Soils classified in the Arboretum Mlyňany, Slovakia

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Abstract

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Successful adaptation of introduced trees requires providing appropriate conditions for their growth and life. In this context, our study aim was a soil survey in the Arboretum Mlyňany, on the basis of which the soils could be classified. Detailed soil investigations were done at seventeen sites under dense monocultures of trees and the grassland. For each site, there was dug one soil pit, near which there were made three soil bores. Over most area of the locality, the prevailing soil-forming substrates were decalcified loess and silt, with gravelly patches, with prevailing medium soil texture, and acid to slightly acid pH. Based on the morphological features and the results concerning the physical and chemical soil properties, seven quality-degrees of soil cover were classified. The lowest-quality was recognised in Fragic Stagnic Retisol, in the highest-situated, east part of Arboretum, and also in the central part of the Ambrozy's park under *Thuja plicata*, where there was discerned also low quality Albic Stagnic Luvisol. The most area east of the manor house is covered with Stagnic Cutanic Luvisol (the North American and East Asian area with Stagnic Cutanic Luvisol (Anthric)). North of the manor, on a slight slope of the North American area was found a Cutanic Luvisol (Anthric). West of the manor, the terrain evenly declines, and there has been developed Luvic Chernozem, whose cultivated form, Luvic Chernozem (Anthric), was determined in the East Asian area.

Keywords

base saturation, Central European hilly area, introduced trees, organic carbon, pH, texture

Introduction

The Arboretum Mlyňany was established in year 1892, as a private collection, by Dr. Ambrózy, whose goal was to collect exotic, mainly sempervirent woody plants and to prove their viability in soil-climatic conditions of Slovakia (Hoťka, 2010). In the year 2013, the number of the taxa grown in the Arboretum was 1,933 (Hoťka et al., 2013).

The introduction of a species involves adaptation, productivity and reproduction success in new environmental conditions. An introduction also requires to ensure that the species related are superior at their natural habitat (Lavadinović et al., 2013). Good knowledge of soil properties is crucial for the successful introduction of woody plants not only into the Arboretum Mlyňany but also to other parks and ornamental zones. Generally, terrestrial vegetation and soils are in very close relationship, influencing each other. Thorough knowledge of these relationships and influences can contribute to the successful plants growing on a particular soil. The vegetation has a considerable and often major influence on the soil, since plants significantly affect soil properties by their root secretions (Jones et al., 2009) and penetration, the plant residues (Polláková et al., 2015a). The plants also influence soil erosion and accumulation, structure (Šimanský, 2011, 2012), organic matter dynamics (Jonczak et al., 2015),

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soil chemical composition (Parzych and Jonczak, 2013) and hydrology (Matejka et al., 2009). On the other side, the soils are to provide to plants adequate mechanical support, sufficient reserves of plant-available water, enough gas exchange and thermal fluxes, and also appropriate quantities of available plant nutrients. These properties are significantly determined by the thickness of the root-accessible soil zone (Blume et al., 2016).

Plants introduced to a foreign environment need appropriate conditions for growth and life – in order to ensure their successful adaptation, since each plant species has specific requirements for soil-ecological environment. Therefore, the objective of this study was a soil survey in the Arboretum Mlyňany, on the basis of which the soils were classified.

Material and methods

Study site

The Arboretum Mlyňany is located in south-western part of the Slovak Republic (48º19'N, and 18º21'E), on the north edge of the Danubian Lowland, in the valley of the Žitava River, on a slightly undulated terrain, with the main slope north-west-oriented, at an altitude of 165–217 m above the sea level. The climate is continental, with a mean annual temperature of 10.6 ºC and an annual precipitation total of 578 mm (Hoťka and Barta, 2012). The geological substrate in the Arboretum is represented by late Tertiary clays, sands and gravel terraces, and it is almost all covered by wind-deposited loess, mostly decarbonated (Steinhübel, 1957). Neogene gravels, patchily located closer to the soil surface, cause significant deterioration of soil conditions, since they are highly permeable and poor in nutrients (Cifra, 1958). On majority of the Arboretum area, the Stagnic Cutanic Luvisol has been developed (Polláková, 2013). The Arboretum Mlyňany consists of: the original Ambrozy's park, the areas of East-Asian, North American, Korean, Slovak dendroflora and exposition of roses (Tábor and Pavlačka, 1992). For coherent impression of vegetation, different tree species have been planted in monocultures.

Soil sampling and analyses

Soil survey was done at seventeen sites under dense monocultures of introduced and indigenous trees and a grassland, each with an area at least 200 m^2. For each examined tree species and the grassland, one soil pit was dug roughly in the middle of the relevant monoculture (1–17), the sampling site design is in Fig. 1.

