EFFECTS OF THINNING REGIME ON THE HUMUS FORM STATE

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Abstract

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Accumulation and chemistry of the surface humus (humus forms) were studied on the Polom locality in the Orlické hory Mts. The plot was established in 1980 in 15 years old Norway spruce plantation. The density effect was studied (control variant and heavy thinning from below) on the accumulation, soil reaction (pH), soil adsorption complex by Kappen, content of total carbon and nitrogen as well as content of macronutrients in the plant available (citric acid) and total forms. Differences in the humus forms were not significant in many aspects. In the surface humus, differences in its accumulation reached 30%, caused also by methodical problems. Differences in the soil reaction were minor, it was documented an acidification process of forest soils in the period 1993–2002 on both sites. In the poor forests soils, there were not observed the changes in the soil adsorption complex and in the nutrient contents. Contents of the total nitrogen and carbon and their dynamics indicate the increasing intensity of decomposition processes. Total bases content decreased more obviously, documenting general trend of the organic matter mineralization and losses of nutrients by leaching.

Key words: humus forms, forest soils, accumulation, soil chemistry, thinning, Norway spruce

Introduction

The thinning effects of the environmental as well as ecological character are studied less often comparing to the production ones, including the effects on the soil ecosystem compartments. Much more attention is paid e.g. to the impacts of mechanized treatments, logging technologies, tree species change or amelioration treatments. The thinning and tending treatment affect the accumulation, transformation and mineralization of the organic litter by two ways, neglecting the tree species effects. The first way is represented by the litter amount in stands of different quantity and density of the canopy (Binkley, 1986; Klimo, 1990; Šály, 1978, 1988). It is supposed, that the amount of litter decreases, at least temporarily, in intensely thinned stands, because the biomass accumulation in the crown layer and lowering of litter production at lower crown (especially foliage) biomass (Hager, 1988; Wright, 1957).

The second factor is represented by changed micro-climatic conditions at the ground level, which are more favorable for organic matter transformation and mineralization in the more opened stands. Chroust (1954) describes in detail the effects of thinning and tending treatments on the microclimate in the oak and beech thickets. Similar effects in the spruce thickets were studied by Nováková (1971). Relatively remarkable changes were described also by Hager (1988) and Vyskot et al. (1962).

Thinning and tending usually results in the improvement of conditions for humification and mineralization of the organic matter, both by changing the humidity and thermic conditions. Effects of many factors were documented also experimentally. The increase of soil moisture did intensify the cellulose decay in the spruce stand soils in the Danish experiments (Beier, Rasmussen, 1994). Šály (1988) stated the activation of microflora by the temperature increase over 0 °C (cellulose decay), 7 °C for lignin decomposition respectively. Even small shifts in the average temperature so can change the transformation of the soil organic matter considerably, or prolong the activity of decomposers in the forest ecosystems. Very important is also the air movement and removing the metabolic products (carbon dioxide) from upper soil layers to prevent their self-suppression effects.

The silvicultural treatments effects were the object of interest only for limited number of specialists. For Czech conditions, the most important are the publications of Šarman (1979, 1982, 1985, 1986), dealing with thinning effects in the stands of the main climax species. From abroad, the presentations of Naumann (1987), Richter, Richter (1990) and Wright (1957) appear the most important. In the presented case, a thinning experiment is evaluated in the sub-mountain location of the Orlické hory Mts.

Material and methods

The experimental plot was established on the reforested clear-cut in the 15-years old thicket of the Norway spruce, originated by planting at the density of 3.000–4.000 pcs/ha in 1980 (Slodičák, 1992). The plantation originated at the locality after snow-break. The altitude is 800 m a.s.l., the forest type group is determined as 6K – acid spruce-beech site, management system as HS53 – spruce management of acid sites of higher altitudes. The soil type is possible to determine as Podzolic Cambisol to Cryptopodzol. The immission zone is B, climatic region C1, moderately cold. The research series includes 3 variants of the area 25x40 m.

The variant 1 is left without any treatment – as the control plot. On the variant 2, the Program 2 recommended for stands, endangered by abiotic factors was destined (Chroust, 1976). Accordingly to this program, reduction of individuals was performed to 2.000 pcs/ha at 15 years age, further treatments followed in the 5-year periods to the age 30 years, when the number 1.500 pcs/ha is reached. Next thinning periods increase to 10 years and the intensity is lowering.

