Green alder effects on the forest soils in higher elevations

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ABSTRACT: Presented study documents the effects of green alder (*Alnus alnobetula* [Ehrh.] C. Koch) on the uppermost forest soil layers in mountain areas, respectively in the top part of the Orlické hory Mts. Three variants effect to the forest soil have been studied: pure groups of green alder, pure groups of Norway spruce and Norway spruce stand under-planted by green alder. The effect of alder stands litter influenced some basic soil characteristics: the surface humus accumulation (low), the bases content and base saturation (decreased). The green alder increased the acidification trends in the forest soils of the humus forms on the studied locality and intensified the mineralization and nutrient losses from the soil profile.

Keywords: immission areas; humus forms; biological amelioration; green alder

As a consequence of extend immission calamity, stands of preparatory broad-leaved (pioneer) species were used for forest restoration on large clearcuts. They should improve the forest environment for climax species regeneration and growth as well as for forest site revitalization (Podrázský 2000, 2001). Their effect is considered to be superior to the chemical amelioration very often (Hruška, Cienciala 2001). Among species of interest, green alder (*Alnus alnobetula* [Ehrh.] C. Koch – syn. *Duschekia alnobetula* Ehrh.) (Dostál 1989) (or *Alnus viridis* Chaix in Vill.), it is considered as potentially important species.

There are some objections from the part of nature conservation (this species is considered as non-indigenous in many areas) quite often, but many research plots were established for the growth and site remediation studies (Balcar, Podrázský 1994). Their evaluation is of great importance, because there is absolute lack of the information concerning the ecological effects of the species of interest. Only the first results concerning the green alder effects on the forest soils were published, indicating acidification effects due to increased nitrogen input (Podrázský, Ulbrichová 2003), in the Jizerské hory Mts. The presented study presents the results from another region with green alder plantations, from the Orlické hory Mts., and compares the effects of green alder on forest soils (humus forms) with those ones of Norway spruce (*Picea abies* [L.] Karst) as a sample of site corresponding needle tree species. The main objective was to study nitrogen and bases dynamics in both forest stands.

MATERIAL AND METHODS

Study was performed on the research plot Malá Deštná in the Orlické hory Mts., in the stand No. 130A. The research plot is located in the altitude around 1000 m, mean annual precipitation is between 1,000–1,200 mm, mean annual temperature varies about 5°C. Soil type was described as Cryptopodzol to Mountain Humic Podzol (Hraško et al. 1987). The bedrock is represented by the micaschists, the forest type as 7K1 – acid beech-spruce site with *Calamagrostis villosa*.

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The research plot was established in years 1985 to 1986. Three variants are studied: pure groups of green alder (18 years at sampling), pure groups of Norway spruce (age 78 years at sampling) and Norway spruce stand under-planted by green alder (78 years and 18 years, respectively). On each partial plot, sampling was performed on one place from L+F and H horizons and from uppermost 10 cm of mineral soil (Ae or Ep character). Samples were analyzed individually in the laboratory Tomáš (former Forestry and Game Management Research Institute, Research Station Opočno) by standard methods. In the fine earth, following soil chemical characteristics were determined: pH in water and 1 N KCl, soil adsorption complex characteristics by Kappen (S – bases content, H – hydrolytical acidity, T – cation exchange capacity, V – bases saturation), total carbon and nitrogen (Kjeldahl) contents, exchangeable acidity characteristics in the HCl solution, and plant available nutrients in the 1% citric acid solution. In this case, plant available P was then determined by the Spekol 210, plant available K by the flame photometry, plant available Ca and Mg by AAS. Total nutrients content (mineralization with sulphuric acid and selene) was determined by the AAS in holorganic horizons only. Statistically significant differences were tested by one factor analysis of variance at 95% level.