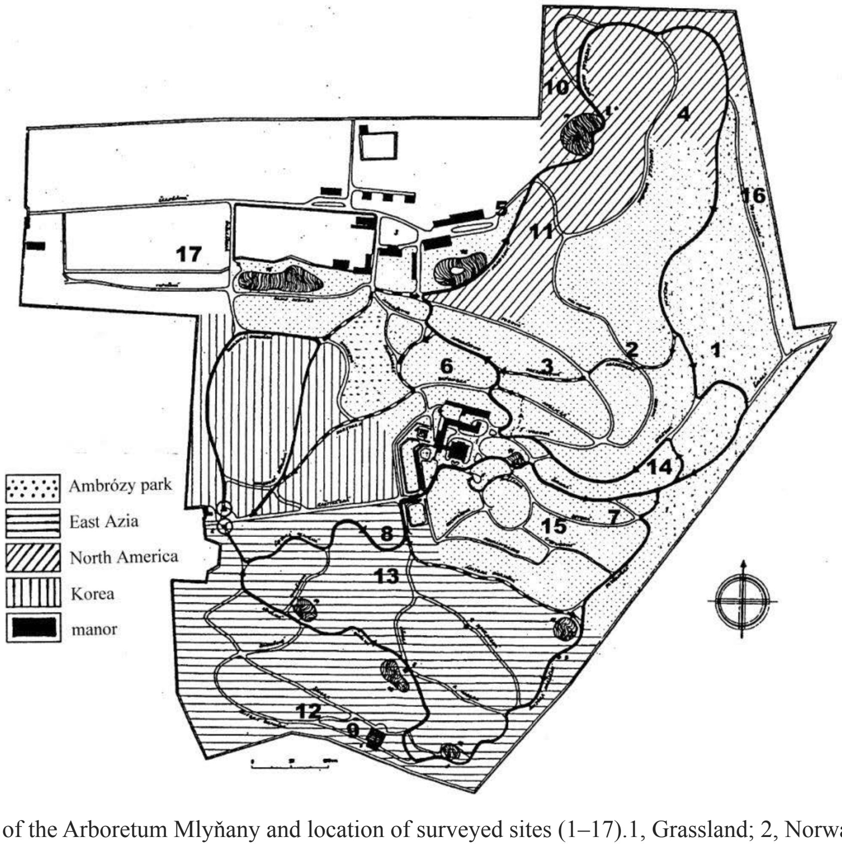

Fig. 1. Map of the Arboretum Mlyňany and location of surveyed sites (1–17).1, Grassland; 2, Norway spruces; 3, Oaks-hornbeams; 4, Sugar maples; 5, White firs; 6, European yews; 7, Cherry laurels; 8, Himalayan pines; 9, Japanese cedars; 10, Lawson cypresses; 11, Tulip trees; 12, Chinese junipers; 13, Oriental thujas; 14, Western redcedars; 15, Oriental spruces; 16, Austrian pines; 17, Eastern arborvitae.

Table 1. Soil texture, textural coefficient and arithmetic mean (± standard deviation) of soil chemical properties in studied profiles

