EFFECTS OF GIANT FIR CULTIVATION ON THE HUMUS FORM*

V. V. Podrázský

Czech University of Agriculture, Faculty of Forestry, Department of Silviculture, Prague, Czech Republic

Presentation summarizes the effects of the Giant fir stand on the humus form status: accumulation of the surface holorganic layers and their pedochemistry comparing to the Norway spruce. Quantitative sampling (end of September 2000) of the holorganic horizons was performed (frame 25 x 25 cm in four replications) and basic pedochemical analyses were done: pH, adsorption complex characteristics by Kappen, exchangeable acidity, total nitrogen, humus, macroelements (N, P, K, Ca, Mg) contents and plant available macroelement content. Giant fir represents an intensively growing introduced tree species with production of relatively favourable litter and intense uptake of nutrients. This is reflected in the lower surface humus accumulation (16.528 t/ha against 28.636 t/ha in the spruce stand), its lower acidity and higher bases content. On the contrary, fir uptake of limited bioelements (especially N and P) decreased their content in the forest soil. High attention has to be paid to the biocycles management on comparable sites from the viewpoint of their stability and forestry sustainability.

silviculture; monocultures; Giant fir; spruce; humus forms; accumulation; organic matter; soil chemistry

INTRODUCTION

Introduction of some selected tree species was considered as an option for forestry intensification in the last centuries. Numerous research plots were established involving plantation, growth and production of them, despite of existing legislation barriers and market as well as technological limits. Topical target of the silvicultural research is represented by their evaluation. Giant fir (*Abies grandis* Lindl.) represents one of interesting introduced tree species with considerable production, ecological and environmental potentials. There are data disposable on its growth and development (e.g. Hofman, 1963; Šika, 1983; Vančura, 1990), but there are totally missing data concerning its effects on forest soils as well as on the other ecosystem compartments. So an aim of the presented study is to document the effects of Giant fir cultivation on the humus forms in conditions of the School Training Forest Kostelec nad Černými lesy.

MATERIAL AND METHODS

Effects of the Giant fir on the uppermost layers of forest soils were studied in the stand 118B2 (altitude 350 m a.s.l., forest type – SLT 3S, fresh oak-beech stand, age 24 years) on the territory of the School Training Forest Kostelec nad Černými lesy. Humus form quality was compared with the neighbouring stand of the Norway spruce of comparable age (118B3). Humus and soil samples were taken (27. 9. 2000) using steel frame 25 x 25 cm in four replications, separately by particular horizons (L + F_1, F_2 + H, Ah). Holorganic horizons were sampled quantitatively, unlike the mineral one. Directly in the field bulk samples were formed, they were analysed in the Laboratory Tomáš (FGMRI RS Opočno) using standard analytical methods. It was determined: dry mass of holorganic horizons and their macroelements (N, P, K, Ca, Mg) content (mineralisation by sulphuric acid and selene, AAS), plant available content in all samples (1% citric acid solution, AAS), pH, soil adsorption complex characteristics by Kappen, exchangeable acidity and its compartments, total humus content by combustion method and total nitrogen content by Kjeldahl. Replication number is on the significance limit of sampling.

RESULTS AND DISCUSSION

Introduction of the Giant fir is also considered as an alternative to the declining domestic Silver fire (*Abies alba* L.), besides of other possibilities, i.e. crossing of fir species (Kobliha, 1989; Kobliha, Janeček, 2000). Our results confirmed visible effects of this species on the humus form ecosystem compartment. Surface humus accumulation was more pronounced in the Norway spruce stand (Table 1), the difference was more obvious in the case of more transformed holorganic horizons (H-horizons). It can be concluded, that the litter decay and transformation is less intense here. Higher values of the soil reaction were registered, on the contrary, in the H layer of the fir stand, opposite situation

* The study was funded by the Research Project of the Ministry of Education, Youth and Sports MSM 414100008 Possibilities of increase of ecological stability, retention and water accumulation in landscape, during the study originated also the diploma thesis of Dipl. Ing. Eva Procházková.

