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OPEN

DOI: 10.1515/ssa-2015-0026

SOIL SCIENCE ANNUAL
Vol. 66 No. 3/2015: 111–118

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Soil quality assessment of Phaeozems and Luvisols from the Kujawy region (central Poland)

Abstract: To assess the soil quality of Phaeozems and Luvisols from Kujawy region (Kujawy-Pomerania Province, Poland), the soil quality indicators such as: content of organic matter and nutrients, as well as bulk density were used. The soils showed similar inherent properties (soil texture, depth to parent material, type of clay) and management practices (tillage, crop rotation, nutrient application). The following properties were determined: bulk density, grain size composition, exchangeable acidity, concentration of available forms of potassium, phosphorus and magnesium, and the content of total organic carbon (TOC) and nitrogen (Nt). The amounts of dissolved organic carbon (DOC) and dissolved nitrogen (DN) were measured in the solution obtained after extraction with 0.004 M $CaCl_2$. The stock of TOC_s, Nt_s and DOC_s, and DN_s were calculated. The total organic carbon content in surface horizon of Phaeozems was significant higher (13.9–20.1 g·kg^{-1}) than in Ap horizon of Luvisols (8.3–11.0 g·kg^{-1}), which is a consequence of their origin. The stock of organic carbon in Ap horizon fell within 5.89 to 8.49 kg·m^2 in Phaeozems and 3.80 to 4.81 kg·m^2 in Luvisols. Although Phaeozems demonstrated a significant higher content of TOC, as compared with Luvisols, the amount of dissolved organic carbon was similar in both soil types, which points to a higher share of DOC in the total organic carbon content in Luvisols (up to 17.5% in Et horizon). The amounts of dissolved organic carbon and dissolved nitrogen and their stock do not depend on the type of soils if the management practices are similar.

Key words: soil quality, organic carbon stock, Phaeozems, Luvisols

INTRODUCTION

Soil quality measurements are a way of investigation of important problems in the agroecosystem. The lower than expected soil productivity can have several causes, of which low nutrient content can be only a symptom and not the cause. The quality of a soil is a specific combination of inherent and dynamic (use-dependent) soil properties. Soil quality assessments should be used to compare the effects of management practices only on associated soils with similar inherent or use-invariant properties. Changes in dynamic properties of soil, such as organic carbon content, depend on tillage practices, crop sequence, and application of organic and mineral fertilizers (Nardi et al. 2004, Sosulski and Korc 2011). Soil organic matter (SOM) consists of organic material at different stages of decomposition. Dissolved organic carbon (DOC), soluble in water or salt solutions, is the most mobile part of SOM which includes polyphenols, simple aliphatic acids, proteins, amino acids and sugar acids. The content of DOC in arable soils depends on the kind of organic material introduced into soil (Gonet and Dębska 2006, Drąg et al. 2010).

The possible movement of dissolved organic carbon (DOC) through the soil profile is an important process in terms of the formation of soil organic matter (Kalbitz et al. 2000). DOC fluxes through soils are a comparatively large source of carbon for microbial activity and represent a potentially important C loss pathway (Neff and Asner 2001). Systematic losses of dissolved organic matter containing C, N, and P can reduce the capacity of ecosystems to support basic productivity. Organic carbon is an important constituent of the arable soil due to its capacity to affect plant growth. SOM increases the availability of nutrients and improves the fertilization efficiency due to its high cation exchange capacity that prevents nutrient losses (Kramer et al. 2006).

Potential soil carbon storage is associated with changes in agricultural soil management (VandenBygaart et al. 2003). Predicting soil C storage requires

The paper was presented at the 29. Congress of the Polish Society of Soil Science, Wrocław, Poland, 31st August – 5th September 2015.

