Soil organic matter quantity and quality of land transformed from arable to forest

Kvantita a kvalita pôdnej organickej hmoty pôdy zmenenej z ornej na lesnú

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Abstract

Comparative studies on quantitative and qualitative characteristics of soil organic matter were studied in arable and afforested in 1964 Stagni-Haplic Luvisol in Arboretum Mlyňany (Slovakia). The studies were conducted at three stands – arable soil located next to Arboretum (control), under thuja trees (*Thuja orientalis* L.) and under junipers (*Juniperus Chinensis* L.). Results of the studies showed, that in A horizons, 50 years of thuja and juniper trees growing on formerly arable land, had resulted to the significant (by 69% under thuja and by 126% under juniper) increase of total organic carbon (C_{ox}) compared to control arable land. $KMnO_4$ oxidisable carbon (C_L) and mainly hot water-soluble carbon (C_{hwd}) had higher contents in soil under studied trees than on arable land. The conversion of cropland to forest led to lowering of soil organic matter quality, assessed as the ratio of total carbon and nitrogen (C_{ox}/N_T), which was in arable soil 10.2, under thuja trees 13.9 and under junipers 12.0. Surprisingly, the quality of humus between examined sites differed only minimally, since the change of humus quality is a long term process.

Keywords: arable soil, arboretum, humus, nitrogen, organic carbon

Abstrakt

V práci boli zisťované vlastnosti organickej hmoty v hnedozemi kultizemnej pseudoglejovej, ktorá bola v roku 1964 zmenená z ornej pôdy na Arborétum v Mlyňanoch (Slovensko) a boli na nej vysadené cudzokrajné dreviny. Vlastnosti pôdy pod porastmi tují východných (*Thuja orientalis* L.) a borievok čínskych

(*Juniperus Chinensis* L.) boli porovnané s pôdou, ktorá zostala ornou, nachádzala sa hneď vedľa Arboréta a predstavovala kontrolné stanovište. Bolo zistené, že vplyvom výsadby tují a borievok na ornej pôde došlo za 50 rokov v A horizontoch k preukaznému zvýšeniu celkového obsahu organického uhlíka (o 69% pod tujami a o 126% pod borievkami) v porovnaní s kontrolnou ornou pôdou. Obsah organického uhlíka oxidovateľného s $KMnO_4$ (C_L), no najmä obsah v horúcej vode rozpustného uhlíka (C_{hwd}) bol vyšší v pôde pod skúmanými drevinami v porovnaní s ornou pôdou. Premenou ornej pôdy na lesnú došlo ku zníženiu kvality pôdnej organickej hmoty, určenej ako pomer celkového uhlíka a dusíka (C_{ox}/N_T), ktorý mal v ornej pôde hodnotu 10,2, pod tujami 13,9 a pod borievkami 12,0. Kvalita humusu sa medzi skúmanými stanovišťami líšila minimálne, nakoľko zmena kvality humusu je dlhodobý proces.

Kľúčové slová: arborétum, dusík, humus, organický uhlík, orná pôda

Detailný abstrakt

V práci boli zisťované vlastnosti pôdnej organickej hmoty hnedozeme kultizemnej pseudoglejovej, ktorej spôsob využívania bol od roku 1964 zmenený z ornej pôdy na Arborétum v Mlyňanoch (Slovensko) a na pôde boli vysadené cudzokrajné dreviny, tuje výhodné (*Thuja orientalis* L.) a borievky čínske (*Juniperus Chinensis* L.). Vlastnosti pôdy pod porastmi tují východných a borievok čínskych boli porovnané s pôdou, ktorá zostala ornou, nachádzala sa hneď vedľa Arboréta a predstavovala kontrolné stanovište. Keďže zmena pôdnych vlastností sa najviac prejavuje vo vrchných vrstvách pôdy, vlastnosti pôdnej organickej hmoty boli hodnotené v humusových A horizontoch (0-20 cm), ktoré boli najviac ovplyvnené opadom drevín a pozberovými zvyškami pestovaných rastlín. Vlastnosti organickej hmoty sme hodnotili ako priemer z každého stanovišťa, ktoré bolo zastúpené tromi pôdnymi vzorkami. Boli skúmané nasledovné parametre pôdnej organickej hmoty: obsah org. uhlíka (C_{ox}) - oxidimetricky metódou Ťurina (Orlov a Grischina, 1981), celkový obsah dusíka metódou Kjeldahla (Bradstreet, 1965), v horúcej vode rozpustný uhlík (C_{hwd}) – methódou Körchensa a Schulza (1999), zloženie humusu frakcionáciou Kononovej a Belchikovej (1961), spektrálne analýzy humusových látok a humínových kyselín boli robené na 6400 Spectrophotometer (Jen Way), potenciálne mineralizovateľný dusík (N_{pot}) (Standford a Smith, 1978), obsah labilného uhlíka (C_L) oxidovateľného 5 $mmol.dm^{-3}$ $KMnO_4$ v kyslom prostredí 2,5 $mmol.dm^{-3}$ H_2SO_4 (Loginow et al., 1993).

