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Effects of afforestation on soil structure formation in two climatic regions of the Czech Republic

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ABSTRACT: The aim of this study was to determine the effect of agricultural land afforestation on soil characteristics. Two sites in two regions of the Czech Republic were evaluated, at lower as well as higher submountain elevations: in the regions of the Orlické hory Mts. and Kostelec nad Černými lesy, afforested, arable and pasture lands were compared for basic chemical and physical characteristics. It was determined: pH, CEC, exchangeable nutrients, SOC, bulk density, volume density, porosity (differentiated by pore size), water conductivity and soil aggregate stability. This study demonstrated the important influence of previous land use upon soil characteristics. The characteristics of the arable horizon can persist for many years; in forests, the mineral horizons (15–30 cm) can persist within 15–30 years after afforestation. Afforestation, which caused an increase in soil porosity by decreasing reduced bulk density and increasing capillary and gravitational pores (increasing the water-holding capacity and soil air capacity), is important for maintaining the soil stability. The positive effect on infiltration and retention capacity resulted not only from the presence of a forest overstorey, but also from the presence of permanent grass cover of pasture land.

Keywords: water-stable aggregates (WSA); mean weighted diameter (MWD)

Forests play a prominent role in carbon (C) transfer fluxes through photosynthesis and respiration and represent an important carbon pool in terrestrial ecosystems (Brown, Lugo 1990; Merganičová, Merganič 2010; Sefidi, Mohadjer 2010; Marková et al. 2011). Occupying roughly 30% of the land surface, forest ecosystems store more than 80% of all terrestrial aboveground C and more than 70% of all soil organic carbon (SOC) (Six et al. 2002). Therefore the multiple effects of soil organic matter (SOM) on nutrient dynamics (Binkley 1995), carbon cycling (Nambiar 1996) and soil structure formation (Caravaca et al. 2001) are important to maintain or enhance SOM in forest ecosystems with the goal of forest resource sustainability. The extensive roots of trees and other forest vegetation affect microbial biomass in the soil by controlling carbon cycling between the atmosphere and the soil (Brown et al. 2002). Land use also has an important influence on soil properties and stabilization (Tisdall, Oades 1982), as do silvicultural treatments (Grashey-Jansen 2012; Malek, Krakowian 2012).

With changes in land use, soil microaggregates and particles may form macroaggregates through the action of temporary and transient binding agents (Elliott 1986). The stability of these soil aggregates, as measured by water-stable aggregates

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(WSA) and mean weighted diameter (MWD), determines the soil structure (Filho et al. 2002). As an important indicator of soil quality, the soil structure directly or indirectly influences other physical and chemical soil properties (Cerda 2000). The biogeochemical dynamics of forest soil improves soil aggregation compared to soil on agricultural lands, mainly by the transfer of organic carbon into deeper soil horizons (e.g. Podrázský et al. 2009). Kaiser et al. (2002) determined that the forest subsoil has about 45% of the SOC of the soil profile; this fraction is bound to clay particles, forming microaggregates of < 20 μm in diameter.

Afforestation results in significant sequestration of new carbon and stabilizes old carbon pools (physically protected SOM fraction), associated with the formation of soil stable microaggregates affected by silt and clay content (Del Galdo et al. 2003). The same authors found that afforestation increases the SOC by 23% in the surface soil. SOC sequestration depends on forest species and management practices (Lal 2002; Del Galdo et al. 2003; Lamlom, Savidge 2003; Blanco-Canqui, Lal 2004). Researchers have found that dominant tree species affect the availability and biochemical composition of organic matter inputs to soil (Leckie et al. 2004). Different properties, exudates and functions of various root systems may also have different effects on aggregation (Chan, Heenan 1988). The nature and degree of soil improvement depend not only on the type of forest but also on land use history. Afforestation is generally found to improve soil carbon compared to cultivated agricultural land but not necessarily compared to pasture land (Guo, Gifford 2002). The soils of former moorland in the United Kingdom benefited from plantations of birch (*Betula* spp.), but not of pines (*Pinus* spp.) (Dimbleby 1952). Other studies did not find a significant difference between microbial biomass under afforested tree species (Priha, Smolander 1997) despite the different nutrient content of the litter under each species.