Site	Horizon	Depth (cm)	Texture	Textural coefficient	pH_{H2O}	BS (%)
Austrian pines (16)	um	0–10	sp	2.17	3.83 ± 0.3	8.7 ± 3.1
	ab	10–38	sp	1.09	4.10 ± 0.1	11.3 ± 4.3
	fg	38–70	sp	8.93	4.15 ± 0.1	12.9 ± 4.6
	st	70–90	tp		4.21 ± 0.0	56.9 ± 6.0
Western redcedars (14)	um	0–10	sh	1.07	4.59 ± 0.2	51.4 ± 6.7
	ab	10–22	sh	1.56	4.20 ± 0.2	36.5 ± 7.1
	fg	22–50	sh	2.70	4.10 ± 0.2	31.3 ± 5.7
	st	50–80	ti		4.24 ± 0.1	55.9 ± 6.9
*Cherry laurels (7)	um	0–23	sp	1.05	4.92 ± 0.1	64.8 ± 5.1
	ab	23–60	sp	2.02	4.8 ± 0.2	60.8 ± 10.5
	st	60–90	sh	1.47		
	st/c	>90	tp			
Tulip trees (11)	mo	0–20	ssh	1.85	6.47 ± 0.5	88.9 ± 6.9
	ab	20–50	sp	2.43	5.66 ± 0.7	74.2 ± 14.5
	lv	50–70	sh	1.59	5.02 ± 0.3	69.2 ± 6.8
	st	70–90	si		4.94 ± 0.3	67.5 ± 3.8
*Grassland (1)	mo	0–25	ssh	1.54	6.15 ± 0.3	91.1 ± 2.6
	lv	25–55	ssi	1.12	6.24 ± 0.4	92.1 ± 1.6
	st	55–140	ssi		5.68 ± 0.2	89.4 ± 2.3
*Norway spruces (2)	um	0–15	ssh	1.56	4.43 ± 0.2	44.9 ± 11.7
	lv	15–48	ssh	1.49	4.6 ± 0.2	51.7 ± 14.4
	st	48–120	si		4.97 ± 0.2	83.4 ± 4.7
*Oaks-hornbeams (3)	um	0–15	ssh	1.14	4.66 ± 0.2	36.1 ± 15.0
	lv	15–50	ssh	1.17	4.73 ± 0.3	44.3 ± 16.2
	st	50–80	ssh	1.54	5.19 ± 0.2	82.5 ± 3.5
	st/c	80–100	si			
*White firs (5)	mo	0–10	sh	1.33	6.12 ± 0.4	89.3 ± 7.6
	mo/lv	10–40	ssh	1.32	6.02 ± 0.5	89.1 ± 7.8
	lv	40–75	ssi	1.16	6.07 ± 0.2	92.1 ± 4.0
	st	75–110	ssh	1.03		
	st/c	>110	ssh			
*European yews (6)	um	0–20	sh	1.37	4.44 ± 0.2	61.4 ± 4.4
	lv	20–60	sh	1.33	4.47 ± 0.3	66.3 ± 11.4
	st	60–90	si	1.39	4.57 ± 0.2	80.2 ± 4.3
	st/c	90–100	ti			
Oriental spruces (15)	um	0–20	ssh	2.72	3.67 ± 0.1	12.7 ± 4.2
	lv	20–40	ssi	1.30	3.80 ± 0.1	16.1 ± 4.7
	st_1	40–62	si	1.13	3.96 ± 0.2	28.3 ± 6.3
	st_2	62–80	ti		4.29 ± 0.0	64.8 ± 1.1
*Sugar maples (4)	ak	0–20	ssh	1.31	4.73 ± 0.3	62.4 ± 9.9
	lv	20–40	sh	1.40	4.63 ± 0.2	62.4 ± 11.0
	st	40–110	si	1.17	4.78 ± 0.4	74.8 ± 4.8
	st/c	>110	si			
*Japanese cedars (9)	ak	0–20	si	1.33	5.06 ± 0.2	79.2 ± 5.3
	st	20–80	ti	1.19	5.13 ± 0.2	85.3 ± 3.0
	st/c	>100	ti			
Chinese junipers (12)	ak	0–20	sh	1.92	6.32 ± 1.0	86.2 ± 12.5
	lv	20–30	ts	1.05	4.93 ± 0.6	64.0 ± 7.3
	st	30–80	ti		5.09 ± 0.6	74.6 ± 6.8
Lawson cypress (10)	ak	0–30	ssh	1.57	6.83 ± 0.7	95.5 ± 4.5
	lv	30–70	si	1.23	7.02 ± 0.5	95.8 ± 2.2
	cc	70–80	sh		7.25 ± 0.1	96.5 ± 1.1

Table 1. Soil texture, textural coefficient and arithmetic mean (± standard deviation) of soil chemical properties in studied profiles – continued

Site	Horizon	Depth (cm)	Texture	Textural coefficient	pH_{H2O}	BS (%)
Eastern arborvitae (17)	mo	0–20	ssh	1.08	7.36 ± 0.2	97.9 ± 1.8
	mo/lv	20–60	ssh	1.06	6.88 ± 0.5	94.9 ± 3.8
	lv/c	60–70	ssi	1.40	7.06 ± 0.8	96.5 ± 4.8
	cc	>70	ssh		7.17 ± 0.8	96.4 ± 5.3
*Himalayan pines (8)	ak	0–20	sh	1.02	6.02 ± 0.2	89.2 ±1.8
	ak/lv	20–35	sh	1.13	6.46 ± 0.3	90.8 ± 2.0
	lv	35–60	sh	1.16	7.30 ± 0.6	94.8 ± 2.0
	lv/c	60–100	sh	1.25		
	cc	>100	sh			
Oriental thujas (13)	ak	0–20	si	1.03	6.81 ± 0.3	94.7 ± 2.4
	ak/lv	20–40	ssi	1.65	7.08 ± 0.4	95.9 ± 2.2
	cc	40–80	ssh		7.84 ± 0.1	99.0 ± 0.4

Horizons: ak, anthric; ak/lv, intermediary; um, umbric; mo, molic; mo/lv, intermediary; ab, albic; lv, luvic; lv/c, intermediary; fg, fragic; st, stagnic; st/c, intermediary; cc, calcic. Texture: ssh, silty-loam; sp, sandy-loam; sh, loamy; ssi, silty-clay-loam; si, clay-loam; spi, sandy clay loam; ts, silty clay; ti, clay; tp, sandy clay. BS, base saturation. Data in profiles marked * were published in (Polláková, 2013). Sites in Table 1 were listed according to Reference Soil Groups with qualifiers: Fragic Stagnic Retisol (16, 14), Albic Stagnic Luvisol (7, 11), Stagnic Cutanic Luvisol (1, 2, 3, 5, 6, 15), Stagnic Cutanic Luvisol (Anthric) (4, 9, 12), Cutanic Luvisol (Anthric) (10), Luvic Chernozem (17), Luvic Chernozem (Anthric) (8, 13).