RESULTS AND DISCUSSION

Results were summarized in the Tables 1–3. It has to be understood, that different tree species and different stand ages combine in their effects on the soil state. The mixed stand showed the maximum thickness of the surface humus layers, this amount was lowered especially by the pure green alder stands, in which effect the species and age shift play their role. In the mixed stand were documented also the highest values of pH, with exception of the uppermost horizon, the lowest values were measured in the green alder stand. On the contrary, the highest contents of exchangeable bases we determined in the pure Norway spruce stand, statistically significant, the admixture or dominance of green alder caused the bases losses. Hydrolytical acidity showed the opposite trend, so the cation exchangeable acidity did not differ significantly among variants. Base saturation was statistically significantly lowered by the green alder presence (Table 1). Very similar trends were studied in similar conditions from the Jizerské hory Mts. (Podrázský, Ulbrichová 2003). On the contrary, the stands of different alder species exhibit significant amelioration effects on degraded sites (Podrázský et al. 2003).

Exchangeable acidity was highly and significantly increased by the green alder presence, only the exchangeable hydrogen, connected with the humus transformation intensity, did show the opposite tendency. Total nitrogen content was surprisingly the highest in the mixed stand and the lowest in the pure green alder one. This can be connected with the large nitrogen losses from the intensively mineralized holorganic horizons under alder stands after clear-cut of the original spruce stand, reaching up to 50 kg of N losses per year and ha (Binkley 1986) and nitrogen immobilization from the alder litter in the mixed stand (Wesemael 1992). Also the total humus content indicated higher activity in holorganic horizons in broad-leaved and mixed stands (Table 2).

Table 1. Soil reaction and soil adsorption complex characteristics in soils of stands of the Malá Deštná locality

Stand	Horizon	Thickness (cm)	pH H_2O	pH KCl	S	H	T	V (%)
					(mval/100 g)			
Norway sp.	L + F	4.8 ab	4.8	4.2	45.0 a	35.5 a	80.5	55.0 a
	H	6.5	4.2	3.5	26.4 a	44.4	70.8	36.0 a
	Ae	10	4.0 a	3.3	3.1	9.5 a	12.6	24.5
Green alder	L + F	4.0 a	4.6	4.1	41.8 ab	38.3 a	80.2	53.6 a
	H	6.2	4.2	3.4	12.8 b	37.1	50.0	28.4 ab
	Ae	10	4.0 ab	3.2	2.5	10.4 a	12.9	19.7
Mixed	L + F	5.2 b	4.8	3.8	22.5 b	59.4 b	81.9	27.8 b
	H	8.8	4.6	3.6	12.0 b	50.4	62.5	19.4 b
	Ae	10	4.4 b	3.5	2.7	15.4 b	18.0	14.6

Table 2. Exchangeable acidity, total humus and nitrogen content in soil of stands of the Malá Deštná locality

Stand	Horizon	Acidity ex.	H ex.	Al ex.	N Kj. (%)	Humus (%)
		(mval/1,000 g)				
Norway sp.	L + F	27 a	8.0 a	19.4 a	2.13	50.7
	H	56	5.8	50.2	1.48 ab	43.7
	Ae	52 a	1.4	50.6 a	0.23	13.6
Green alder	L + F	53 ab	5.4 b	47.7 ab	1.75	47.2
	H	88	4.4	83.4	1.09 a	30.4
	Ae	71 ab	1.5	69.3 ab	0.21	5.6
Mixed	L + F	121 b	5.5 b	115.7 b	2.21	59.3
	H	129	3.3	126.0	1.91 b	45.6
	Ae	99 b	1.6	97.1 b	0.37	10.6

Table 3. Total and plant available nutrients content in soil of stands of spruce and green alder of the Malá Deštná locality

Stand	Horizon	N total	P total	K total	Ca total	Mg total	P_2O_5 avail.	K_2O avail.	CaO avail.	MgO avail.	Fe_2O_3 avail.
Norway sp.	L + F	2.14	0.15	0.25	0.22	0.29	325	602	5,626	2,340	501 a
	H	1.66 ab	0.12 a	0.46	0.02	0.12	200	227 a	1,983	840	704 a
	Ae						80 a	49	243	110	367 a
Green alder	L + F	1.79	0.13	0.48	0.08	0.31	264	250	5,946	2,630	854 a
	H	1.15 a	0.10 a	0.54	0.01	0.05	174	99 b	976	537	640 a
	Ae						92 a	36	201	118	430 a
Mixed	L + F	2.38	0.18	0.22	0.05	0.17	590	427	3,180	1,382	1,573 b
	H	1.84 b	0.24 b	0.94	0.01	0.05	656	162 ab	403	172	1,918 b
	Ae						391 b	37	148	48	820 b