The stability of aggregates in the rhizosphere of forest stands is strongly correlated with the C-biomass and soluble C-fractions as well as with dehydrogenase and phosphatase activities. The combination of residue amendment and level of available low-molecular-weight organic fraction of forest stands significantly improves soil aggregate stability (WSA); the beneficial effect appears to be mainly the result of reactivation of microbiological activity (Caravaca et al. 2001). It appears that macroaggregates (0.25–2 mm) may play an important role in aggregate dynamics in mature forests, independently of tree species (Gartzia-Bengoetxea et al. 2009). This result may be attributed to differences in annual organic matter inputs (Kavvadias et al. 2001) and litter quality (Sariyildiz et al. 2005), as well as the enmeshing effect of roots and associated mycorrhizal hyphae (Miller, Lodge 1997). All of these effects may contribute to stabilization of topsoil aggregates (Six et al. 2000).

The rate of change during the transition from agricultural to forest land use has not been well described to date and there is limited knowledge of the impacts of these changes at the landscape/regional level. Our hypothesis is that forest establishment can lead to considerable soil changes in just a few decades. The aim of this study was to determine the impact of recent afforestation on soil properties and soil structure formation in two regions with different climates. We specifically studied changes in soil characteristics 15–30 years from afforestation.

MATERIAL AND METHODS

Site descriptions. The study was conducted at two localities (marked 1, 2) at 21 sites, which represent two typified the soil type and climatic conditions within the Czech Republic. The soil characteristics of three land uses (afforested, pasture, cultivated) were compared; the factor of forest type differences has not been evaluated in this study.

Site (1) – highland was in the Rychnov nad Kněžnou district in the Orlické hory Protected Landscape Area at an average altitude of 700 m a.s.l. (total area of this mountainous region is 204 km^2). For this study, we selected an area of 2 km^2 (16°25'53–56''E; 50°09'29–37''N). Climatic conditions are determined as a mildly warm and very moist climate classified as an MT3 climatic region (Quitt 1971), with mean annual temperature of approximately 7°C and mean annual precipitation of 848 mm (Moravec, Votýpka 1998). The geological bedrock is metamorphic in origin and consists of paragneiss and phyllites. The soil type was identified as Haplic Cambisol (according to FAO 2007).

We compared the following cases:

- afforested (6 sites) – a site of forest species mainly *Picea abies*/minor species, e.g. *Fagus sylvatica*, *Abies alba*, *Larix decidua*, *Alnus glutinosa* and *Betula pendula*;
- pasture (2 sites) – a site dominated by herbaceous species/various grasses (*Poaceae*);
- cultivated (1 site) – a site representing arable land used for agriculture.

Site (2) – lowland was established in the Prague-East district at an average elevation of 390 m a.s.l. It is situated in the vicinity of the town of Kostelec nad Černými lesy (total area of 18 km^2). The experimental plots, representing an area of approximately 1 km^2 (14°55'27–36''E; 49°56'40–57''N), were established in 1967 by planting on agricultural soils. Climatic conditions are determined as a mildly warm and slightly dry climate classified as an MT9 climatic region (Quitt 1971), with mean annual temperature of 8.4°C and mean annual precipitation of 591 mm (Moravec, Votýpka 1998). The bedrock is formed of Permian-carboniferous sandstones with shale inserts. The soil type was classified as Haplic Stagnosol (according to FAO 2007).

We compared the following cases:

– afforested (7 sites) – a site of forest species *Picea abies*, *Pinus sylvestris*, *Betula verrucosa* and *Pseudotsuga menziesii*; each forest type was represented by one sample site. Productivity of the tree species was evaluated in a separate study (Podrázský et al. 2009, 2010b);
– pasture (1 site) – a site situated close to the afforested zone;
– cultivated (4 sites) – a site representing intensive agricultural use.

Soil sampling and analyses. Soil sampling was conducted from 2008 through 2010. We took soil samples at both localities from the upper soil mineral horizons at a depth of 15–20 cm (Ap – arable, Ad – pasture, Ah – forest organomineral horizon) to enable a comparison of soil characteristics under different land management regimes.