Soil pits in the original Ambrozy's park established in 1892 in an oak-hornbeam forest: under grassland, Norway spruces (*Picea abies,* (L.) Karsten), under the rest of the original oak-hornbeam forest (*Quercus cerris,* L., *Carpinus betulus,* L.), under white firs (*Abies concolor,* Lindl. et Gord.), European yews (*Taxus baccata,* L.), cherry laurels (*Prunus laurocerasus,* L.), western redcedars (*Thuja plicata*, Donn ex D. Don), oriental spruces (*Picea orientalis*, L.), Austrian pines (*Pinus nigra*, Arnold), eastern arborvitae (*Thuja occidentalis malony*, L.). Soil pits in the East Asian area established in 1964 on land that was until 1960 used as arable: under Himalayan pines (*Pinus wallichiana,* Jacks.), Japanese cedars (*Cryptomeria japonica,* D. Don.), Chinese junipers (*Juniperus Chinensis*, L.), oriental thujas (*Thuja orientalis*, L.). Soil pits in the North American area founded in 1975 on land that was previously used as vineyard: under sugar maples (*Acer saccharinum,* L.), Lawson cypresses (*Chamaecyparis lawsoniana*, A. Murray, Parl), tulip trees (*Liriodendron tulipifera*, L.).

Immediately after digging soil pits, the morphological features of soil profiles were specified. Then, for determining the physical properties according to the standard methods (Hrivňáková et al., 2011), undisturbed soil samples (100 cm^3) were collected by using steel cylinders, per each of 0.1 m layer, down to a depth of 0.8/0.9 m. The textural composition was determined for each horizon, using the pipette method (Hrivňáková et al., 2011). Also chemical properties were analyzed per each of 0.1 m layer. Near each pit, there were made three soil bores which were analysed only for selected chemical properties. The content of total soil organic carbon (C_T) was analyzed by dichromate oxidation according to the Tyurin method (Orlov and Grishina, 1981); active pH – potentiometrically in H_2O (1:2.5); for the calculation of base saturation (BS) BS = BC · 100/(H + BC), there were determined (BC) sum of exchangeable base ions (Ca^{2+}, Mg^{2+}, K^+, Na^+) and (H) hydrolytic acidity by the Kappen's method (Hrivňáková et al., 2011).

Each analysis was done in three repeats. The chemical parameters shown in Table 1 represent the arithmetic mean (mean ± SD) of the three soil bores and one soil pit made in the particular stand.

Results and discussion

Soils classified in the Arboretum Mlyňany

Morphological characters in the studied soil profiles differed significantly, mainly by the presence and thickness of various horizons, colour, texture, structure, occurrence of Fe^{3+} and Fe^{2+} mottles reflecting seasonal waterlogging, and cycles of reducing and oxidising conditions, manganese shots, carbonates content, depth and rooting intensity. Under Norway spruces, sugar maples, European yews, cherry laurels, tulip trees, western redcedars, oriental spruces and Austrian pines, there was found also rounded gravel with a size of 10–50 mm. A detailed description of the morphological features of the studied profiles as well as the soil classification according to the Morphogenetic Soil Classification System of Slovakia (MSCS, 2014) has been published in Polláková (2018). Nevertheless, the first soil survey in Arboretum was done by Cifra (1958). However, at that time, many analysis were done by other methods and the results were evaluated differently. Similarly, the soil types were determined according to the system valid fifty years ago.

Based on the morphological features, results of physical and chemical soil properties, three Reference Soil Groups (Luvisols, Retisols and Chernozems) were recognised in the Arboretum according to the World Reference Base (WRB, 2014). The results of physical, chemical and textural soil studies in the Arboretum Mlyňany were published in previous works (Labudová et al., 2009; Polláková, 2013; Polláková and Konôpková, 2012; Polláková et al., 2011, 2015a, 2015b, 2016, 2017).

The spatial distribution of selected stands, where there were dug soil pits and done soil survey, is illustrated in Figure 1. Considering the Reference Soil Groups (RSG), the location of the manor house represents approximate boundary in Arboretum, as the terrain to the west of the manor evenly declines. Stagnic Cutanic Luvisol is the most widespread soil, occupying most of the area east of the manor house, with predominant soil-forming substrate loess without carbonates and loam (Fig. 1). Stagnic Cutanic Luvisol was found under the grassland (1), Norway spruces (2), oaks-hornbeams (3), white firs (5), European yews (6) and oriental spruces (15).