Bolo zistené, že vplyvom výsadby tují a borievok na ornej pôde došlo za 50 rokov v A horizontoch k preukaznému zvýšeniu celkového obsahu organického uhlíka (o 69% pod tujami a o 126% pod borievkami) v porovnaní s kontrolnou ornou pôdou. Ešte viac sa zdôraznili rozdiely medzi kultivovanou a lesnou pôdou v labilných formách organického uhlíka (C_L), ktoré boli o 121% a 208% vyššie pod skúmanými drevinami ako v ornej pôde. Labilnosť organickej hmoty ako aj zastúpenie labilného z celkového organického uhlíka boli taktiež vyššie (avšak nepreukazne) pod porastmi drevín, čo svedčí o vyššom zastúpení ľahko rozložiteľných organických látok a teda vyššej zásobe ľahko dostupnej energie a živín pre pôdne organizmy v porovnaní s ornou pôdou. Rovnako aj obsah v horúcej vode rozpustného uhlíka (C_{hwd}) bol preukazne vyšší o 127% pod tujami a o 291% pod borievkami ako v ornej pôde. Premenou ornej pôdy na lesnú došlo ku zníženiu kvality pôdnej organickej hmoty, určenej ako pomer celkového uhlíka a dusíka (C_{ox}/N_T), ktorý mal v ornej pôde hodnotu 10,2, pod tujami 13,9 a pod borievkami 12,0. V labilných formách uhlíka a dusíka boli rozdiely ešte výraznejšie. Prekvapivo, kvalita humusu skúmaná ako pomerné zastúpenie humínových kyselín a fulvokyselín bola nepatrne vyššia pod porastmi stromov, keď pomer v pôde pod borievkami bol 0,78 a pod tujami 0,65, kým v ornej pôde 0,63. Farebné koeficienty humusových látok aj humínových kyselín potvrdili vyššiu kvalitu humusu len pod tujami.

Celkovo, vplyvom výsadby tují a borievok na ornej pôde došlo už v priebehu 50 rokov v A horizontoch ku značnému zvýšeniu celkového obsahu organickej hmoty a najmä jej labilných foriem a zároveň ku zníženiu kvality pôdnej organickej hmoty – čo je typické pre lesné ekosystémy v porovnaní s agroekosystémami. Na druhej strane, kvalita humusu sa medzi skúmanými stanovišťami líšila minimálne, nakoľko zmena kvality humusu je dlhodobý proces.

Introduction

Plant-soil feedbacks are crucial for the development and functioning of terrestrial ecosystems. Soil, as key component of these ecosystems provides nutritional, water and oxygen conditions (Hanáčková et al., 2008), as well as resistance to parasites (Mateille et al., 2014). Spatial variability in soil properties is an important factor influencing variability of plant communities in different spatial scales. Influence of plants on soil cover is realised by production of litterfall (Jonczak and Mackiewicz, 2012), quantitative and qualitative transformation of rain waters (Jonczak and Parzych, 2012), uptake of water and nutrients and secretion of different substances by root systems as well as by impact of growing roots on some physical properties (Phillips and Marion, 2004; Šimanský, 2013; Šimanský and Kováčik, 2014).

