

COMPARISON OF THE STATUS OF HUMUS FORMS IN YOUNG STANDS OF SPRUCE AND BEECH IN THE ŽÁKOVA HORA NATURE RESERVE*

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Presentation compares the status of humus forms in two young stands (35–40 years) of different tree species composition, of similar age, growing in the same site conditions. The humus forms reflect the effects of particular tree species, i.e. Norway spruce (*Picea abies*) and European beech (*Fagus sylvatica*), on humus form after several decades of growth. It was determined: the accumulation and basic soil chemistry characteristics. The territory of study was the virgin forest Žákova Hora Nature Reserve, in typical selected parts (forest site type 6D1 – *Piceeto-Fagetum acerosum deluvium – Impatiens noli-tangere*). Results document the progressing accumulation of holorganic layers in the spruce stand, together with the acidification of the soil surface. This is caused by the quality and quantity of litter, by the different transformation processes and different level of primary production of the both studied ecosystems.

natural forest ecosystems; middle altitudes; species composition; soil chemistry

INTRODUCTION

European beech (*Fagus sylvatica* L.) represents the most important ameliorative and stabilizing tree species considered in the forest management of the Czech Republic today. Economically and environmentally relevant increase of its rate is supposed in the tree species composition of the Czech forests: its original percentage reached 37.9%, being reduced to 6.2% today. The official aim is the increase to 18.0% of the forested area. In the last years, the annual increase of the beech rate is some 0.1% (Zprávy o stavu lesa a LH ČR – Mze ČR, 1998–2002). This tendency is documented by the necessity of the stabilization of forest stands, their biodiversity restoration and by the higher demands for ecological and environmental functions of forests. On the other side, there is really a low number of information on actual effects of particular tree species and tree species mixtures on different forest ecosystem compartments as well as on the environment. Partial results are documented e.g. by Školek, Bublinec (1981) and Podrázský (1999). The aim of this presentation is to describe the effects of growth and development of different tree species (European beech – Norway spruce) on the humus forms in conditions minimally disturbed by the man on the territory of the Nature Reserve (NR) Žákova Hora.

MATERIAL AND METHODS

The state of humus forms in the Norway spruce and European beech of the IInd age class was studied on the

area of the above-mentioned NR (beech group) and in its border (spruce part). Both stand groups originated by plantation 35–40 years ago, original site characteristics are very similar (identical) and the differences in the soil state can be considered mainly as a function of different tree species composition. The forest site type is determined as 6D1 (*Piceeto-Fagetum acerosum deluvium – Impatiens noli-tangere*), enriched spruce-beech site with *Mercurialis perennis* and *Impatiens noli-tangere* in the understorey. Description is documented in detail by Vrška et al. (1999). The humus form sampling was performed on both localities accordingly to particular layers (L, F₁, F₂, H, Ah – Green et al., 1993) in the autumn 2000. Samples were transported to the laboratory Tomáš (FGMRI – Station Opočno), where the quantity and chemical soil characteristics were determined. The steel frame 25 x 25 cm was used for the quantitative holorganic layers sampling, the dry matter was determined at 105 °C. From chemical soil characteristics it was determined: pH (H₂O, 1N KCl), soil adsorption complex characteristics by Kappen (S – bases content, T – cation exchange capacity, H – hydrolytical acidity, V – base saturation), further the exchangeable acidity, total nutrients content (holorganic horizons) after mineralisation by sulphuric acid and Se, AAS, total nitrogen content by Kjeldahl, carbon by combustion method, plant available nutrients in the 1% citric acid leachate. Older analytical methods were used for comparison with past determinations. Samples of particular horizons were taken in 4 replications. Bulk samples for financial reasons were formed directly in the field. The number of replications is on the significance limit, no statistical evaluation was enabled using bulk sample method.