The land of East Asian and North American areas was up to the year 1960 and 1975 used as arable and vineyard, respectively. As such this soil had been cultivated and the homogenized pattern of the ploughing horizon is still obvious (especially lighter colour as a result of decreased carbon content due to intensive cultivation). Therefore, the soil on these areas was classified as Stagnic Cutanic Luvisol (Anthric). Specifically, it includes the land on the west slope of North American area under sugar maples (4) and on the north slope of East Asian area under Japanese cedars (9) and Chinese junipers (12).

North of the manor, on a slight slope of North American area under Lawson cypresses (10), the soil was classified as Cutanic Luvisol (Anthric).

The least quality soil in the Arboretum Mlyňany, Fragic Stagnic Retisol, was found in the highest position near the east boundary of the Arboretum, under the growth of Austrian pines (16), and also in the central part of the Ambrozy's park under western redcedars (14). In the central part of the Ambrozy's park, there was also a low quality Albic Stagnic Luvisol, under cherry laurels (7) and also under tulip trees (11).

On the other hand, west of the manor the terrain evenly declines, and there is prevailing a superior, deeper, even carbonate loess substrate, on which the Luvic Chernozem has been formed (under eastern arborvitae – 17), of whose cultivated form, i.e. Luvic Chernozem (Anthric), was determined on East Asian area under the Himalayan pines (8) and oriental thujas (13).

Particle-size distribution in soil profiles

The most represented textural classes in the studied soil profiles were loam, silty-loam, clay-loam, silty-clay-loam and clay. It was observed a substantial migration of clay from surface to subsurface horizons in the process of lessivage (Fig. 2), and the coefficient of textural difference in all profiles was higher than 1.2 (Table 1). It is known, that soils containing high percentage of clay are prone to compaction (Mati et al., 2011), suffer with poor aeration and are low permeable or impermeable for water. In the profile under Austrian pines, there was observed an abrupt textural difference between the fragic (fg) and stagnic (st) horizons 8.93. Another considerable textural difference was also found in the profile under western redcedars (2.70). The main reason of such intensive lessivage was permeable substrate containing up to 50% of sand and 5–30% of gravel. In particular, on these sites, the gravel and sand substrate was covered with a thinner layer of loam than at other sites.

On the contrary, the distribution of clay in the profile of Luvic Chernozem under eastern arborvitae, and Luvic Chernozem (Anthric) under Himalayan pines and oriental thujas was reverse (Fig. 2). The clay content in the mo, mo/lv, lv/c, ak, ak/lv and lv (molic, intermediary, intermediary, anthric, intermediary, luvic) horizons in the frame of particular profiles was almost the same (29.6–24.3%), while the clay content in cc (calcic) horizons was considerably lower (21.2%, 16.7% and 16.6%). Thus, under the eastern arborvitae, Himalayan pines and oriental thujas, the whole profile, beside carbonate soil-forming substrate, was enriched with the clay.

The highest percentage of clay was in the profile under Japanese cedars and Chinese junipers. According to Tábor and Pavlačka (1992), the land of East Asian dendroflora had been as far as 1960 used as arable. During rainstorms, the significant amount of soil material eroded from the adjacent arable land accumulated just in this area. Moreover, the lateral washout of clay by soil solutions from the surrounding slopes and lessivage caused a considerable accumulation of clay at this site.

Selected chemical properties in soil profiles

The high heterogeneity of soil chemical characteristics in the Arboretum (Table 1) could be caused by various soil forming substrates (Steinhübel, 1957), agricultural land use before East Asian and North American area establishment, or also due to the influence of different tree species on soil properties (Polláková et al., 2011, 2015a).

Soil organic carbon is an essential determinant for soil quality, because of its positive impact on the soil structure and aggregation, water and nutrient retention, biotic activity, including the microbial biomass, erosion control, nonpoint-source-pollution abatement, carbon sequestration, and increase in biomass production (Manhas et al., 2015). In the forest soil, the main source of organic carbon inputs are plant residues, whose quality significantly affects their decomposition, and thus the accumulation and loss of carbon from the soil. In all the investigated profiles of the Arboretum Mlyňany, the total organic carbon content (C_T) steadily decreased with depth (Fig. 3). Among the forest soils, the lowest C_T content in topsoils was found in the East Asian and North American areas under Himalayan pines, Japanese cedars and Lawson cypresses. As it has been mentioned before, the land on East Asian and