Therefore, the change of vegetation and in addition land use has substantial influence on soil properties, mainly soil biodiversity (Gajić, 2013; Sojneková and Chytrý, 2015; Szombathová, 2010), its biological activity (Augusto et al., 2002) and quantitative and qualitative parameters of soil organic matter (Jonczak, 2013; 2014).

There is considerable amount of information about soil properties that were affected by the change of natural ecosystems to agro-ecosystems (Gajić, 2013; Szombathová, 2010; Toenshoff et al., 2013) or even to the urban ecosystems (De Lucia et al., 2013; Szombathová et al., 2009). Yet, there is relatively little information about the properties of former arable land converted to forest ecosystem, which in addition was planted by exotic introduced tree species (Polláková, 2013).

Therefore, present study explored differences in soil organic matter characteristics between the land on which were for 50 years grown introduced junipers and thuja trees (area was used as arable till 1964) and adjacent arable land that remained used for intensive crop production.

Materials and methods

Study site

Arboretum Mlyňany, located in southern Slovakia (48º19'N and 18º21'E) was established 123 years ago by Dr. Ambrózy and Mišák. Nowadays, it is divided to: original Ambrózy's park founded in year 1892; area of the East Asia dendroflora in year 1964 on former arable land; area of the North America, Korea and Slovak dendroflora (Tábor and Pavlačka, 1992). Current number of taxa grown in the Arboretum is 1,933 (Hoťka et al., 2013). Arboretum is located in the valley of the Žitava river, on slightly undulated terrain, at an altitude of 165–217 m above sea level. It is situated on a late Tertiary geological formation, represented by Neogene clays, sands and rubble sands. This substratum is almost all covered by wind-deposited loess, mostly without carbonates (Cifra, 1958). Mean temperature in the area is 10.6 ^{o}C and mean annual total precipitation is 541 mm (Hrubík et al., 2011). Soil subtype classified on investigated area was cultivated Stagni-Haplic Luvisol (Polláková, 2013). Arboretum increased the area in 1964 when was bought the adjacent arable land on which was established area of East Asia dendroflora.

Soil sampling and analytical methods

Soil characteristics were studied under two introduced tree species planted in year 1964:

dense growth of thuja trees (*Thuja orientalis* L.) – site 1

dense growth of junipers (*Juniperus Chinensis* L.) – site 2

and on adjacent:

arable land that remained used for crop production – control site 3

Tree species were planted in dense monoculture groups consisting of minimally five trees. Nowadays the area occupied by each tree species exceeded 100 m^2. Soil samples were collected in year 2014. Since changes of soil properties due to trees growing are the most distinctive in the upper layers, characteristics of soil organic matter were assessed in samples collected from A horizons (0-20 cm), which were the most affected by trees litter and by crop residues. After drying, from soil samples were removed plant and root residues, samples were grinded and homogenized by sieving through sieves with mesh diameter < 2 mm and <0.25 mm. In such prepared soil samples were determined following soil organic matter characteristics: total soil organic carbon (C_{ox}) was analysed by Tyurin method (Orlov and Grischina, 1981), total nitrogen content (N_T) by Kjeldahl (Bradstreet, 1965), hot water soluble carbon (C_{hwd}) – by method of Körchens and Schulz (1999), humus fractionation - by Kononova and Belchikova method (1961), spectral analyses of humic acids – 6400 Spectrophotometer (Jen Way), potentially mineralizable nitrogen (N_{pot}) (Standford and Smith, 1978), organic carbon oxidable by 5 mM $KMnO_4$ in acidic medium (C_L) – by Loginow et al. (1993).

To compare SOM quality and quantity of the cultivated soil and the soils from under trees the Carbon Management Index (CMI) proposed by Blair et al. (1995) was calculated according formula: CMI = CPI*LI*00.