The variant on the plot 3 follows the prescriptions of Tesař (1976), for the immission loaded stands in the fir-beech vegetation altitudinal zone. The basis is represented by 1 heavy thinning at the age 15 years, forming enough space for crown development of relatively resistant individuals. Following are less intense cut in longer periods for closing the canopy. For comparison of humus form development, plots 1 (control) and 3 were selected. The development of stands characteristics is documented in the Table 1.

T a b l e 1. Basic stand characteristics of the studied variants on the Polom locality.

Age variant	15					25				
Characteristics	N	BA	DBH	H	V	N	BA	DBH	H	V
	pcs/ha	m^2/ha	cm	m	m^3	pcs/ha	m^2/ha	cm	M	m^3
1	3.150	10.7	6.6	5.0	34.7	2.370	27.4	12.1	11.0	171.2
3	2.950	10.3	6.7	5.0	33.2	1.600	24.2	23.9	11.0	151.2

Note: N – number, BA – basal area, DBH – diameter at brest height, H – average height, V – volume

On each studied locality, samples of humus form layers were taken – L + F1, F2, H and Ah. Sampling was done in 4 replications in years 1993 and 2002. Layer determination was based on Green et al. (1993). The not disturbed sites were selected typical for the given variant: on the control plot, even in 1993 the higher number of windfalls and windbreaks was registered, resulting in local density decrease. The holorganic horizons were sampled quantitatively using steel frame 25x25 cm, not so the mineral Ah horizon.

The soil samples were processed in the laboratory of the Research Station Opočno by standard methods: the dry mass of holorganic layers at 105 °C, pH in water and 1 N KCl, soil adsorption complex characteristics by Kappen (S – bases content, H – hydrolytical acidity, T – cation adsorption capacity, V – bases content), total carbon and nitrogen content estimation by the Springer-Klee method, plant available nutrients (P, K, Ca, Mg) contents using AAS and spectrophotometry in 1% citric acid solution, total nutrients content in holorganic layers using mineralisation by selene and sulphuric acid and AAS (K, Ca, Mg) and spectrophotometry (P). Statistical evaluation was applied using analysis of variance at 95% confidence level.

Results and discussion

The humus form state, in the dependence on the stand density, was studied only in limited number of studies. All our results have to be considered as the pilot ones. In the case of the Polom research plot, the soil had always the forest character, without any interruption. The depth of particular organic horizons was very similar and no differences were documented. To be under differentiation limit, they were not measured.

T a b l e 2. Accumulation of the surface humus on particular variants of the Polom locality (t/ha).

Plot	1 K – Control				3 – Heavy thinning from below			
Horizon Year	L + F_1	F_2	H	Total	L + F_1	F_2	H	Total
1993	9.23	15.34	92.90	117.47	7.71	13.82	59.73	81.26
2002	7.15	20.80	29.02	56.97	5.25	16.98	44.51	66.82

Considerably higher surface humus amount was accumulated on the control plot in the year 1993 (Table 2). This was caused by two reasons:

– more early closure of the canopy and more rapid protection of the soil in the case of the dense control variant,

– more intense litter fall in the more dense stand.

In the period 1993–2002, the decrease of the surface amount was observed on both variants because of:

– accelerated decomposition of the surface organic matter in loosening stands, caused by thinning (thinned variant) and wind- as well as snow breaks of the unstable control plot,
– the bioturbation of the organic matter in the more deep mineral horizons. This was probably caused by the canopy opening. The ground vegetation appeared largely, which should be prevented by the canopy in similar stands,
– also the subjective factors at sampling could play the role, despite the attention it has had been paid.

The mixing of organic and mineral soil material was obvious especially in the more liberated control stand, where the humus content reached the values typical for holorganic horizons almost. Further reason can be the high frequency of visitors, with mechanical impact on the upper soil layers. Also Šarman (1982, 1985, 1986) documented variable but relevant for conclusions results, describing the simultaneous decline of the surface humus amount and of the stand density. The same was described by Naumann (1987), Richter, Richter (1990) and Wright (1957).

The soil reaction measured as the pH was similar among variants in the year 1993 (Table 3). During last 10 years, the values decreased in horizons F and H on the control variant. Other changes were minimal. Also the pH in KCl was similar between variants in 1993. The decrease was registered in the period 1993–2003 in deeper horizons, similarly on both plots. So the slight acidification is registered in the studied period.