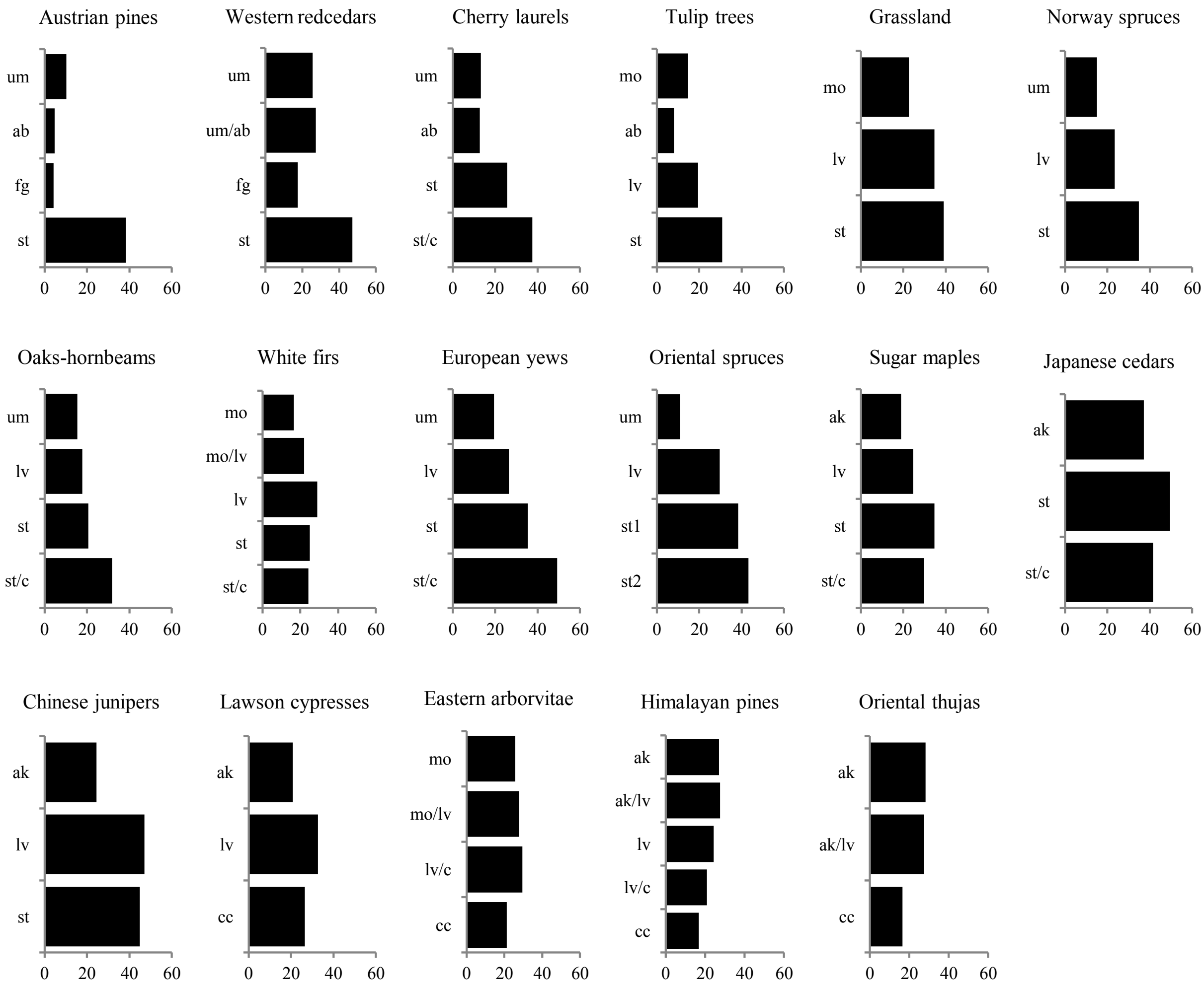

Fig. 2. Percentage of clay in the soil profiles in the Arboretum Mlyňany. Charts were listed according to the Reference Soil Groups with qualifiers (see Table 1).

North American areas was in the past cultivated, and the decreased organic carbon due to intensive cultivation is still obvious. On the other side, in the frame of studied soil sites, the highest accumulation of C_T, thus carbon sequestration, was in topsoils under Austrian pines and eastern arborvitae (Fig. 3). Significant sequestration of carbon in the soil, especially forest, has been confirmed by several authors (Lal, 2005; Uri et al., 2012; Polláková and Konôpková, 2012). Low C_T content was found also in the topsoil under grassland, but lower organic carbon supply in grasslands compared to forest is typical and documented in many works (McCulley et al., 2004; Tobiašová et al., 2014).