Table 1. Accumulation of surface humus and its basic pedochemical characteristics in the stands of Giant fir and Norway spruce

Stand	Horizon	Accumulation		pH H_2O	pH KCl	S	H	T	V	Aci ex.	H ex.	Al ex.
		g/0.25 m^2	t/ha			mekv/100 g			%	meqv/kg		
Fir	L + F_1	109.5	4.38	5.9	4.0	63.2	11.1	74.2	85.1	79.2	9.6	69.6
	F_2 + H	303.7	12.148	5.7	3.8	54.2	24.6	78.8	68.8	65.3	2.1	63.2
	Ah			5.1	3.3	5.2	9.1	14.3	36.2	34.1	1.6	32.6
Total			16.528									
Spruce	L + F_1	150.4	6.016	5.6	4.0	57.6	16.8	74.4	77.4	92.6	11.2	81.4
	F_2 + H	565.0	22.62	5.1	3.1	34.1	43.6	77.7	43.9	92.2	2.8	89.4
	Ah			5.3	3.1	2.2	9.1	11.3	19.2	44.6	1.7	43.0
Total			28.636									

S – bases content, H – hydrolytical acidity, T – cation ex. capacity, V – bases saturation, Aci, H, Al ex. – exchangeable acidity, hydrogen, alluminum (meqv/kg)

was documented in the upper layer of the mineral soil for the pH (H_2O). Soil reaction determined in 1 N KCl was lower in the spruce stand again, indicating higher acidity here.

This tendency is connected also with the bases content (S-value), being lower also in the humus forms of the spruce stand, in the whole studied soil profile. Opposite tendency was shown by the hydrolytical acidity (H-value). Almost similar values of the cation exchange capacity were observed as a result (T). Base saturation values are finally visibly higher in the Giant fir stand – this characteristics was considerably low in the A horizon of the Norway spruce stand. This is corresponding with clearly higher contents of exchangeable acid cations in the soils and humus of the spruce stand.

Total humus content in holorganic layers was higher in the spruce stand again (Table 2), indicating slower mineralisation and transformation of the organic matter, as well as its higher accumulation. More rapid decay of the fir litter is documented also by lower total nitrogen content in the holorganic layers, litter of this species is so decomposed more rapidly and the mixing of organic matter with the mineral one is more intense. This is documented both by higher total carbon as well as nitrogen contents in the mineral A horizon of the Giant fir stand.

In the whole studied profile, i.e. in the litter to mineral A horizons, the plant available phosphorus content is higher in the spruce stand. This fact documents, that the phosphorus is a limiting nutrient on the given site. Intensively growing Giant fir shows considerable uptake of it. Similar situation is documented in the neighbouring stand, where the phosphorus showed similar tendency (in order of primary production intensity) in stands of Norway spruce and Douglas fir (Podrázský et al., 2001a, b). The bases content is or similar or it is lower in the spruce stand - this is in accordance with higher soil (humus) acidity here. Also the content of iron sesquioxides is higher in the fir stand, indicating higher root activity.

At least, Table 3 documents total nutrient content in holorganic horizons of both stands. The nitrogen content is lower in the fir stand, this fact was commented yet, the same tendency was observed for total phosphorus. On the contrary, the bases content is higher in the humus form created by this tree species.

Results of soil analyses document slower dynamics of the organic matter and lower intensity of nutrient cycling in the Norway spruce stand compared to the stand of Giant fir. Both tree species affected the soil environment similarly by a high nutrient uptake and litter deposition. Giant fir formed a humus form with higher organic matter turnover rate and lower acidity. There is more intense nutrient cycling in stands of this species. Limiting bioelements are used more effectively and the soil is depleted with this respect. During the rotation, the soil can be depleted in nutrients by biomass fixing, even the degradation can be expected. Greater biomass removal should be prevented also to control soil fertility here.