The Carbon Pool Index (CPI) was calculated as follows:

CPI = C_{ox} in forest*(C_{ox} in arable (control) soil)$^{-1}$

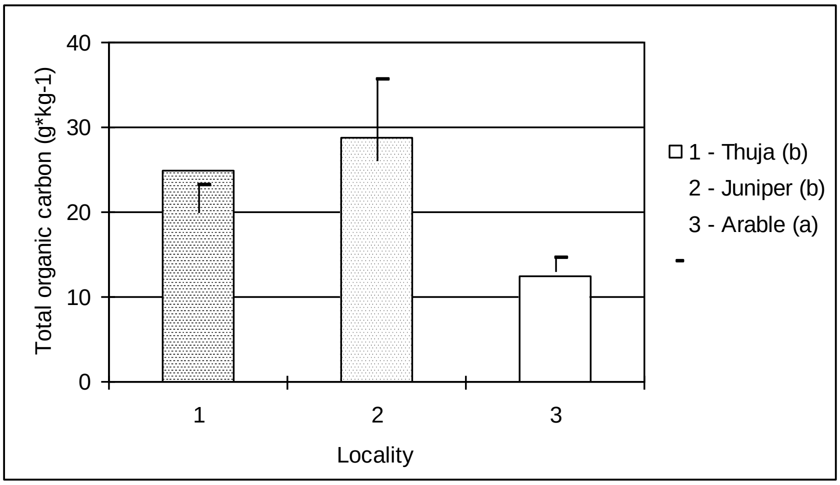
Lability of organic carbon (L) = C oxidized by $KMnO_4$*(C unoxidized by $KMnO_4$)$^{-1}$

Lability Index (LI) = L in forest*(L in arable (control) soil)$^{-1}$

Soil characteristics were evaluated for each site, which was represented by three soil samples. In tables are present average values. For statistical evaluation was used one-way analysis of variance, and differences between the variants (tree species and arable land) were assessed using LSD test with minimum significance level of P ≤ 0.05.

Results and discussion

In this work were compared soil organic matter (SOM) characteristics of Stagni-Haplic Luvisol, which in the year 1964 had changed use from arable to the Arboretum in Mlyňany, and on area were planted introduced trees. Soil properties of A horizons (0-20 cm), under thuja trees and junipers were compared with the adjacent arable land (control).



Different letters (a-c) indicate significant difference at P < 0.05

Rôzne písmená (a-c) indikujú preukazný rozdiel pri P < 0,05

Figure 1. Total organic carbon content in soil under thuja, juniper and arable

Obrázok 1. Celkový obsah organického uhlíka v pôde pod tujami, borievkami a v ornej pôde

Generally, total organic carbon (C_{ox}) is the main indicator of SOM quantity and its reserves are the result of the balance between organic carbon inputs and the mineralization average of each soil organic matter groups (Post and Kwon, 2000). Since in forest the all biomass remains in anthropogenically undisturbed soil, and from arable land a greater amount of the produced biomass is harvested and moreover the mineralization of SOM is accelerated by cultivation, it is expected that in the A horizon of forest soil the stock of SOM will be higher than that in arable. This assumption has been confirmed by results obtained in this study. Research showed, that in A horizons, 50 years of thuja and juniper trees growing on formerly arable land, had resulted to the significant (by 69% under thuja and by 126% under juniper) increase of C_{ox} compared to control arable land (Table 1). Findings are in agreement with that of Zhao et al. (2008) who stated that afforestation of arable soils after 40 years resulted in a distinct stabilization of C_{ox} as indicated by the smallest carbon mineralization (0.48 mg C g^{-1} C d^{-1}) and the highest C_{ox} content (2.3%) compared to adjacent arable soils (0.9–1.8%). Contrariwise, Vesterdal et al. (2002) concluded, that afforestation of former arable land did not lead to increased C storage in the soil in a short term perspective of 30 years. However, nutrient-rich afforestation soils may become greater sinks for C in the long term (200 years).

