increased with depth, up to 1.35-1.54 $g.cm^{-3}$ in sandy parent material and 1.58-1.79 $g.cm^{-3}$ in loamy inter-beddings. The pH varied in soil profiles. In beech stand and in beech patches of mixed stand the pH of Ol horizon was 5.01 and 5.05, whereas, in beech-pine stand was 4.3 and in beech-spruce stand 4.0. Comparable values of pH were noticed in Ofh horizon of pure beech stand (4.4), beech patches of mixed stand (4.2) and in Of horizons of beech-pine (4.6) and beech-spruce stands (4.1). In Oh horizons of the soils of beech-pine and beech-spruce patches the pH was 3.2 and 3.0, respectively. Minimum values of the pH were found in AEs horizons (3.2–3.7). An increase of pH with depth was observefound up to 5.5. The content of TN in AEs horizons was 0.94% in beech stand, 0.26% in beech patches of mixed stand, 0.0% in beech-pine stand and 0.59% in beech-spruce stand. The highest C:N ratios were found in Ol horizon – 55:1 for beech stand and beech patches of mixed stand, 80:1 in beech-pine stand and 76:1 in beech-spruce stand. The decreasing of C:N ratio with depth was observefound (Table 2).

TABLE 2. SELECTED PROPERTIES OF THE SOILS IN PROFILES

Tree stand	Horizon	Depth (cm)	Textural group*	Bulk density (%)	pH H_2O	pH KCI	TOC (%)	TN (%)	TOC:TN
Beech stand	OI	4–2	–	–	5.01	4.33	52.56	0.948	55
	Ofh	2–0	–	–	4.34	3.59	44.57	1.566	28
	AEs	0–5	s	1.29	3.77	2.93	3.77	0.194	19
	Bhs	5–9	s	1.26	3.90	3.22	1.58	0.083	19
	BhsBv	9–31	s	1.32	4.50	4.04	0.66	0.038	17
	C1	31–61	sl	1.58	4.70	3.85	–	–	–
	C2	61–86	l	1.79	4.73	3.74	–	–	–
	C3	86–140	ls	1.54	4.98	3.90	–	–	–
Mixed stand beech patches	OI	4–2	–	–	5.05	4.36	54.19	0.990	55
	Ofh	2–0	–	–	4.52	3.83	47.68	1.361	35
	AEs	0–5	s	0.97	3.70	2.94	2.61	0.126	21
	Bhs	5–9	s	1.24	3.97	3.18	1.24	0.057	22
	BhsBv	9–25	s	1.28	4.62	4.21	0.49	0.037	13
	Bv	25–50	s	1.44	4.61	4.27	0.17	0.017	10
	C	50–140	s	1.46	5.75	4.32	–	–	–

TABLE 3. CONTINUATION

Mixed stand beech-pine patches	OI	6–4	–	–	4.33	3.66	54.93	0.686	80
	Of	4–2	–	–	4.36	3.68	50.35	1.263	40
	Oh	2–0	–	–	3.62	2.62	37.66	1.167	32
	AEs	0–5	s	1.35	3.72	2.80	2.05	0.090	23
	Bhs	5–13	s	1.44	4.17	3.30	0.94	0.043	22
	BhsBv	13–27	s	1.41	4.66	3.92	0.56	0.035	16
	BvC	27–49	s	1.50	4.93	4.25	0.24	0.018	13
	Ab	49–75	s	1.38	4.94	4.11	0.29	0.019	15
	Bvb	75–88	s	1.35	4.51	4.12	0.16	0.014	12
	C	88–138	s	1.50	4.65	4.23	–	–	–
Mixed stand beech-spruce patches	OI	7–5	–	–	4.30	3.43	52.84	0.695	76
	Of	5–3	–	–	4.31	3.63	49.73	1.209	41
	Oh	3–0	–	–	3.90	3.07	38.51	1.310	29
	AEs	0–5	s	1.12	3.62	2.81	2.83	0.159	18
	Bhs	5–11	s	1.34	3.82	3.13	1.78	0.092	19
	BhsBv	11–30	s	1.33	4.53	3.91	0.76	0.042	18
	Bv	30–64	s	1.35	4.85	4.17	0.34	0.023	15
	C1	64–75	s	1.35	5.13	4.22	–	–	–
	C2	75–86	s		4.87	4.06	–	–	–
	C3	86–140	s	1.49	5.47	4.28	–	–	–

* s – sand, sl – sandy loam, ls – loamy sand.