CONCLUSIONS

Presented results are the first data available concerning the effects of Giant fir on the soil compartment of forest ecosystems. Comparing to the Norway spruce, i.e. standardly cultivated species in even-aged monocultures country-wide, which is supposed to degrade soils on non-natural sites, Giant fir formed the humus forms of more moderate chemistry. Its high primary production was documented as intense bioelement uptake causing considerable soil nutrient depletion and limited the nutrient cycling.

Less accumulation of surface humus and more rapid humification as well as mineralisation can be expected in the stands of the Giant fir. Also the mixing of organic and mineral soil compartments is more intense. Bases are recycled more effectively and their content is higher in the soil of the fir stand, soil acidity characteristics are lower on the contrary here. Intense growth of the Giant fir results in the fixation of limiting bioelements (in the studied stand especially nitrogen and phosphorus) by the growing forest stand. From the point of view of the sustainable site fertility, the minimizing of biomass removal by logging is recommended. Harvest of assortments of

Table 2. Contents of total humus, nitrogen and plant available nutrients in the stand of Giant fir and Norway spruce – humus forms

Stand	Horizon	Humus total	N total	P_2O_5	K_2O	CaO	MgO	Fe_2O_3
		%		mg/kg				
Fir	L + F_1	51.9	1.36	447	1760	11 200	880	227
	F_2 + H	42.1	1.14	404	457	7 467	421	608
	Ah	5.8	0.26	133	100	500	57	898
Spruce	L + F_1	64.6	1.44	756	887	10 933	797	200
	F_2 + H	52.2	1.22	461	607	6 333	451	429
	Ah	5.0	0.20	168	97	260	55	786

Table 3. Content of total nutrients in holorganic horizons of Giant fir and Norway spruce stands

Stand	Horizon	N	P	K	Ca	Mg
		%				
Fir	L + F_1	1.47	0.21	0.18	1.50	0.076
	F_2 + H	1.30	0.21	0.30	1.10	0.018
Spruce	L + F_1	1.53	0.32	0.13	1.32	0.062
	F_2 + H	1.39	0.26	0.24	0.58	0.018

the highest quality is desirable, and/or soil amelioration treatments can be applied.

REFERENCES

HOFMAN, J.: Pěstování jedle obrovské (Cultivation of Giant fir). 1st ed. Praha, SZN 1963. 116 pp.

KOBLIHA, J.: Some results of hybridization and conservation of the genofund of *Abies alba*. In: Proc. Int. Symp. Forest Genetics, Breeding and Physiology of Woody Plants, Voronezh, September, 24–30, 1989: 59–63.

KOBLIHA, J. – JANEČEK, V.: Growth of progenies from spontaneous hybrids within genus *Abies* in comparative plantations. In: Proc. 9th Int. Europ. Silver Fir Symp., Skopje, Macedonia, May, 21–26, 2000: 27–36.

PODRÁZSKÝ, V. – REMEŠ, J. – LIAO, C. Y.: Vliv douglasky tisolisté (*Pseudotsuga menziesii* /Mirb./ Franco) na stav lesních půd. In: Krajina, les a lesní hospodářství (Effect of Douglas fir /*Pseudotsuga menziesii* Mirb. Franco/ on the forest soils). I. In: Proc. Conf., Czech University of Agriculture Prague, 22.–23. 1. 2001a: 24–29.

PODRÁZSKÝ, V. – REMEŠ, J. – MAXA, M.: Má douglaska degradační vliv na lesní půdy? (Does have the Douglas fir a degradation effect on forest soils?). Lesn. Práce, *80*, 2001b: 393–395.

ŠIKA, A.: Introdukce jedle obrovské v ČSR (Introduction of Giant fir in the Czech Republic). Zprávy lesn. výzkumu, *28*, 1983: 1–3.

VANČURA, K.: Provenienční pokus s jedlí obrovskou série IUFRO ve věku 13 let (Provenance experiment of Giant fir – IUFRO series – at the age of 13 years). Práce VÚLHM, *75*, 1990: 47–66.