Table 1. Contents of labile fractions of carbon and nitrogen

Tabuľka 1. Obsah labilných frakcjí uhlíka a dusíka

Locality	C_{hwd}	C_L [g*kg^{-1}]	N_{pot}	C_L/N_{pot}
Thuja	1.12 b	3.76 ab	0.086 a	43.8 b
Juniper	1.93 c	5.23 b	0.103 ab	50.9 b
Arable	0.49 a	1.70 a	0.108 b	15.7 a

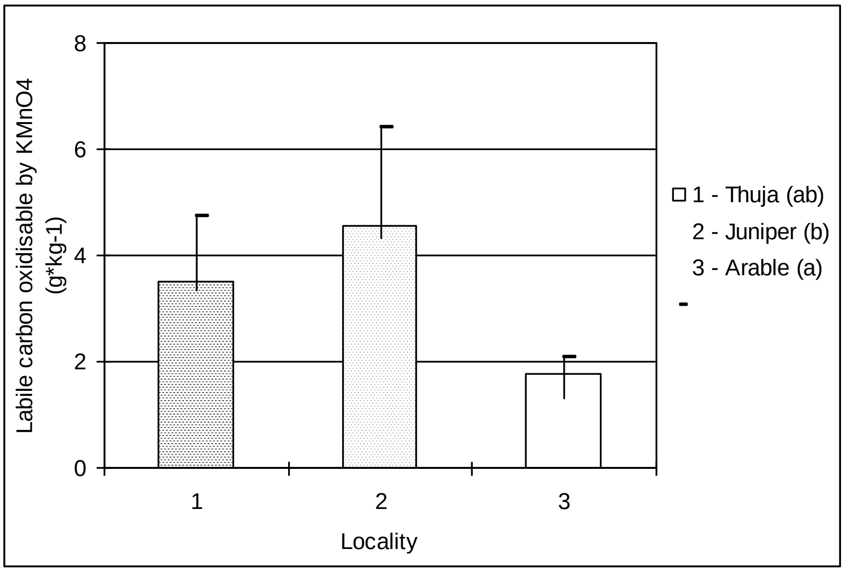
Different letters (a-c) indicate that soil properties in A horizons are significantly different at P < 0.05 according to LSD test

C_L – organic carbon oxidisable by 0.005 mol*dm^{-3} $KMnO_4$ in acidic medium, C_{hwd} – hot water soluble organic carbon, N_{pot} – potentially mineralizable nitrogen, C_L/N_{pot} – ratio C_L/N_{pot}

Rôzne písmená (a-c) indikujú, že vlastnosti pôdy v A horizontoch sú preukazne rozdielne pri P < 0,05 podľa testu LSD

C_L –organický uhlík oxidovaný 0.005 mol*dm^{-3} $KMnO_4$ v kyslom prostredí , C_{hwd} – organický uhlík rozpustný v horúcej vode, N_{pot} – potenciálne mineralizovateľný dusík, C_L/N_{pot} – pomer C_L/N_{pot}

Whereas the conversion of cropland to Arboretum was performed 50 years ago, evident increase of SOM was justified. However, according to many authors, compared to total SOM in forest ecosystems, the labile forms of organic matter (labile carbon, hot water soluble carbon, microbial biomass carbon) with turnover times of few days to months can be considered as finer indices of soil quality and therefore can sensitively respond to changes in plant vegetation and land use (Blair et al., 1995; Maková et al., 2011; Šeremešić et al., 2013).



Different letters (a-c) indicate significant difference at P < 0.05

Rôzne písmená (a-c) indikujú preukazný rozdiel pri P < 0,05

Figure 2. Labile organic carbon content in soil under thuja, juniper and arable

Obrázok 2. Obsah labilného uhlíka v pôde pod tujami, borievkami a v ornej pôde

Results in Figure 2 did not confirm this argument and showed that pool of labile organic carbon (C_L) indicated non significant differences between cultivated land and thuja trees site (C_L was higher under trees by 121%), but significant differences between cultivated land and junipers (C_L was higher under trees by 208%). On the other side, the way of land use statistically significantly affected ($P < 0.05$) the content of hot water soluble carbon (C_{hwd}), which was higher under thuja (by 127%) and under juniper trees (by 291%) than on arable land, and likewise the percentage C_{hwd} of C_{ox} were higher under studied trees (by 35% and 73%). This indicates a greater proportion of easily degradable organic substances, and therefore, higher stock of readily available energy and nutrients for soil organisms under trees, compared with arable land. In addition, compared to other carbon fractions, only C_{hwd} (as easily extractable) differed between tree species. Significantly, the highest content of C_{hwd} was found in A horizon under junipers (Table 1). This finding was supported by work of Pabst et al. (2013), Wang and Wang (2011) who stated that forest vegetation type significantly affected water-soluble soil organic matter fractions and in addition that hot-water-soluble method could be a suitable measure for labile SOM in subtropical forest soils.