Content and stocks of SOM and TOC

Mean content of SOM in Ol horizons was 93.9% in beech stand, 94.3% in beech patches of mixed stand, 95.2% in beech-pine and 95.4% in beech-spruce stand. In Ofh horizons the resulting values were as follows 66.5%, 66.9%, 66.9% and 65.8% respectively, were observed. The content of SOM in A horizons was comparable in every stand and equaledled 5.2–5.6% (Table 3).

TABLE 3. CONTENT OF SOM (%) IN O AND A HORIZONS

Tree stand	Ol	Ofh	A
Beech stand	93.9 ± 2.0* 89.7 – 96.8**	66.5 ± 13.3 29.3 – 90.0	5.6 ± 1.3 3.6 – 8.5
Mixed stand beech patches	94.3 ± 2.6 85.9 – 96.5	66.9 ± 13.1 33.4 – 84.9	5.3 ± 0.7 4.1 – 6.5
Mixed stand beech-pine patches	95.2 ± 1.7 90.5 –97.4	66.9 ± 13.8 38.8 – 82.5	5.2 ± 0.9 3.9 – 6.5
Mixed stand beech-spruce patches	95.4 ± 1.4 93.7 – 96.7	65.8 ±9.6 50.8 – 76.2	5.4 ± 1.7 3.5 – 7.4

* mean ± standard deviation; ** min – max.

The stocks of SOM in beech stand were 578 g m^{-2} for Ol horizon, 960 g m^{-2} for Ofh horizon and 3312 g m^{-2} for A horizon. In beech patches of mixed stand higher stocks of SOM in O horizon (911 g m^{-2} for Ol horizon and 1315 g m^{-2} for Ofh horizon) were noticed and slightly lower in A horizon (2763 g m^{-2}) in relation to pure beech stand. In beech-pine stand the stocks of SOM were 980 g m^{-2} in Ol horizon, 3504 g m^{-2} in horizon Ofh, and 2541 g m^{-2} in A horizon. In beech-spruce stand the resulting values were as follows: 856 g m^{-2}, 1922 g m^{-2} and 2853 g m^{-2}, respectively,were observed (Table 4).

TABLE 4. STOCKS OF SOM (g m^{-2}) IN O AND A HORIZONS

Tree stand	Ol	Ofh	A
Beech stand	<u>578 ± 117</u>* 324 – 859**	<u>960 ± 440</u> 258 – 2023	<u>3312 ± 1102</u> 1424 – 6075
Mixed stand beech patches	<u>911 ± 219</u> 619 – 1416	<u>1315 ± 639</u> 433 – 2923	<u>2763 ± 683</u> 1530 – 4555
Mixed stand beech-pine patches	<u>980 ± 211</u> 663 – 1418	<u>3504 ± 1836</u> 961 – 5534	<u>2541 ± 771</u> 1483 – 3932
Mixed stand beech-spruce patches	<u>856 ± 251</u> 574 – 1167	<u>1922 ± 859</u> 655 – 2962	<u>2853 ± 733</u> 1720 – 3748

* mean ± standard deviation; ** min – max.

The stocks of TOC were related to the stocks of SOM. The sum of TOC stocks in O and A horizons was 2437.4 g m^{-2} in beech stand, 2675.5 g m^{-2} in beech patches of mixed stand, 3642.5 g m^{-2} in beech-pine stand and 2959.3 g m^{-2} in beech-spruce stand (Table 5).