We took a total of 252 soil samples (4 types of samples from 21 sites with 3 replications). The sample type was: (*i*) disturbed soil sample for chemical analyses prepared by a standard process to air-dried and sieved soil sample of fine particles (< 2 mm) (ISO 11464). SOC (soil organic carbon) was determined as C_{ox} (total oxidized carbon in ISO/FDIS 14235), SOM (soil organic matter) was expressed by 1.724 C_{ox} (assumption that SOM contains 58% of organically bound carbon in Nelson, Sommers 1982), fractionation of humic substances (HS) as a ratio of HA:FA (according to the method described in Richter, Hlušek 1999), pH_{KCl} by potentiometry (according to ISO 10390), cation exchange capacity (CEC) and exchangeable cations measured by AAS-Varian240 (according to ISO 13536); (*ii*) undisturbed soil samples (Kopecký cylinders – volume 100 cm^3, according to ISO 11508) for determination of physical characteristics of soil: total porosity was expressed from the values of reduced bulk density (Blake, Hartge 1986) and particle density (Danielson, Sutherland 1986), porosity system was defined as a sum of capillary (CP), semi-capillary (SP) and gravitational (GP) pores and calculated by the value of suction capacity (Qs) according to the standard ČSN 13040; (*iii*) Kopecký rings for saturated hydraulic conductivity (K_{sat}) described by Klute and Dirksen (1986) and determined according to the standard ČSN 721020; (*iv*) samples for determination of aggregate stability (weight of sample – 3 kg) were air-dried and sifted through nested sieves (Retch – ISO 3310-1) to particles of 1–2 mm (WSA) and 3–5 mm in size (MWD), WSA method was described by Kemper and Rosenau (1986), MWD method was described by Le Bissonais (1996).

Statistical evaluation of analyses. Each soil characteristic was evaluated separately. We expressed each of the values as an arithmetic mean ± standard deviation of the total number of measurements for each land use. Differences in the soil parameters between the climatic regions of ČR were tested by the Mann-Whitney pairwise test (comparing two independent samples). Statistical comparisons of bulk density, WSA and SOC for each land use were performed by using One-Way Analysis of Variance (ANOVA) with a 0.05 level of confidence; multiple comparison procedure (post-hoc testing) was processed by Sheffé's test. The values of soil structure stability (WSA) were correlated with selected soil parameters by Pearson's correlation coefficients at the 0.05 significance level. All measurements were statistically evaluated by Statistica 10 (StatSoft CR 2012)

RESULTS AND DISCUSSION

Comparison of basic physical characteristics of soil and evaluation of the effect of afforestation in both regions

For each site, soil texture characteristics reflect the historical land use; the soil texture undergoes changes very slowly (Szujecki 1996). Characteristics of the arable horizon can persist for a very long time despite repeated afforestation. Therefore, the influence of afforestation and grass establishment on these soils cannot be determined with statistical certainty.

The texture and other physical characteristics of soil are documented in Table 1, the comparison of their differences in Fig. 1. The *T*-testing of site differences results from higher clay contents (particle size < 0.002 mm) and surprisingly implies a lower degree of soil structure stability (WSA) for SITE 2

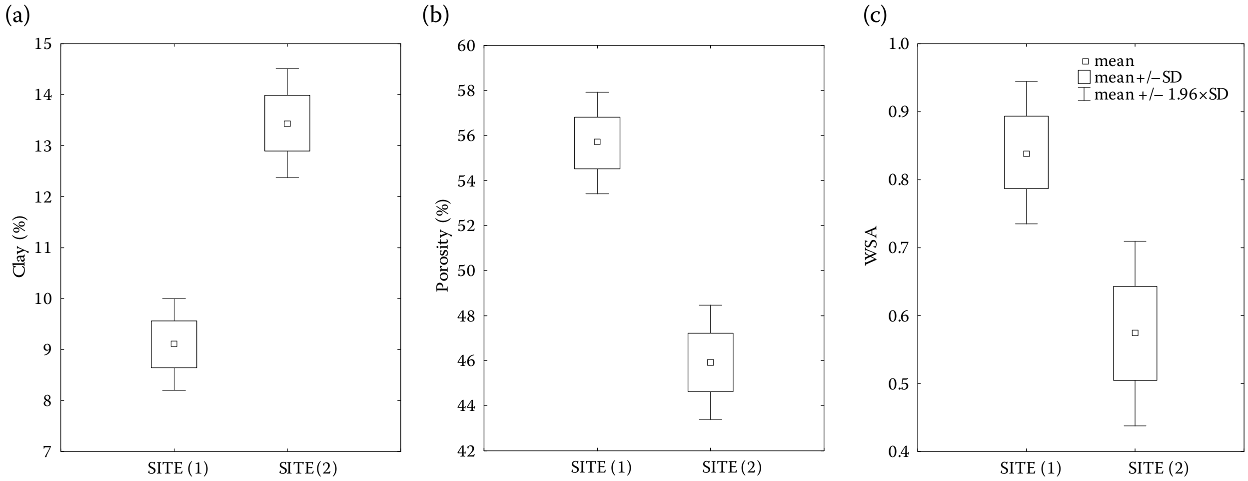

Fig. 1. *T*-test of clay content (a), porosity (b), water-stable aggregates (c)

(Fig. 1). The fraction of silt particles (0.002–0.05 mm) is comparable for both sites.