Beside the pool of labile carbon, it has to be considered also the percentage C_L of C_{ox}, and “lability” (L) calculated as labile to non-labile (not oxidable by $KMnO_4$) carbon ratio. Obtained results (Table 2) showed that the change of land use form forest to arable led to differences in these parameters, but the effect was not significant ($P < 0.05$). Compared to arable land, the lability of organic matter increased by 33% under thuja trees and by 40% under junipers. Also the percentages C_L of C_{ox} were higher under trees.

Table 2. Carbon and nitrogen fractions and Carbon Managment Indicies for forest soils and soil from an adjoing arable soil

Tabuľka 2. Frakcie uhlíka a dusíka a indexy veľkosti zdroja uhlíka pre lesnú a ornú pôdu

Locality	C_L	C_{hwd}	N_{pot}	L	LI	CPI	CMI
	[% of C_{ox}]		[% of N_T]				
Thuja	16.9 a	5.0 b	5.4 b	0.20 a	1.33	1.69	224.9
Juniper	17.6 a	6.5 c	4.1 a	0.21 a	1.40	2.26	315.9
Arable	12.9 a	3.7 a	8.3 c	0.15 a	–	–	–

Different letters (a-c) indicate that soil properties in A horizons are significantly different at P < 0.05 according to LSD test

C_{ox} – total soil organic carbon, C_L – organic carbon oxidisable by 0.005 mol*dm^{-3} $KMnO_4$ in acidic medium, C_{hwd} – hot water soluble organic carbon, N_{pot} – potentially mineralizable nitrogen, N_T - total nitrogen content, L – lability of organic carbon, LI – lability index, CPI – carbon pool index, CMI – carbon management index

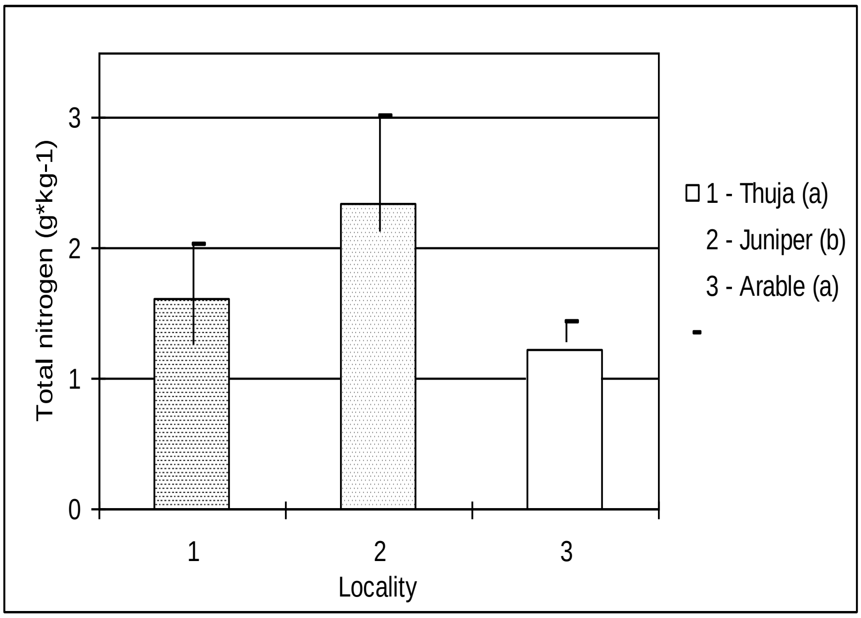
Rôzne písmená (a-c) indikujú, že vlastnosti pôdy v A horizontoch sú preukazne rozdielne pri P < 0,05 podľa testu LSD