TABLE 5. STOCKS OF TOC (g m^{-2}) IN O AND A HORIZONS

Tree stand	Ol	Ofh	A
Beech stand	<u>278.2 ± 574</u>* 156.8 – 415.8**	<u>436.8 ± 212.2</u> 114.2 – 947.5	<u>1722.4 ± 631.2</u> 851.6 – 3775.3
Mixed stand beech patches	<u>442.9 ± 107.4</u> 301.5 – 682.1	<u>654.4 ± 329.3</u> 199.0 – 1513.0	<u>1578.4 ± 480.3</u> 837.9 – 3239.8
Mixed stand beech-pine patches	<u>481.0 ± 108.8</u> 333.2 – 727.9	<u>1700.2 ± 904.4</u> 478.6 – 2798.8	<u>1461.3 ± 429.1</u> 728.4 – 2180.1
Mixed stand beech-spruce patches	<u>416.3 ± 121.5</u> 291.2 – 567.4	<u>978.0 ± 414.0</u> 373.8 – 1495.4	<u>1565.0 ± 379.7</u> 977.4 – 1999.6

* mean ± standard deviation; ** min – max.

Content and Stocks of TN and TOC:TN Ratio

Mean content of TN was comparable in examined stands both in O and A horizons and ranged from 1.335 to 1.533% in Ol horizon, 1.217–1.437% in Ofh horizon and 0.130–0.160% in A horizon (Table 6). Therefore, only in some cases the found differences were statistically significant (Table 10). Spatial differentiation of the stocks of TN was found. The stocks of TN in Ol horizon were 8.3 g m^{-2} in beech stand, 14.9 g m^{-2} in beech patches of mixed stand, 13.8 g m^{-2} in beech-pine and 12.0 g m^{-2} in beech-spruce patches of the stand. In Ofh horizon the resulting values were as follows 18.3; 28.6; 63.0 and 36.7 g m^{-2}, and in A horizon 94.4; 79.6; 62.9; 68.5 g m^{-2}, respectively, were observed (Table 7).

TABLE 6. CONTENT OF TN (%) IN O AND A HORIZONS

Tree stand	Ol	Ofh	A
Beech stand	1.337 ± 0.168* 0.898 – 1.624**	1.292 ± 0.222 0.769 – 1.776	0.160 ± 0.042 0.096 – 0.268
Mixed stand beech patches	1.533 ± 0.091 1.336 – 1.750	1.437 ± 0.198 0.943 – 1.715	0.151 ± 0.025 0.111 – 0.223
Mixed stand beech-pine patches	1.335 ± 0.145 1.050 – 1.624	1.217 ± 0.239 0.748 – 1.562	0.130 ± 0.034 0.080 – 0.175
Mixed stand beech-spruce patches	1.359 ± 0.121 1.197 – 1.532	1.285 ± 0.111 1.120 – 1495.4	0.130 ± 0.043 0.083 – 0.180

* mean ± standard deviation; ** min – max.

TABLE 7. STOCKS OF TN (g m^{-2}) IN O AND A HORIZONS

Tree stand	Ol	Ofh	A
Beech stand	8.3 ± 2.2* 4.8 – 12.8**	18.3 ± 8.6 4.6 – 42.1	94.4 ± 32.4 39.9 – 196.9
Mixed stand beech patches	14.9 ± 3.8 10.0 – 22.7	28.6 ± 13.5 9.2 – 59.5	79.6 ± 24.0 41.3 – 161.7
Mixed stand beech-pine patches	13.8 ± 2.5 10.4 – 19.2	63.0 ± 32.9 18.5 – 107.3	62.9 ± 20.9 30.2 – 104.3
Mixed stand beech-spruce patches	12.0 ± 2.7 9.4 – 15.3	36.7 ± 14.1 14.4 – 51.9	68.5 ± 18.7 39.1 – 91.1

* mean ± standard deviation; ** min – max.

TABLE 8. TOC:TN RATES

Tree stand	Ol	Ofh	A
Beech stand	35 ± 6* 27 – 53**	24 ± 3 11 – 32	18 ± 2 14 – 21
Mixed stand beech patches	30 ± 3 25 – 36	23 ± 3 16 – 28	20 ± 2 17 – 24
Mixed stand beech-pine patches	35 ± 4 29 – 44	27 ± 3 21 – 34	24 ± 4 19 – 31
Mixed stand beech-spruce patches	34 ± 3 31 – 39	26 ± 2 25 – 29	23 ± 2 21 – 26

* mean ± standard deviation; ** min – max.