In detail, we recorded the highest contents of sand (0.05–2 mm) and the lowest contents of coarse silt particles (0.01–0.05 mm) on cultivated lands, likely the result of degradation on temporarily uncovered soils. The lower content of sand and higher content of silt in pasture soils and afforested sites might also be the result of bioturbation, the transportation of small-grained particles on the soil surface by earthworms, which are the most populous in grasslands and afforested sites.

When comparing changes in the physical characteristics of soil in the two independent climatic regions (Table 2, Fig. 1b), we found a significant decrease in bulk density (BD) and thus an increase in porosity (P) for climatic region MT3 (SITE 1 – Highland). Significantly higher soil structure stability (WSA) of SITE 1 – Highland (Fig. 1c) creates a high porosity soil system (Fig. 1b).

T-testing of differences between climatic regions (variability of physical properties) – SITE (1) Orlické hory (Highland) compared to SITE (2) Kostelec nad Černými lesy (Lowland) (Fig. 1)

Table 1. Soil texture ± standard deviation, by study area: Orlické hory Mts. (1) and the town of Kostelec nad Černými lesy (2), Czech Republic, 2008–2010 (in %)

Study area	Land-use type	Horizon	Particle size distribution (mm)			
			< 0.002	0.002–0.01	0.01–0.05	0.05–2.00
(1)	afforested	Ah	9.2 ± 1.4	19.7 ± 2.5	30.0 ± 7.4	44.9 ± 10.5
	pasture	Ad	8.9 ± 1.6	19.6 ± 3.5	30.1 ± 9.2	20.2 ± 5.1
	cultivated	Ap	9.0 ± 0.5	18.5 ± 0.4	19.6 ± 4.3	54.1 ± 0.8
(2)	afforested	Ah	14.7 ± 1.5	13.6 ± 3.3	37.4 ± 11.8	37.3 ± 15.5
	pasture	Ad	10.5 ± 1.4	22.4 ± 2.3	38.4 ± 9.7	29.7 ± 11.1
	cultivated	Ap	12.7 ± 1.3	12.3 ± 4.0	25.9 ± 7.2	51.5 ± 12.1

Ad – pasture, Ah – forest organomineral horizon, Ap – arable

Table 2. Physical characteristics of soil ± standard deviation, by study area: Orlické hory Mts. (1) and the town of Kostelec nad Černými lesy (2), Czech Republic, 2008–2010

Study area	Land-use type	Horizon	Density ($g \cdot cm^{-3}$)		Porosity (%)	K_{sat} ($ms^{-1} x\ 10^{-6}$)	WSA	MWD (mm)
			bulk	particle				
(1)	afforested	Ah	1.16 ± 0.04	2.65 ± 0.04	56.29 ± 1.48	1.53 ± 1.15	0.92 ± 0.04	2.29 ± 0.22
	pasture	Ad	1.15 ± 0.15	2.61 ± 0.03	56.02 ± 5.13	0.51 ± 0.11	0.92 ± 0,01	2.00 ± 0.05
	cultivated	Ap	1.22 ± 0.08	2.64 ± 0.01	53.77 ± 3.32	0.62 ± 0.12	0.69 ± 0.07	1.29 ± 0.02
(2)	afforested	Ah	1.39 ± 0.09	2.64 ± 0.02	47.50 ± 3.12	103.3 ± 61.3	0.75 ± 0,14	2.50 ± 0.38
	pasture	Ad	1.25 ± 0.07	2.60 ± 0.02	51.89 ± 2.47	78.2 ± 11.2	0.83 ± 0.05	2.18 ± 0.02
	cultivated	Ap	1.55 ± 0.07	2.66 ± 0.02	41.67 ± 2.68	54.5 ± 9.6	0.31 ± 0.12	1.44 ± 0.01