The exchangeable bases content was similar on both plots in 1993, with exception of the Ah horizon, lower at the control variant. This characteristic did not change prominently to the year 2002, shifts were documented in different ways. The same was mentioned at the hydrolytic acidity (H-value by Kappen).

On the contrary, the cation exchange capacity values were higher in the holorganic horizons of the thinned variant in 1993, being similar in the mineral layer. There is documented an increase at the control variant in 1993–2002 and a stable state in the thinned one, this resulting in similar state on both variants in 2002. This can be the consequence of the canopy opening on the control variant, too.

Base saturation was similar on both variants in 1993. During the study period, the decrease of values on the control variant was documented (increase only in the mineral horizon), as well as the general increase on the thinned one. Changes in the base saturation copy to big extent the shifts in the total C and N content.

Higher values of the total nitrogen content were documented on the thinned variant in 1993, which is in co-incidence with lower cover and more intense mineralization here (correlation with surface humus amount and carbon content in the mineral horizon). The high stand density decrease especially on the control variant (due to damages) resulted in N-content increase during the period of study.

The plant available phosphorus content did not show any visible trend. On the contrary, the available potassium content was higher at the thinned variant, corresponding probably

T a b l e 3. Pedochemical characteristics of humus form layers on particular variant sof the Polom locality.

	Plot	1 K – control				3 – heavy from below			
Char	Horizon Year	L + F_1	F_2	H	Ah	L + F_1	F_2	H	Ah
C %	1993	n.d.	n.d.	n.d.	6.29	n.d.	n.d.	n.d.	7.17
	2002	n.d.	n.d.	n.d.	25.2	n.d.	n.d.	n.d.	8.6
pH H_2O	1993	4.05	3.88	3.40	3.43	4.05	3.78	3.37	3.52
	2002	4.10	3.55	3.20 a	3.48	4.08	3.62	3.50 b	3.48
pH KCl	1993	3.21	2.93	2.79	2.90	3.18	2.97	2.79	2.88
	2002	3.18 a	2.85	2.57	2.52	3.22 a	2.82	2.62	2.60
S	1993	12.8	12.6	4.4	1.4	14.9	13.1	5.0	3.0
	2002	4.12	8.52 a	4.02	4.50 a	5.40	13.2 b	10.48	2.78
H	1993	15.9	43.8	34.0	21.2	17.9	53.2	55.3	22.2
	2002	15.4	48.6	58.1	27.6	10.72	40.3	57.7	23.3
T	1993	28.8	43.8	38.3	22.6	32.8	66.3	60.3	25.2
	2002	19.5	57.2	62.1	32.1	16.1	53.5	68.2	26.0
V %	1993	44.7	22.4	11.4	6.1	45.4	19.7	8.3	11.8
	2002	18.7	14.9 a	6.4	14.1	27.2	27.4 b	14.4	49.1
N %	1993	1.65	1.61	0.98	0.38	1.61	1.85	1.17	0.41
	2002	1.43	1.77	1.55	1.25 a	1.32	1.71	1.57	0.45 b
P_2O_5	1993	n.d.	n.d.	n.d.	247	n.d.	n.d.	n.d.	190
	2002	463	384	273	254	628	375	288	120
K_2O	1993	n.d.	n.d.	n.d.	42	n.d.	n.d.	n.d.	60
	2002	739	465	258	174	920	512	371	122
CaO	1993	n.d.	n.d.	n.d.	300	n.d.	n.d.	n.d.	533
	2002	4.;120	2.;140	994	440	4.;440	2.;854	1.;260	278
MgO	1993	n.d.	n.d.	n.d.	47	n.d.	n.d.	n.d.	127
	2002	445	220	135	74	420	256	149	48
P tot	1993	0.101	0.097	0.089	n.d.	0.129	0.120	0.086	n.d.
	2002	0.142	0.160	0.120	n.d.	0.127	0.130	0.122	n.d.
K tot	1993	0.135	0.075	0.080	n.d.	0.120	0.100	0.093	n.d.
	2002	0.085	0.095	0.135	n.d.	0.133	0.095	0.165	n.d.
Ca tot	1993	0.320	0.180	0.100	n.d.	0.370	0.220	0.180	n.d.
	2002	0.360	0.038	n.d.	n.d.	0.207	0.052	n.d.	n.d.
Mg tot	1993	0.057	0.100	0.129	n.d.	0.065	0.110	0.109	n.d.
	2002	0.040	0.026	0.022	n.d.	0.025	0.028	0.030	n.d.