The parameter pH is one of the most important indicators of the soil state, fertility and functioning, since this parameter provides information about the potential soil microbial activity, chemical degradation, and availability of elements to plants. In the studied soil profiles of the Arboretum Mlyňany there predominated acid to slightly acid pH_{H2O}. The most remarkable acidification and, thus strongly acid pH_{H2O} (3.83–4.59), occurred under the Austrian pines and western redcedars in Fragic Stagnic Retisol, for which the acid pH is typical. Somewhat milder acidification, i.e. acid to weakly acid pH_{H2O} (4.80–6.47) was found in the Albic Stagnic Luvisol under cherry laurels and tulip trees (Table 1). In the prevailing soil, Stagnic Cutanic Luvisol and its cultivated form, i.e. Stagnic Cutanic Luvisol (Anthric), the pH_{H2O} values were within the range of 3.67–6.24. A slightly acid pH_{H2O} value was found under grassland and white firs, acid under oaks-hornbeams, sugar maples, Japanese cedars and Chinese junipers. In addition to the soil-forming substrate, also the long term influence of coniferous litter distinctly contributed to the strong acidification under the Norway spruces, European yews and oriental spruces. A neutral pH_{H2O} was found under the Lawson cypresses in the Cutanic Luvisol (Anthric), and a slightly alkaline in the loess soil-forming substrate (6.83–7.25). The carbonates in loess substrate of Luvic Chernozem and Luvic Chernozem (Anthric) considerably reduced the acidity of the soil already in the intermediary and luvic horizons under the eastern arborvitae, Himalayan pines and oriental thujas, where pH_{H2O} was slightly acid to slightly alkaline (6.02–7.84).

Beside pH, another substantial indicator of soil acidity is the cationic composition of their sorption complex and