C_{ox} – celkový obsah organického uhlíka, C_L – organický uhlík oxidovaný 0.005 mol*dm^{-3} $KMnO_4$ v kyslom prostredí , C_{hwd} – organický uhlík rozpustný v horúcej vode, N_{pot} – potenciálne mineralizovateľný dusík, N_T – celkový obsah dusíka, L – labilnosť organického uhlíka, LI – index labilnosti organického uhlíka, CPI – index veľkosti zdroja uhlíka, CMI – index hospodárenia s organickým uhlíkom

As Blair et al. (1995) stated that carbon fractionation and calculation of Carbon Management Index (CMI) are appropriate for determining the state and rate of change in SOM in agro- and natural ecosystems, in this work also the CMI indices were calculated. The results are shown in Table 2. It was found that Lability Index (LI) as well as Carbon Pool Index (CPI) were greater for the soil from under junipers (1.4 and 2.26), than for the soil under Thuja trees (1.33 and 1.69). Resulting from the Carbon Management Index formula it is logical that studied trees sites considerably differed also in CMI, which was greater for the soil under junipers (315.9), than that under Thuja trees (224.9). Generally, higher values of CMI indicate better soil quality.

Usually, CMI indices are calculated for SOM characterization after natural ecosystem (forest or grassland) conversion to agro-ecosystem or urban ecosystem. Szombathová (2010) studied changes in SOM pool and quality in soil converted from forest to arable on the same soil subtype as is in this study (cultivated Stagni-Haplic Luvisol) in Dolná Malanta locality, Slovakia. Calculated CMI indices were 44.1 and 43.7, whereas in cultivated Chernozem the CMI was 70. In this work could be obtained very interesting results, if arable land was chosen as control and compared to the studied trees stands, because calculated CMI (44.5 and 31.6 for thuja and juniper) were similar to those ascertained by Szombathová (2010) in cultivated

Stagni-Haplic Luvisol. CMI in both works were calculated for labile carbon determined by method of Loginow et al. (1993).



Different letters (a-c) indicate significant difference at P < 0.05

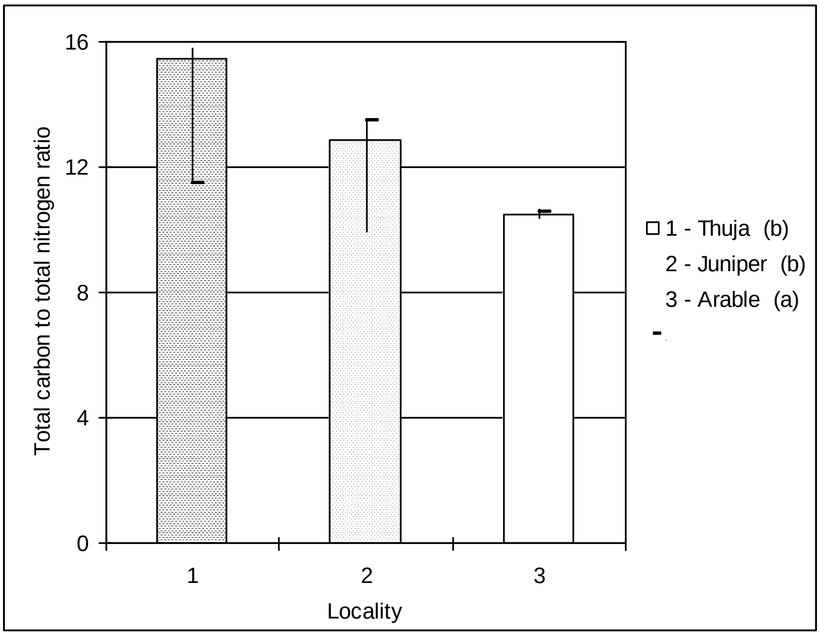
Rôzne písmená (a-c) indikujú preukazný rozdiel pri P < 0,05

Figure 3. Total nitrogen content in soil under thuja, juniper and arable

Obrázok 3. Celkový obsah dusíka v pôde pod tujami, borievkami a v ornej pôde

Results obtained in this study showed, that conversion of cropland to forest led to lowering of soil organic matter quality, assessed as increased ratio of total carbon and nitrogen (C_{ox}/N_T). Significant difference ($P < 0.05$) of C_{ox}/N_T ratio was found between arable soil (10.2) and soil under thuja trees (13.9), not significant between cultivated soil and that under junipers (12.0) (Table 1). Batjes (1996) stated that since soil forming processes are hardly noticeable in studied soils, continuing humus forming process can be presumed from the C/N ratio which narrows with the soil depth and indicates a higher degree of decomposition, humification and/or stabilization of SOM.