Ad – pasture, Ah – forest organomineral horizon, Ap – arable, WSA – water stable aggregate, MWD – mean weight diameter

Table 3. Evaluation of porosity ± standard deviation, across both study areas, highland and lowland of the Czech Republic (in %)

Land-use type	Horizon	P	GP	SP	CP
Afforested	Ah	56.28 ± 0.47	5.5 ± 0.8	11.1 ± 1.0	26.3 ± 0.4
Pasture	Ad	50.90 ± 0.34	1.7 ± 0.2	9.4 ± 0.8	31.7 ± 0.7
Cultivated	Ap	50.45 ± 0.54	2.3 ± 0.3	10.3 ± 1.2	34.4 ± 0.2

Ad – pasture, Ah – forest organomineral horizon, Ap – arable, P – porosity, GP – gravitational pores, SP – semi-capilar pores, CP – capillary pores

For the selected soil horizon we evaluated porosity in detail (Table 3). This comparison showed the correlation of afforestation with increased total porosity. The higher infiltration capacity of forested soils was caused mainly by the higher percentage of gravitational pores, which was considerably influenced by the activity of soil biota (Grashey-Jansen 2012). We found no evidence that soil porosity was affected by the presence of grass on the sites. We observed another positive effect of afforestation while evaluating K_{sat} (Table 2).

Table 4. Scheffé's test

Land use	Cultivated	Pasture	Afforested
Bulk density			
Cultivated		0.006	0.002
Pasture	0.006		0.701
Afforested	0.002	0.701	
WSA			
Cultivated		0.000	0.000
Pasture	0.000		0.773
Afforested	0.000	0.773	
SOC			
Cultivated		0.165	0.935
Pasture	0.165		0.351
Afforested	0.935	0.351	

WSA – water-stable aggregates, SOC – soil organic carbon

Changes in the soil physical character 15 to 30 years after afforestation were evaluated by Scheffé's test of bulk density (Table 4). We determined a statistically significant difference between afforested and pasture sites compared to cultivated land, and not significant each other (Fig. 2a). This confirms the observations of Reiners et al. (1994) and Celik (2005).

The lower bulk density and higher porosity of afforested sites resulted in greater ability to infiltrate water into the soil profile because of the channelling effect of tree root systems. This effect was shown by the higher soil structure stability index by the WSA method (Fig. 2b). The significantly higher soil structure stability was determined for afforested and pasture sites, compared to cultivated ones (Fig. 2b, Table 4). This result was also reported by Jabro (1992).

According to the evaluation of WSA for both climatic regions we estimate the hierarchy of soil structure stability as follows: Afforested = Pasture >> Cultivated, which confirms the conclusions of Celik (2005). The correlation of WSA values with selected physical characteristics of soil was statistically evaluated as: (a) high – MWD (94%), bulk density (75%), porosity (70%); (b) middle – K_{sat} (57%) and (c) low – particle density (21%).