TABLE 9. REACTION (pH_{H_2O}) IN O AND A HORIZONS

Tree stand	Ol	Ofh	A
Beech stand	5.34 ± 0.18* 4.95 – 5.76**	4.84 ± 0.26 4.33 – 5.33	3.71 ± 0.19 3.36 – 4.17
Mixed stand beech patches	5.13 ± 0.17 4.75 – 5.42	4.24 ± 0.25 3.81 – 4.83	3.67 ± 0.07 3.59 – 3.84
Mixed stand beech-pine patches	4.76 ± 0.26 4.29 – 5.14	3.87 ± 0.39 3.33 – 4.52	3.59 ± 0.09 3.41 – 3.79
Mixed stand beech-spruce patches	4.75 ± 0.43 4.37 – 5.42	3.82 ± 0.17 3.64 – 4.07	3.56 ± 0.10 3.45 – 3.69

* mean ± standard deviation; ** min – max.

The C:N ratios ranged from 30:1 to 35:1 for Ol horizons and 24:1–27:1 for Ofh horizons. In A horizon the C:N ratio was minimum in pure beech stand (18:1) and beech patches of mixed stand (20:1), and maximum in beech-pine stand (24:1) and beech-spruce stand (23:1) (Table 8).

pH

The pH of O and A horizons of examined soils was strongly acid, but spatially varied and related to tree-species composition of the stands. Maximum values of pH were found in pure beech stand and minimum in beech-pine and beech-spruce (Table 9). The pH ranged from 4.5 to 5.76 (average 5.34) in pure beech stand, 4.75–5.42 (average 5.13) in beech patches of mixed stand, 4.29–5.14 (average 4.76) in beech-pine patches and 4.37–5.42 (average 4.75) in the patches with the admixture of spruce. In Ofh horizon the resulting values were as follows: 4.33–5.33 (average 4.84), 3.81–4.83 (average 4.24), 3.33–4.52

(average 3.87) and 3.64–4.07 (average 3.82), and in A horizon: 3.36–4.17 (average 3.71), 3.59–3.84 (average 3.67), 3.41–3.79 (average 3.41) and 3.45–3.69 (average 3.56), respectively (Table 9).

TABLE 10. STATISTICAL SIGNIFICANCE OF DIFFERENCES BETWEEN TREE--STANDS IN SOME PROPERTIES OF O AND A HORIZONS

Compared data	Ol	Ofh	A
SOM stocks			
BS vs MS beech patches	+	+	+
BS vs MS beech-pine patches	+	+	+
BS vs MS beech-spruce patches	+	+	-
MS beech patches vs MS beech-pine patches	-	+	-
MS beech patches vs MS beech-spruce patches	-	-	-
Content of TN			
BS vs MS beech patches	+	+	-
BS vs MS beech-pine patches	-	-	+
BS vs MS beech-spruce patches	-	-	-
MS beech patches vs MS beech-pine patches	+	+	-
MS beech patches vs MS beech-spruce patches	+	-	-
Stocks of TN			
BS vs MS beech patches	+	+	-
BS vs MS beech-pine patches	+	+	+
BS vs MS beech-spruce patches	+	+	-
MS beech patches vs MS beech-pine patches	-	+	-
MS beech patches vs MS beech-spruce patches	-	-	-
C:N			
BS vs MS beech patches	+	-	+
BS vs MS beech-pine patches	-	+	+
BS vs MS beech-spruce patches	-	-	+
MS beech patches vs MS beech-pine patches	+	+	+
MS beech patches vs MS beech-spruce patches	+	+	+
pH			
BS vs MS beech patches	+	+	-
BS vs MS beech-pine patches	+	+	+
BS vs MS beech-spruce patches	+	+	-
MS beech patches vs MS beech-pine patches	+	+	+
MS beech patches vs MS beech-spruce patches	+	+	+

$p<0,05$; BS – beech stand, MS – mixed stand,
- – differences statistically insignificant,
+ – differences statistically significant.