Notes: S, H, T – meq/100 g of fine earth, n.d. – not determined, available nutrients – in the oxide forms – mg/kg, total nutrients – %, statistically significant differences among comparable horizons are indicated by different indexes, absent if they are not present

with the lower uptake. In the mineral horizon, the content increase was registered in the period 1993–2002 (there were not performed these analyses in the holorganic layers in 1993). Also the content of plant available calcium was higher on the thinned variant in the holorganic horizons, the contrary was documented for the mineral one. In this case, the increase of its content was documented on the control variant, the contrary trend to the significant decrease on the thinned plot. Similar trend was documented for the available magnesium content.

The total phosphorus content increased in general in the holorganic horizons in the period of study, it was higher on the thinned variant in 1993, and on the control variant in 2002. Values were comparable. The same was documented for the total potassium content. In 1993, the total Ca and Mg contents were slightly higher on the thinned plot, a drastic decrease was observed in the period 1993–2002 for both elements.

Also Šarman (1982, 1985, 1986) proved the decrease of soil acidity after thinning and the better humification processes, which was reflected also in the nutrient cycles. Similar trend was documented also by foreign authors (Wright, 1957). In general, only limited number of references is available from comparable conditions, results from other regions are less relevant (e.g. Binkley, 1986). Evaluating the published and measured data, it is obvious, that the amount and quality of soil organic matter is affected to different level by thinning and tending, nevertheless, these treatments have smaller effects comparing to other silvicultural measures. This is a result of sustaining of the forest environment, its continual modification respectively, of the conservation of the litter type and moderate shifts in the litter as well as throughfall quality and quantity. The problems of thinning effects on the humus forms have to be studies also because of non-production functions of the forest and principles of sustainable forest management. The relation to the carbon and nitrogen cycle will be studied supposingly more intensively in the future, too.

Conclusion

In general it can be stated, that the differences between variants were not big on the locality with continual forest ecosystem. In the first period, at the forest stand sustained stable, the differences were approximately 30% in the surface humus accumulation in favour of the more dense variants. Further, the differences decreased since the forest canopy released together with humus decomposition changes. The changes in the soil reaction were smaller, there was documented the tendency in the soil acidification in the period 1993–2002. The shifts in the poor forest soils were not prominent as for the soil adsorption complex. The content of total nitrogen and its dynamics indicated the increased level of decomposition processes. The total bases content decreased obviously, documenting the total tendency of organic matter mineralization and nutrient losses by leaching. The humus form changes are minor in thinning treatments comparing to other silvicultural and forest management measures, but their importance can increase in specific conditions, e.g. at forest stand regeneration.

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Podrázský V.: **Vliv výchovných zásahů na stav humusových forem.**

Akumulace nadložního humusu a jeho pedochemické vlastnosti byly studovány na lokalitě Polom v předhůří Orlických hor, na ploše založené v r. 1980 v 15 let staré mlazině smrku ztepilého. Byl sledován vliv hustoty (kontrolní plocha bez zásahu a silný podúrovňový zásah) na množství nadložní organické hmoty, půdní reakci jednotlivých

holorganických horizontů, stav půdního sorpčního komplexu podle Kappena, obsah celkového uhlíku a dusíku a konečně obsah makroelementů v přístupné (výluh kyselinou citrónovou) a v celkové formě. Rozdíly ve stavu humusových forem nebyly nijak výrazné. Rozdíly v akumulaci nadložního humusu dosahovaly až 30%, způsobené byly částečně i metodickými aspekty. Rozdíly v hodnotách půdní reakce byly mírné, v období 1993–2002 byla doložena tendence acidifikace lesních půd. U chudých lesních půd nedošlo k jednoznačným změnám ve stavu půdního sorpčního komplexu a v obsahu přístupných živin. Obsah celkového uhlíku, dusíku a jeho dynamika indikuje rostoucí intenzitu dekompozičních procesů. Poklesl výrazně obsah celkových bází, to může souviset s celkovým trendem mineralizace organické hmoty a ztrát živin vyplavením.