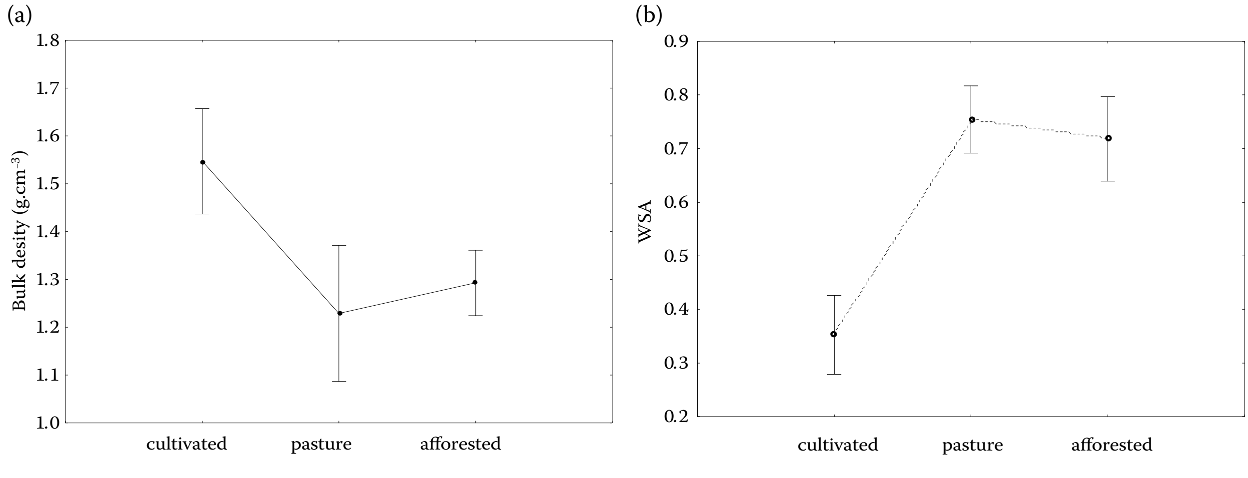

Fig. 2. Effect of afforestation and grass planting on the physical character by bulk density (a), the soil structure stability (WSA) (b) across both study areas, highland and lowland of the Czech Republic

Table 5. Chemical characteristics of soil ± standard deviation, by study area: Orlické hory Mts. (1) and the town of Kostelec nad Černými lesy (2), Czech Republic, 2008–2010

Study area	Land-use type	Horizon	Exchangeable ions (mmol(+)/ 100 g)			CEC (mmol(+)/100 g)	pH_{KCl}	SOM (%)
			Ca^{2+}	Mg^{2+}	K^{+}			
(1)	afforested	Ah	6.06 ± 2.71	1.20 ± 0.45	0.33 ± 0.13	19.31 ± 2.88	4.73 ± 0.57	4.58 ± 1.45
	pasture	Ad	3.75 ± 0.42	0.58 ± 0.15	0.12 ± 0.07	17.59 ± 3.45	4.23 ± 0.19	4.32 ± 1.27
	cultivated	Ap	7.71 ± 0.29	1.10 ± 0.04	0.27 ± 0.01	16.67 ± 0.28	5.08 ± 0.10	3.33 ± 0.11
(2)	afforested	Ah	1.65 ± 0.93	0.62 ± 0.22	0.10 ± 0.01	9.54 ± 1.14	3.58 ± 0.13	1.93 ± 1.48
	pasture	Ad	12.59 ± 1.35	1.86 ± 0.12	0.11 ± 0.02	15.37 ± 1.31	5.94 ± 0.25	2.71 ± 0.12
	cultivated	Ap	6.57 ± 0.44	0.86 ± 0.33	0.10 ± 0.02	9.56 ± 0.95	5.11 ± 0.23	1.94 ± 0.28

Ad – pasture, Ah – forest organomineral horizon, Ap – arable, CEC – cation exchange capacity, SOM – soil organic matter

Comparison of basic chemical characteristics of soil and evaluation of the effects of afforestation at both sites

If we made a pairwise comparison of changes in the chemical characteristics of soil in the two independent climatic regions (Table 5), we found a significantly higher SOC content (Fig. 3a) of SITE 1 (Highland) compared to SITE 2 (Lowland). Higher, but not significantly is the acidification level of highland SITE 1 as well (Fig. 3b). High-humidity highland sites are destined for higher C sequestration that leads to higher CEC (higher buffer capacity), and on the other hand, they are more often acidified than lowlands.

The cation exchange capacity (CEC) showed significant differences between the climatic regions (Fig. 3c). We were surprised by its increased value in pasture SITE 2, which was likely also caused by pasture management (Table 5). Afforestation for lowland sites resulted in a decrease in the content of exchangeable calcium, which may have been caused by the cessation of liming in the former agricultural sites (Table 5). The explanation for the decrease in exchangeable magnesium was less obvious, as this element is intensively recycled by all types of ecosystems (Kacálek et al. 2007). The content of exchangeable potassium had almost the same value as under agricultural management. This very mobile element was likely intensively leached into the soil of submountain pastures in the Orlické hory Mts.

The effect of soil chemical composition on the soil structure stability formation was determined by Pearson's correlation coefficients in this paper. The WSA values resulted as follows: (a) statistically significant: SOM (71%), (b) low correlation: CEC (47%), pH_{KCl} (34%); (c) not statistically significant: exchangeable K+ (27%), Mg^{2+} (25%), Ca^{2+} (7%).

T-testing of differences between climatic regions (variability of chemical properties) – SITE (1) Orlické hory (Highland) compared to SITE (2) Kostelec nad Černými lesy (Lowland) – showed the results documented in the Fig. 3.