DISCUSSION

The quantity and quality properties of the litter fall and the process of its decomposition [9, 10, 15, 17, 22, 23, 25], the chemistry of the through fall, stem flow and soil water [4, 5, 7, 14, 18, 20, 24], comparison studies of soil properties [11, 12, 19, 21] or comprehensive studies including a few links of elements and balance of chemical compounds can be the basis for the assessment of the influence of tree-species composition on soil properties. However, evaluations based on pedological studies can be risky due to the fact that currently studied properties of the soils were formed under the influence of past plant communities which were usually replaced by secondary communities as a result of silviculture. Full reconstruction of the history of plant community development is usually impossible. Only the properties of O and A horizons form in a relatively short time, so they can be a good reflection of the contemporary plant communities' influence on the soil.

The properties of O horizon of forest soils are the result of plant-species composition as the source of litter fall of different chemical compositions and habitat conditions where plant litter is mineralized and humified [26, 27]. In the studied stands the average annual input of plant litter fall to the soil was comparable during 2007–2009 and was 2.806-5.398 t ha^{-1} (average 4.025 t ha^{-1}) in beech stand and 3.234–4.871 t ha^{-1} (average 4.288 t ha^{-1}) in mixed stand (Table 11). Differences in the pH and the chemical composition of beech, pine and spruce litter fall were found. Beech litter was richer in nitrogen, phosphorus, potassium and calcium, had higher values of pH and lower C:N and C:P ratios in relation to

TABLE 11. PLANT LITTER FALL MASS DURING 2007–2009 [15]

Year	Litter fall mass ($t \cdot ha^{-1}$)				
	beech	pine	spruce	other components	SUM
Beech stand					
2007	2.806	–	–	–	2.806
2008	3.871	–	–	–	3.871
2009	5.398	–	–	–	5.398
Mean	4.025				4.025
Mixed stand					
2007	1.879	0.386	0.205	0.764	3.234
2008	2.419	0.566	1.143	0.632	4.760
2009	3.416	0.555	0.079	0.821	4.871
Mean	2.571	0.502	0.476	0.739	4.288

pine and spruce [15]. Spatial variability of the quality of litter fall was reflected in the properties of O and A horizons of the examined soils. Higher stocks of SOM in O horizon in beech-pine and beech-spruce stand in relation to pure beech were found. The stocks of SOM in A horizon were less varied, slightly higher in beech stand. The most of SOM stocks in beech stand were concentrated in A horizon, in beech-spruce stand the stocks were comparable in O and A horizons, whereas in beech-pine stand the most of SOM was in ectohumus. The admixture of pine and spruce in beech stand had no significant influence on the content of TN and C:N ratio. This is a consequence of the fact that even in mixed stands the the beech litter fall and mean annual percentage of coniferous litter does not exceed 23% of its total weight.

The pH of the examined soils, especially in O horizon, referred to the spatial heterogeneity of the tree-species composition. Lower values of pH were noticed in the parts of tree-stands with the admixture of coniferous species. Such regularities were found by other authors too [1,4,6]. Slightly lower pH found in beech patches of mixed stand, in relation to pure beech stand, resulted probably from the influx of acidified under-crown water (in the form of an aerosol) from beech-pine and beech-spruce patches.

The admixture of coniferous species, which produce poor in nitrogen and very acid litter fall caused the reduction of the biological turnover intensity in the examined stand (Table 12). The intensity of the biological turnover in beech-pine stand was about 3-times and in beech-spruce stand about 2-times lower in relation to a pure beech stand. Despite the found differences, the intensity of the biological turnover was low in every stand [3].

TABLE 12. RATES OF BIOLOGICAL TURNOVER

Tree-stand	Rate of biological turnover
Beech	3.61
Mixed beech patches	5.60
Mixed beech-pine patches	10.50
Mixed beech-spruce patches	6.07

CONCLUSIONS

The results of the studies show significant influence of pine and spruce admixture in a beech stand on some properties of O and A horizons of the examined soils.

1. About 3-times higher stocks of SOM in ectohumus were found in beech-pine and about 2-times higher in beech-spruce in relation to a pure beech stand.