Different indexes indicate statistically significant differences

The total phosphorus trend was similar to the nitrogen dynamics, indicating the general quality of the organic matter in particular stands. The total potassium contents were increased in the stands with green alder, reflecting so the presence of grass layer here too. Grass contents in K are substantially higher comparing to the tree species. On the contrary, total Ca as well as Mg contents were lowered by the alder presence.

Plant available phosphorus content was the highest in the mixed stand and the lowest in the pure green alder stand again, indicating positive effects of the alder on the organic matter in the case of under-plantings. Alder presence significantly lowered the plant available potassium contents both in pure or mixed stands and the same was detected for the available forms of calcium as well as magnesium. Plant available (soluble) iron content was on the contrary significantly increased, especially in the mixed stand (Table 3).

Similar effects of green alder were documented in the Jizerské hory Mts., as mentioned above (Podrázský, Ulbrichová 2003). The increased input of nitrogen led to increase of its contents, connected with accelerated mineralization and losses of nitrates connected with bases. Alder species in the case of intact surface humus layer cause the losses of bases and acidification of the soil surface (Binkley 1986), on the contrary, on the scarified soils and on the reforested agricultural lands, they can substantially improve and accelerate the favorable holorganic layers formation (Podrázský et al. 2003; Remeš, Podrázský 2002).

CONCLUSIONS

Results of the presented study confirmed the potential for both positive as well as negative consequences of the green alder plantations in the higher mountain localities.

In the presence of intact surface humus (holorganic) layers, the green alder, similarly to other alder species:

- produces the litter of more favorable composition,
- recycles more rapidly some nutrients,
- provides nitrogen fixing into the forest ecosystem.

On the contrary, on localities with naturally slower nutrient cycling this means:

- increased mineralization of the surface organic matter on localities without tree shelter, or with forest stands of reduced vitality,
- increased nutrient, especially bases losses from the soil compartments of forest ecosystems,
- accelerated forest soil acidification due to nitrate leaching.

The cultivation of alder species, including the green alder, can be useful tool in the forest soil restoration in convenient conditions and on suitable localities. They can be generally indicated as: localities without effective holorganic layers, degraded of reforested after other use. On intact localities with high holorganic horizons amount, it on the contrary can increase the ecological risks.

References

BALCAR V., PODRÁZSKÝ V., 1994. Založení výsadbového pokusu v hřebenové partii Jizerských hor. Zprávy lesnického výzkumu, *39* (2): 1–7.

BINKLEY D., 1986. Forest Nutrition Management. New York, J. Wiley: 289.

DOSTÁL J., 1989. Nová květena ČSSR. 1. díl. Praha, Academia: 106.

HRAŠKO J. et al., 1987. Morfogenetický klasifikačný systém pôd ČSSR. Bratislava, ČSAV: 107.

HRUŠKA J., CIENCIALA E. (eds.), 2001. Dlouhodobá acidifikace a nutriční degradace lesních půd – limitující faktor současného lesnictví. Praha, MŽP: 160.

PODRÁZSKÝ V., 2000. Vliv druhového složení porostů na stav lesních půd. Práce VÚLHM, *82*: 115–124.

PODRÁZSKÝ V., 2001. Effect of substitute tree species on the forest soils. In: Perspectives of the Ecological Research in Mountain Forest Ecosystems, Conference 22.–25. Oct., Polana. Zvolen, Forest Research Institute: 57.

PODRÁZSKÝ V.V., REMEŠ J., ULBRICHOVÁ I., 2003. Biological and chemical amelioration effects on the localities degraded by bulldozer site preparation in the Ore Mts. – Czech Republic. Journal of Forest Science, *49*: 141–147.