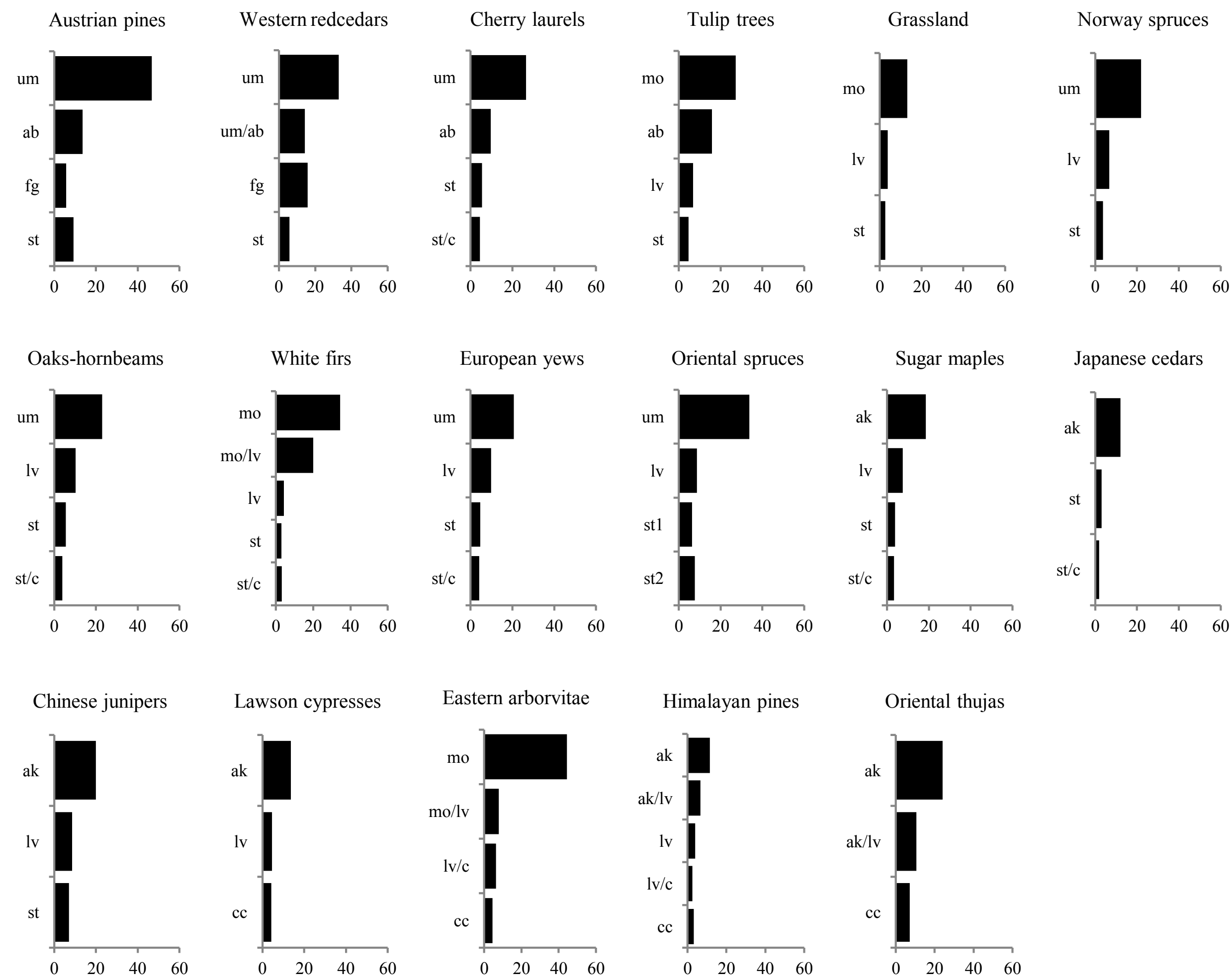

Fig. 3. Total organic carbon content (g kg^{-1}) in profiles of Arboretum Mlyňany. Charts were listed according to the Reference Soil Groups with qualifiers (see Table 1).

the resulting base saturation. Šebesta et al. (2011) found that the gradual acidification ongoing over 60 years in anthropogenically undisturbed forest soils decreased their pH values by 0.1–0.3 units in the A and B horizons, but their base saturation decreased by a half compared to the original state. Also in the soils of the Arboretum Mlyňany, more distinct differences between the studied profiles showed their base saturation (BS), compared to pH values. On the other side, the correlation between pH and BS was, as expected, highly significant (r = 0.853; $P < 0.001$).

The highest hydrolytic acidity was recorded in the topsoils, which were the most affected by acidic products coming from the decomposition of the poor-quality litter produced by trees. The acids in the soil reacted with the base cations, and the percolating water moved them from the upper to lower parts of the profile. Simultaneously, the sorption complex in the topsoils, albic, luvic and fragic horizons, was saturated with acidic cations, while in the lower parts of the profiles, there were accumulated base cations. This resulted to an increased sum of base cations, as well as base saturation of sorption complex in the lower parts of soil profiles (Table 1). Extremely unsaturated were horizons of the Fragic Stagnic Retisol under the Austrian pines and western redcedars and Stagnic Cutanic Luvisol under oriental spruces and Norway spruces. On the other side, a full base saturation was found in the profiles of Luvic Chernozem and Luvic Chernozem (Anthric) and also Cutanic Luvisol (Anthric) developed on carbonate loess.

The obtained results also enabled us to ascertain the extent of changes in the studied soil chemical properties under the deciduous compared to coniferous trees. Since the topsoils are the most influenced by tree litter and root residues and exudates, the differences were studied in the upper horizons. The organic carbon content in the topsoils under deciduous trees was in a range of 18.6–27.2 g kg^{-1}, while under the conifers the range of C_T content was considerably wider 11.5–46.8 g kg^{-1}. Also the range of pH_{H2O} values and base saturation in topsoils under the deciduous trees was narrower (pH_{H2O} 4.66–6.47, BS 36.1–88.9%) compared to the coniferous ones, representing pH_{H2O} 3.67–7.36 and BS 8.7–97.9%. From the results, there follows that chemical properties of the studied topsoils under the coniferous trees were much more variable than under the deciduous. Since all the studied deciduous trees in the Arboretum were grown only on one Reference Soil Group, while coniferous on three RSG, we expect that beside the decomposed litter, also the soil-forming substrate, soil properties, past and present way of land using, have considerably contributed to modifying mainly the pH and BS values.

In the Arboretum, the tree species were not planted depending on soil properties, but according to the tree origin. According to this principle, there were created areas of: East-Asian, North American, Korean and Slovak dendroflora. Only Austrian pines were planted intentionally on a hill-top, to serve as a protective strip for other introduced trees, mainly against the wind, and also due to the bad soil properties on the site.

Conclusions

Based on the morphological features, results of physical and chemical soil analyses, three Reference Soil Groups (RSG) were identified in the Arboretum Mlyňany: Luvisols, Retisols and Chernozems.

Considering RSG, the location of the manor house represents an approximate boundary of the Arboretum, as the terrain to the west of the manor evenly declines, and there is prevailing a superior, deeper, even carbonate loess substrate, on which there has been formed Luvic Chernozem, the cultivated form of which, Luvic Chernozem (Anthric), was found on East Asian area.

East of the manor, the predominant soil-forming substrate is loess without carbonates and loam. The least quality, Fragic Stagnic Retisol, was identified in the highest, east part of the Arboretum, and also in the central part of the Ambrozy's park, where there was also present low quality Albic Stagnic Luvisol. The most area east of the manor is occupied by Stagnic Cutanic Luvisol (on the North American and East Asian area the Stagnic Cutanic Luvisol (Anthric)). North of the manor, on a slight slope of the North American area, there was identified Cutanic Luvisol (Anthric).

The diverse substrates, the past and present way of soil use, but also the tree species and the duration of their impact on the soil, significantly affected the soil properties in the Arboretum.

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