The increase of SOM stocks in mixed stands resulted from the reduction of the biological turnover intensity caused by the influx of coniferous litter of unfavorable features in terms of its decomposition. The stocks of SOM in A horizons were less varied between the stands, slightly higher in beech stand in relation to the mixed.

2. Lower values of soil pH were found in mixed stand in relation to beech.

3. There were no found statistically significant differences between the stands in nitrogen content, both in O and A horizons. The recorded spatial variability of nitrogen stocks related to spatial variability of SOM stocks in the soils studied.

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WPŁYW DOMIESZKI SOSNY I ŚWIERKA W DRZEWOSTANIE BUKOWYM NA WYBRANE WŁAŚCIWOŚCI POZIOMU ORGANICZNEGO I PRÓCHNICZNEGO GLEB BIELICOWO-RDZAWYCH ORAZ INTENSYWNOŚĆ OBIEGU BIOLOGICZNEGO

Celem przeprowadzonych badań była ocena wpływu domieszki sosny zwyczajnej *(Pinus sylvestris* L.) i świerka pospolitego *(Picea abies)* w drzewostanie bukowym *(Fagus sylvatica)* na zasoby materii organicznej oraz wybrane właściwości poziomu organicznego i próchnicznego gleb bielicowo-rdzawych oraz intensywność obiegu biologicznego. Badania przeprowadzono na terenie leśnictwa Łysomice (Nadleśnictwo Leśny Dwór, RDLP Szczecinek) w obrębie dwóch powierzchni badawczych zlokalizowanych w sąsiadujących ze sobą oddziałach leśnych. Jedna z powierzchni była położona w 120-letnim drzewostanie bukowym, a druga w drzewostanie bukowo-sosnowo-świekowym w podobnym wieku. Powierzchnia badawcza w drzewostanie mieszanym, na podstawie zasięgu koron poszczególnych gatunków drzew, została podzielona na płaty buka, płaty buka z domieszką sosny i płaty buka z domieszką świerka. Na każdej z powierzchni wytyczono sieć 41 punktów rozmieszczonych w sposób regularny, z których pobrano próbki poziomu organicznego i próchnicznego gleb. Na podstawie analiz określono zawartość i zasoby materii organicznej, węgla organicznego i azotu oraz odczyn gleb. Obliczono wartości średnie poszczególnych parametrów i porównano je z użyciem testu T-Studenta. Dysponując danymi o zasobach materii organicznej w poziomie organicznym gleb oraz masie opadu roślinnego w latach 2007–2009 obliczono wskaźnik obiegu biologicznego dla drzewostanu bukowego oraz poszczególnych płatów w drzewostanie mieszanym.

Stwierdzono istotny wpływ domieszki sosny i świerka w badanym drzewostanie bukowym na niektóre właściwości poziomu organicznego i próchnicznego gleb bielicowo-rdzawych. Na tle czystej buczyny we fragmentach drzewostanu z domieszką sosny obserwowano około 3-krotnie, a we fragmentach z domieszką świerka około 2-krotnie większe zasoby materii organicznej w ektopróchnicy. Wzrost zasobów materii organicznej w płatach z domieszką gatunków iglastych był związany ze spowolnieniem obiegu biologicznego spowodowanym dopływem iglastego opadu roślinnego o niekorzystnych cechach z punktu widzenia jego rozkładu. Zasoby materii organicznej w poziomach próchnicznych gleb były mniej zróżnicowane, nieco wyższe w czystej buczynie. Obserwowano wyraźny wpływ domieszki gatunków iglastych na odczyn gleb, szczególnie w ich poziomie organicznym. Niższe wartości pH obserwowano w płatach drzewostanu z domieszką sosny i świerka w porównaniu z płatami buka. Domieszka sosny i świerka nie znalazła wyraźnego odzwierciedlenia w stężeniu azotu zarówno w poziomie organicznym jak i próchnicznym gleb. Obserwowane przestrzenne zróżnicowanie zasobów tego pierwiastka wynikało z przestrzennej zmienności zasobów próchnicy w badanych poziomach.