Compared to C_{ox}/N_T, the differences in ratios of labile carbon and nitrogen (C_L/N_{pot}) were between arable soil and that under trees more significant (Table 1). In arable soil the C_L/N_{pot} reached value 15.7, under thuja trees 43.8 and under junipers 50.9. Wider C_L/N_{pot} ratio, as well as percentage N_{pot} of N_T indicates considerably less amount of labile nitrogen available to plants and microbes in forest soil compared to arable. Darrouzet-Nardi and Weintraub (2014) stated that in nitrogen limited ecosystems are expected low concentrations of labile nitrogen compounds such as NH_4^+, NO_3^-, and amino acids because N-limited plants and microbes should efficiently consume these compounds as they are produced.



Different letters (a-c) indicate significant difference at P < 0.05

Rôzne písmená (a-c) indikujú preukazný rozdiel pri P < 0,05

Figure 4. Total carbon and nitrogen ratio in soil under thuja, juniper and arable

Obrázok 4. Pomer celkového uhlíka a dusíka v pôde pod tujami, borievkami a v ornej pôde

Table 3. Humus content and quality (fractionation by Kononova & Belchikova)

Tabuľka 3. Obsah a kvalita humusu (frakcionácia podľa Kononovej & Belčikovej)

Locality	C_{HS} [g*kg^{-1}]	C_{HA} [g*kg^{-1}]	C_{FA} [g*kg^{-1}]	C_{HA}/C_{FA}	C_{HS} [% of C_{ox}]	C_{HA} [% of C_{ox}]	C_{FA} [% of C_{ox}]	$Q_{HS}^{4/6}$	$Q_{HA}^{4/6}$
Thuja	8.55	3.23	5.32	0.65	34.2	13.4	20.8	6.45	5.18
Juniper	10.57	4.57	6.00	0.78	38.9	17.1	21.7	8.31	6.55
Arable	4.96	1.93	3.04	0.63	40.1	15.5	24.5	7.33	6.18

C_{HS} – humus substances carbon, C_{HA} – humic acids carbon, C_{FA} – fulvic acids carbon, C_{HA}/C_{FA} – humic acids to fulvic acids ratio, $Q_{HS}^{4/6}$- absorbance ratio $A_{4/6}$ of humus substances, $Q_{HA}^{4/6}$- absorbance ratio $A_{4/6}$ of humic acids

C_{HS} – uhlík humusových látok, C_{HA} – uhlík humínových kyselín, C_{FA} – uhlík fulvokyselín, C_{HA}/C_{FA} – pomer zastúpenia uhlíka humínových kyselín a fulvokyselín v humuse, $Q_{HS}^{4/6}$- farebný koeficient humusových látok $Q_{HA}^{4/6}$- farebný koeficient humínových kyselín

Unlike to labile SOM fractions, the quality of humus studied as humic to fulvic acids ratio (C_{HA}/C_{FA}), differed only slightly between studied sites (Table 3). Surprisingly, higher amount of humic acids as fulvic acids was ascertained under trees, where

C_{HA}/C_{FA} in soil under junipers was 0.78, thuja 0.65, but on arable land 0.63. Low values of colour coefficients of humus substances and humic acids confirmed higher humus quality only under thuja.

Conclusions

Considerable changes of soil organic matter due to plantation of thuja and juniper trees on formerly arable land have occurred in A horizons already after 50 years.

Conversion of formerly arable land to Arboretum resulted to significant increase of the total organic carbon content and in particular of its labile forms and also to decrease the quality of soil organic matter - what is typical for forest, compared to cultivated soil.

The quality of humus between examined sites differed only minimally, since the change of humus quality is a long term process.

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