We did not show a significant beneficial effect of forest cover on SOC (Fig. 4, Table 4) compared to pastures and cultivated sites, as reported by Caravaca et al. (2001). The failure to document an effect is likely due to the very short time interval (15–30 years) from afforestation, where the characteristics of the arable

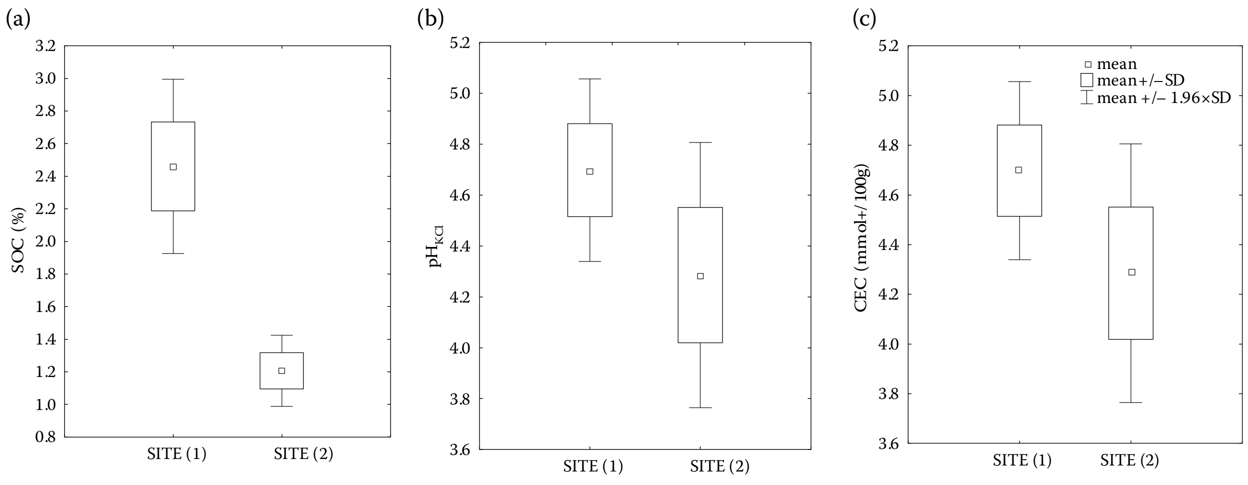

Fig. 3. T-test of soil organic carbon (SOC) (a), pH_{KCl} (b), cation exchange capacity (CEC)(c)

Table 6. Evaluation of SOM quality ± standard deviation, across both study areas, highland and lowland of the Czech Republic

Land-use type	Horizon	HSaq	FA	HA	HA:FA	Q 4/6
		(%)				
Afforested	Ah	2.4 ± 2.5	0.8 ± 0.8	1.5 ± 1.8	1.5 ± 0.6	4.8 ± 0.9
Pasture	Ad	0.6 ± 0.2	0.2 ± 0.2	0.1 ± 0.1	0.8 ± 0.2	5.9 ± 1.6
Cultivated	Ap	0.5 ± 0.1	0.3 ± 0.1	0.2 ± 0.1	0.9 ± 0.5	4.0 ± 1.6

Ad – pasture, Ah – forest organomineral horizon, Ap – arable, HSaq – aquatic humic substances, FA – fulvic acids, HA – humic acids, Q4/6 – optical quocient of aromacity

horizon were still prevailing. In the first decades, organic soil dynamics in the newly established forest stands results in higher accumulation of surface humus on less favourable sites; mixing of organic matter in deeper horizons (Ah, B horizons) requires longer periods of time (Kacálek et al. 2007; Podrázský 2008). Other studies have found improvements in soil organic carbon in as little as 19 years after afforestation of desertification-affected lands (Shirato et al. 2004). However, those sites were on sandy soils, where the gain in organic matter was more dramatic because the initial value was so low.

But we found that organic matter under forest cover generally had a ratio of HA:FA (Table 6) close to the optimum value 1.5 (Richter, Hlušek 1999). The higher HA:FA ratio (higher aromaticity and greater complexity of organic parts) under afforested sites leads to the higher stability of soil organic compounds and creates more stable soil aggregates. Litter and its subsequent decomposition are essential factors in the soil structure stability formation (Binkley 1995).