PODRÁZSKÝ V., ULBRICHOVÁ I., 2003. Soil chemistry changes in green alder [*Alnus alnobetula* (Ehrh.) C. Koch] stands in mountain areas. Journal of Forest Science, *49*: 104–107.

REMEŠ J., PODRÁZSKÝ V.V., 2002. Vliv opatření biologické a chemické meliorace na obnovu humusového profilu na stanovišti degradovaném buldozerovou přípravou v Krušných horách. In: Krajina, les a lesní hospodářství. Sekce IV: Obnova funkčních lesních ekosystémů Krušných hor. Praha, ČZU: 43–51.

WESEMAEL B. VAN, 1992. Soil organic matter in Mediterranean forests and its implications for nutrient cycling and weathering of acid, low-grade metamorphic rocks. [Thesis Universiteit van Amsterdam.] Amsterdam, University of Amsterdam 1992: 140.

Vliv olše zelené na lesní půdy ve vyšších nadmořských výškách

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ABSTRAKT: Příspěvek dokumentuje vliv olše zelené (*Alnus alnobetula* [Ehrh.] C. Koch) na nejsvrchnější vrstvy lesních půd v horských oblastech, resp. ve vrcholové části Orlických hor. Studovaly se tři varianty: čistý porost olše zelené, čistá dospělá smrčina a smrčina stejného věku s podsadbou olše. Porost olše měl vliv na základní půdní charakteristiky, jako je akumulace humusu (v tomto případě nejnižší), obsah výměnných bází a nasycení sorpčního komplexu, kde došlo ke snížení. Olše zelená dále zvyšovala podle všech charakteristik půdní aciditu, zvyšovala mineralizaci humusu a zvyšovala ztráty bází z půdního profilu.

Klíčová slova: imisní oblasti; humusové formy; biologická meliorace; olše zelená

Studie dokládá vliv olše zelené (*Alnus alnobetula* [Ehrh.] C. Koch) na nejsvrchnější vrstvy lesních půd v horských oblastech, resp. ve vrcholové části Orlických hor. Výzkumné plochy jsou v nadmořské výšce kolem 1 000 m, průměrná roční teplota je zde 4–5°C, průměrné roční srážky 1 000–1 200 mm. Půdní typ je charakterizován jako kryptopodzol až horský humusový podzol, lesní typ jako 7K1 – kyselá buková smrčina se třtinou chloupkatou. Geologický podklad tvoří svor. Výzkumné plochy byly založeny v letech 1985–1986, studovaly se tři varianty: čistý porost olše zelené (věk 18 let v době odběru vzorků), čistá dospělá smrčina (78 let) a smrčina stejného věku s podsadbou olše. Sledovali jsme mocnost horizontů nadložního humusu a základní pedochemické charakteristiky humusových forem.

V porostu olše byla doložena nejnižší akumulace nadložního humusu spolu s nejnižšími hodnotami pH (tab. 1). Skládal se v tom věk porostu založeného na holině a vliv opadu s rychlých rozkladem. Příměs nebo dominance olše vede k poklesu obsahu výměnných bází, ke statisticky významnému poklesu nasycení sorpčního komplexu, na druhé straně byla zvýšena hydrolytická a výměnná acidita (tab. 1 a 2). Obsah humusu byl rovněž nižší v porostu olše, což indikuje intenzivnější dekompoziční procesy. Totéž platí pro obsah celkového dusíku, ten byl naopak nejvyšší ve smíšeném porostu. Přítomnost olše tak zvyšovala ztráty bází z půdního profilu, zvyšovala acidifikační trendy a ztráty živin (tab. 3). Zvýšeno bylo vyplavování a ztráty draslíku (to bylo zčásti kompenzováno jeho zvýšenou fixací travní vegetací), ale především vápníku a hořčíku. Kultivace různých druhů olše včetně olše zelené se jeví jako vhodné opatření biologické meliorace půd na degradovaných nebo zalesňovaných lokalitách, na místech s intaktními holorganickými horizonty ve vyšších nadmořských výškách však představuje určité ekologické riziko.

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