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dependable estimates of the current C stocks at the local scale as the base which is graded by land-use, soil type and climate region (Arrouays et al. 2001, Taghizadeh-Toosi et al. 2014). Researchers recommend SOC stocks to be determined by horizons for the soil profile in order to precisely evaluate the impact of land use changes (Kobierski and Wojtasik 2009, Kondras et al. 2010, Wiesmeier et al. 2012). The knowledge of TOC and DOC content, and of the interplay between C stocks and soil factors, could also help to identify the types of land-use changes or areas which are of special interest for losses and gains of soil carbon (Leifeld et al. 2005).

The depletion of the SOC stocks in cultivated soils is caused by conventional tillage method, crop growth, and crop type. The cultivation of some types of crops include cultivated row crops such as sugar beets, corn and potatoes, which can have a negative effect on soil quality, by causing losses of the organic matter of soil. An increase in the TOC content can be possible using the soils in the no-till system or in simplified systems (Conant et al. 2007, Van Eerd et al. 2014). The extent of the losses of the organic matter resources as a result of conventional tillage mostly depends on the physical soil properties and local climate conditions. Carter et al. (2003) report on about 60% of organic carbon in soil being found in the waterproof structures and C and N content increases with an increase in the content of the clay and silt fractions.

Arable soils in Poland show a slightly higher risk of the losses of resources of organic carbon than the other countries of the European Union (Louwagie et al. 2009). The loss of SOC resources in arable soils of Poland is mostly due to an inadequate crop rotation, unbalanced mineral fertilisation, and a lack of manure in fertilisation (Siuta and Żukowski 2010). Stuczyński et al. (2007) predicted the content of organic matter in arable soils of Poland over 2007 and 2020, as well as determined the risk of the loss of functions of soils due to SOM mineralization. The forecast of organic matter losses from the soils of the Kujawy and Pomorze agricultural land for the 2020 perspective (CO_2 emissions) will be 39.2 $Mg \cdot ha^{-1}$.

In the Kujawy region's landscape with low-relief ground moraine one will find associations of Phaeozems with Luvisols. Phaeozems in the Kujawy region represent the soils with the highest yield potential in Poland, however, some of them demonstrate unfavourable physical properties: a high bulk density and a low total porosity (Wojtasik 1989). Soil bulk density is often used as a parameter for various descriptive soil models (Suuster et al. 2011). It is an important indicator of soil quality and site productivity and is essential for evaluating the C stock and necessary for the assessment of nutrient pools. Soil bulk density is often studied due to its effects on crop yield reduction (Batey 2009).

Soil quality is evaluated to learn about the effects of management practices on the soil function. The purpose of this paper has been to evaluate the functional characteristics of the soils which differ in their pedogenesis but similar tillage systems, crop rotation and fertilizer management practices. We evaluated dynamic soil properties and how they change in relation to the inherent properties of the soils. To determine this, we used soil indicators such as: organic carbon level, content of nutrients, as well as bulk density. The stock of TOC_s, Nt_s and DOC_s and DN_s were calculated and compared in the Phaeozems and Luvisols sampled in the Kujawy region.

MATERIALS AND METHODS

Samples were taken from the arable soils in the Kujawy region (northern part of central Poland) in the vicinity of 10 localities (P-I Szadłowice, P-II Cieślin, P-III Gnojno, P-IV Dobre, P-V Orłowo, P-VI Wybranowo, L-I Rucewko, L-II Lipionka, L-III Liszkowo, L-IV Zduny). The soils was sampled in September 2012 from arable fields from which, a dozen or so years earlier, soil material was collected for mineralogical composition analysis. Mixed (1 kg) and undisturbed (100 cm^3) soil samples (3 replications each) were collected from different depths (Table 1) at all places after the harvest of crop plants. For the last 2 decades, conventional tillage with ploughing down to about 25–30 cm was done in place. The mean NPK fertilisation ranged from 132 to 170 $kg \cdot ha^{-1} \cdot yr^{-1}$ for plants (sugar beet, wheat, maize, triticale). The soil types included Gleyic Phaeozems and Haplic Luvisols (IUSS Working Group WRB 2015) derived from glacial till. The mean annual temperature is 7.8°C and the mean annual precipitation does not exceed 500 mm, and over the growing season, it reaches only 340 mm. The precipitation of this region is one of the lowest in Poland.