Received for publication on January 21, 2003
Accepted for publication on February 11, 2003

PODRÁZSKÝ, V. V. (Česká zemědělská univerzita, Lesnická fakulta, katedra pěstování lesů, Praha, Česká republika):

Vliv pěstování jedle obrovské na stav humusových forem.

Scientia Agric. Bohem., *34*, 2003: 63–66.

Jedle obrovská (*Abies grandis* Lindl.) patří k nejvýznamnějším introdukovaným dřevinám pro svůj rychlý růst, produkci hodnotného dříví i krajinářské využití. Rovněž hynutí domácí jedle bělokoré (*Abies alba*) přispělo k zájmu o tuto dřevinu jako druh substituční. Jedle obrovská je po stránce růstu a produkce sledována v řadě experimentů a provenienčních pokusů, zcela však chybí zhodnocení jejího vlivu na jiné složky lesních ekosystémů, především na lesní půdy. Cílem předloženého příspěvku je proto zhodnotit vliv jedle obrovské na stav humusových forem v konkrétním porostu (ŠLP Kostelec nad Černými lesy, 118B2, n. v. 350 m a. s. l., SLT 3S, stáří 24 let) ve srovnání s rovněž stanovištně nepůvodní, ale domácí dřevinou používanou nejčastěji (sousední porost smrku 118B3, srovnatelné stáří cca o 10 let vyšší, stejné stanovištní podmínky).

Vzorky horizontů nadložního humusu a minerálních horizontů Ah byly odebírány koncem září 2000 ve čtyřech opakováních a přímo v terénu byly tvořeny směsné vzorky. Holorganické vrstvy byly odebírány kvantitativně pomocí

rámečku 25 x 25 cm. V laboratoři VÚLHM VS Opočno (fa Tomáš) bylo stanoveno: množství nadložního humusu a obsah celkových živin po mineralizaci kyselinou sírovou a selenem (AAS), u minerálních vzorků obsah přístupných živin ve výluhu 1% kyselinou citronovou (AAS), u všech vzorků půdní reakce aktivní i potenciální, stav sorpčního komplexu podle Kappena, hodnoty výměnné acidity, obsah celkového uhlíku (humusu – žíháním) a celkového dusíku (metoda dle Kjeldahla).

Získané výsledky jsou shrnuty v tabulkách 1–3. Dokládají, že v porostech jedle obrovské dochází ve srovnání se smrkem k tvorbě opadu s příznivějším chemismem, k nižší akumulaci nadložního humusu (jedle 16,528 t/ha, smrk 28,636 t/ha), jeho rychlejší transformaci a mineralizaci a k intenzivnějšímu mísení organické a minerální půdní složky v povrchových půdních horizontech – to indikuje vyšší biologickou aktivitu půdy. Báze jsou recyklovány mnohem intenzivněji, půdní kyselost je ve sledovaném profilu nižší. Intenzivní růst jedle má za následek značný příjem živin a jejich fixaci v biomase porostu, což vede u stanovištně deficitních bioelementů k jejich poklesu v půdě. V případě konkrétního sledovaného porostu se jednalo o dusík a fosfor. Při zakládání a pěstování porostů jedle obrovské musí být výživě porostů věnována zvýšená pozornost, neboť jednostranné vyčerpání půdních živin může (i ve srovnání se smrkem) vést k degradaci stanoviště. Pozornost tedy musí být věnována vlivu meliorační příměsi, otázkám ztrát odběrem biomasy a eventuálně úpravě výživy prostředky chemické meliorace (hnojení).

pěstování lesů; monokultury; jedle obrovská; smrk; humusové formy; akumulace; organická hmota; půdní chemismus

Contact Address:

Prof. Ing. Vilém V. Podrázský, CSc., Česká zemědělská univerzita v Praze, Lesnická fakulta, katedra pěstování lesů, Kamýcká 957, 165 21 Praha-Suchdol, Česká republika, tel.: +420 224 383 403, e-mail: podrazsky@lf.czu.cz