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RESULTS AND DISCUSSION

Despite the thickness of the humus did not differ profoundly, considerable differences in the surface humus accumulation were determined: 32.3 t/ha in the beech and 92.7 t/ha in the spruce stand part (Table 1). Comparing to older stands, the thickness decrease of 1 to 2 cm was documented (P o d r á z s k ý , 2002). In both stands, the humus form can be described as Mor (G r e e n et al., 1993), despite the lower thickness of the particular holorganic layers (with exception of H horizon) in the beech stand. The results of the morphological survey of the humus forms document more rapid decomposition and transformation of the beech litter on the given locality.

Soil reaction (pH H₂O) was not distinctly different in the humus layers of both compared stands, a little lower it was in the mineral horizon of the spruce stand. Soil reaction in KCl showed similar tendencies, with bigger differences in favor of the beech stand. Significant was the lower content of bases in the spruce plot, especially of surface horizons (L + F₁), with considerable higher values in the beech. Those trends were reflected also by the higher hydrolytical acidity in spruce stands, by relatively comparable values of the cation exchange capacity and by the extreme low values of base saturation in the spruce stand part (Table 1).

Higher acidification in the soil compartment of the spruce stand was reflected also by higher values of the exchangeable acidity, which was determined especially by greater activity of the exchangeable aluminum (Table 2). Values of the total nitrogen content were (with exception of the H layer) similar in both stands. On the other side, higher content of the total phosphorus was documented in holorganic horizons of the spruce stand, which indicates bigger consumption and uptake by the broad-leaved stand. Similar trend was described also in other cases comparing spruce and broad-leaves (P o d r á z s k ý et al., 2002). The bases content (K, Ca, Mg)

was significantly higher in the top soil of the beech stand, being more effectively fixed and recycled, as well as the litter content is bigger on these elements there.

The humus content did not show simple and distinct differences between both stands. In the beech litter and less transformed fermentation horizon, the total nitrogen was slightly lower, indicating more rapid decomposition. The opposite trend in the F₂ horizon and lower, documents more favorable humus form under beech. The plant available P content was higher at the humus form layers of the beech stand with the exception of the H horizon – opposite dynamics to this element in total form. Dynamics of particular nutrient form needs more detailed research. Seasonality could be an explanation in this case. In the soil of the spruce stand, there was a lower content of plant available calcium and magnesium documenting bigger demands and soil depletion in these elements, as well as lower retention capacity of the spruce ecosystem. As for potassium, its content was lower in holorganic and higher in mineral horizons of the spruce stand – this can be considered as leaching of this macroelement in the lower horizons of the soil profile. The Fe sesquioxides were more accumulated in the layers of the spruce stand, accordingly to their higher acidity. In the Ah horizon of the beech stand, higher Fe contents were documented – this can be explained by its leaching from the A horizon of the spruce ecosystem – by the beginning crypto-podzolization (Table 3).

CONCLUSIONS

In general, the development trends can be evaluated as:

- relative more pronounced accumulation of surface humus in the spruce stand,
- more rapid and intense humus form (soil) acidification, especially of the top soil layers,

Table 1. Comparison of humus forms of young stands of beech and spruce – amount of surface humus and adsorption complex state

Stand	Thickness	Dry matter	pH H ₂ O	pH KCl	S	H	T	V
	cm	g/m ²			meq 100 g fine earth			%
Beech stand								
L	0.5	50.8	5.0	4.0	18.7	19.1	37.8	49.6
F ₁	0.5	288.4	5.1	4.0	27.6	33.3	60.9	45.3
F ₂	1.2	1811.2	4.4	2.9	2.0	30.2	32.1	6.2
H	2.25	1079.9	4.2	2.5	4.7	55.8	60.6	7.8
Ah			5.0	3.2	2.9	16.6	19.5	14.9
Total	4.5	3230.1						
Spruce stand								
L + F ₁	1.2	497.6	5.0	3.6	3.3	21.3	24.7	13.5
F ₂	1.6	2236.8	4.4	2.8	1.2	54.5	55.7	2.1
H	2.2	6538.0	4.4	2.5	1.1	55.1	56.2	1.9
Ah			4.7	3.1	3.3	20.7	24.0	13.8
Total	5.0	9272.4						