Higher microbial activity and in general higher quantity, as well as quality, of soil organic matter are prerequisites for the improved soil aggregation ability of forest and grassland soils. This effect is often highlighted by a lower pH on forest land and

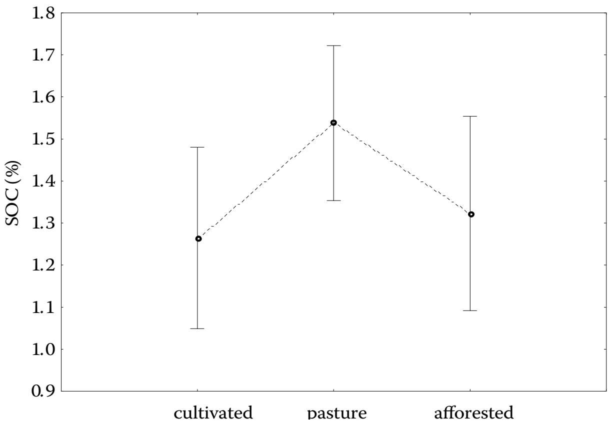

Fig. 4. Evaluation of the effect of afforestation on soil organic carbon (SOC) across both study areas, highland and lowland of the Czech Republic

grassland; the higher the degree of soil substrate weathering, the greater the aggregation potential. Also the impact of forest or grassland litter (above- as well as belowground) and the reduced use of fertilizers contribute to the higher acidity of A horizons under forest or grass cover.

The effect of afforestation controlled by soil organic matter quality and microbial activity, like in the study Chen et al. (2000), was confirmed in this paper. The main cause for the formation of stable soil macroaggregates in the uppermost horizon (15–20 cm) appeared to be the activity of soil macrofauna and mesofauna and subsequent activity of soil microbes, which subsequently led to the higher stability (quality) of SOM.

Another important factor was the tree species composition (Podrázský, Remeš 2008; Kupka, Podrázský 2011). Broadleaved species and *Pseudotsuga menziesii* particularly promote humus establishment and development (Menšík et al. 2009; Kupka, Podrázský 2011). Similar trends were also documented in other regions of the Czech Republic, such as the Krušné hory Mts. (Podrázský 2008; Podrázský et al. 2010a) and the Bohemian-Moravian uplands (Podrázský, Procházka 2009).

In another study, Podrázský and Remeš (2005) found minimal differences in the values of physical characteristics of soil between forest covers of *Picea, Pseudotsuga* and mixed broadleaves. On the other hand, a clear-cut site displayed a decrease in the capacity of soil to store water. Here, the forest type had a significant influence. On degraded sites in the Bohemian Forest, Jačka et al. (2012) confirmed the important effects of the ground vegetation on infiltration characteristics of the forest floor and the upper part of the soil. A meta-analysis of studies of tropical afforestation found an improvement in water infiltration over that of agricultural lands, up to three times (Istedt et al. 2007). Whether conversion to forests is beneficial, however, depends upon the methods of afforestation. Mimicking the impact of cultivation upon agricultural lands, mechanized forestry activities can also affect the soil hydraulic character (Rejšek et al. 2011).

CONCLUSIONS

Afforestation of agricultural soils can result in important changes in physical characteristics of soil and soil structure formation in a relatively short time. The pattern of changes and soil conditions in each phase depend on location, where macroclimatic, microclimatic, geological and biological factors and their interactions can play decisive roles. Based on our observations, the creation of stable soil structure was related to the quality of soil organic matter, determined by the characteristics as well as the quantity of the litter.

We concluded that there is a significant residual influence persisting from previous land use. The characteristics of the arable horizon still persist within 15–30 years from afforestation.

Afforestation had a positive influence on physical characteristics of soil, which are important for maintaining the soil stability in both climatic regions. The influence of forest cover on increasing soil porosity, by reducing bulk density and increasing capillary and gravitational pores (increase of water-holding capacity and soil air capacity), is critical. The improvement in infiltration and soil water-holding capacity resulted not only from the presence of forest overstorey, but also from the presence of permanent grass cover in pasture lands. In this case, the improvement of measured soil characteristics in afforested areas was not significantly different from pasture land, similar to other landscapes (Guo, Gifford 2002).

The main reason for a relatively fast soil improvement after afforestation is the quite rapid creation of soil stable aggregates, represented in this study mainly by WSA index. The enhancement of stable soil structure is one of the ways of restoring eroded and otherwise degraded soils. Forest cover on afforested agricultural soils thus shows sharp functional impacts on the soil structure formation and the regeneration of natural pedogenetic processes in revitalized forest ecosystems.

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