Table 2. Comparison of humus forms of young stands of beech and spruce – exchangeable acidity and total nutrients content

Stand	Acidity _{ex}	H _{ex}	Al _{ex}	N total	P total	K total	Ca total	Mg total
	meq/kg fine earth			%				
Beech stand								
L	31.7	18.7	13.0	1.41	0.12	0.24	0.28	0.050
F ₁	33.5	21.0	12.5	1.74	0.20	0.14	0.54	0.036
F ₂	54.7	20.7	34.0	1.92	0.12	0.14	0.20	0.026
H	93.7	15.6	78.1	1.48	0.11	0.18	0.20	0.008
Ah	72.5	3.6	68.8					
Spruce stand								
L + F ₁	35.2	17.0	18.2	1.66	0.15	0.12	0.48	0.018
F ₂	68.2	18.2	50.0	1.92	0.18	0.12	0.08	0.008
H	132.8	12.0	120.8	1.33	0.15	0.22	0.08	0.008
Ah	90.8	3.7	87.1					

Table 3. Comparison of humus forms of young stands of beech and spruce – content of total humus, nitrogen and plant available nutrients

Stand	Humus	A Kj.	P ₂ O ₅	K ₂ O	CaO	MgO	Fe ₂ O ₃
	%		mg/kg fine earth				
Beech stand							
L	59.1	1.49	–	–	–	–	–
F ₁	43.7	1.85	949	1233	5547	387	61
F ₂	60.8	2.07	399	557	2000	223	43
H	51.1	2.06	180	407	693	140	447
Ah	11.9	0.46	110	97	97	35	2211
Spruce stand							
L + F ₁	51.8	1.65	516	553	3573	360	85
F ₂	53.9	2.01	327	227	2053	197	152
H	55.5	1.82	210	353	453	93	567
Ah	11.2	0.40	81	103	90	32	1690

- this is caused by the more acid spruce litter, its quantity and more intense nutrient (base) uptake based on different primary production,
- different level of acid deposition in particular forest ecosystem types can also play important role,
- in any case, beech admixture in the spruce forest can ameliorate considerably the humus form quality.

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Srovnání stavu humusových forem v mladých porostech smrku a buku na území NPR Žákova hora.

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Na území NPR Žákova hora byl sledován stav humusových forem ve 2. věkové třídě porostů přirozené bučiny a nepřirozené smrčiny. Bylo vybráno stanoviště náležející do SLT 6D1 (obohacená smrková bučina netýkavková). Na podzim 2000 byly odebrány jednotlivé humusové horizonty L, F₁, F₂, H a Ah (Green et al., 1993). Na vzorkování byl použit kovový rámeček 25 x 25 cm. Suchá hmotnost byla určena vysušením při teplotě 105 °C. Z chemických charakteristik byly zjišťovány: pH (H₂O a 1N KCl), půdní adsorpční komplex podle Kappena, výměnná acidita, celkový obsah živin (holorganických horizontů) mineralizací v kyselině sírové a Se, AAS, celkový obsah dusíku podle Kjeldahla, celkový obsah uhlíku spalovací metodou a rostlinám dostupné živiny vyluhováním v 1% kyselině citronové. Tyto starší analytické metody byly použity z důvodu srovnání s dřívějšími analýzami. Vzorky jednotlivých horizontů byly odebírány ve čtyřech opakováních.

Z výsledků lze vyvodit tyto vývojové trendy:

- relativně výraznější akumulace povrchového humusu ve smrčině,
- rychlejší a silnější okyselení humusu, zvláště při půdním povrchu,
- je to důsledkem kyselejšího smrkového opadu, jeho množství a větší spotřebou bází,
- různá hladina kyselé depozice v určitých typech lesního ekosystému může též hrát důležitou roli,
- buková příměs ve smrčině může výrazně zlepšit kvalitu humusu.

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