The soil analyses were performed following commonly applied methods: texture using the areometric method (PN-ISO-11277: 2005), pH determined in a 1M KCl solution (soil:solution ratio 1:2.5) (ISO 10390:2005), a hydrolytic acidity with the Kappen method. Soil bulk density was determined gravimetrically from undisturbed soil cores. It was calculated by dividing the oven-dry weight of soil by its volume. Particle density was determined by the picnometric method in three repetitions. Cation exchange capacity (CEC) was calculated by adding the content of H^+ (hydrolytic acidity) and exchangeable cations Ca^{2+},

Mg^{2+}, K^{+}, Na^{+} following the barium chloride method (PN-EN ISO 11260, 2011). The concentration of cations was evaluated with the atomic absorption spectrometer PHILIPS PU 9100X. The amount of dissolved organic carbon (DOC) and dissolved nitrogen (DN) were measured in the solutions obtained after extraction with 0.004M $CaCl_2$. The total organic carbon content (TOC), total content of nitrogen, DOC, and DN were assayed with analyser Vario Max CN (Elementar Analysensysteme GmbH).

Soil organic carbon stock ($kg \cdot m^{-2}$) for a given depth was calculated using Eq. (1)

$$SOC_s = [C \; x \; \rho_a \; x \; t \; x \; (1\text{-}\theta\%)] \quad (1)$$

where: C – carbon content ($g \cdot kg^{-1}$); ρ_a – bulk density ($Mg \cdot m^{-3}$); t – thickness of horizon (m) and θ – content of gravel $\phi > 2.0$ mm.

Porosity was calculated using Eq. (2)

$$P=[(\rho_s - \rho_a)/\rho_s] \; x100\% \quad (2)$$

where: ρ_s – particle density; ρ_a – bulk density.

To evaluate the natural vulnerability of soils to compaction in subsoil, we calculated the value of packing density (Jones et al. 2003), which integrates the bulk density and clay content, defined as:

$$PD = Db + 0.009 \; C \quad (3)$$

where: PD = packing density in $Mg \cdot m^{-3}$; Db= actual bulk density in $Mg \cdot m^{-3}$; C is clay fraction content (%). Three classes of PD were recognised: low: <1.40 $Mg \cdot m^{-3}$, medium 1.40–1.75 $Mg \cdot m^{-3}$, and high >1.75 $Mg \cdot m^{-3}$. Soils with packing density >1.75 $Mg \cdot m^{-3}$ are not very susceptible to further compaction whereas those with medium and low packing density are sensitive at critical moisture content and loads.

The soil properties of Phaeozems and Luvisols were treated with standard statistics and statistical tests (ANOVA). The significance of the differences between means was evaluated drawing on the Tukey test for uneven numbers. Pearson's correlation analysis was also performed for the soil properties. The statistical analyses were made using Statistica 7.0 (StatSoft Inc, Tulsa, USA).

RESULTS AND DISCUSSION

Many soil properties change depending on recent field operation and require observations throughout the year, preferably throughout a few years. When soil quality is assessed over time one can collect more information about the sustainability of management practices. The results of the current research can be compared with the results of the analyses performed a dozen or so years ago previously since they cover arable fields in similar area (Kobierski and Dąbkowska-Naskręt 2003a,b, Kobierski et al. 2005). The results of these studies showed very compact soils with low porosity and in some profiles, tillage pan compaction was observed. In the Phaeozems of the region studied there has been a tendency of decreasing humus content due to excessive dehydration and intensive use. The predominant minerals of the clay fraction in the surface horizon were illite and illite-smectite (Kobierski and Dąbkowska-Naskręt 2003b), which affected the CEC value and, as a result, fertility and crop production (Kobierski and Dąbkowska-Naskręt 2005).

The soil sampled in 2012 demonstrated surface horizon texture of fine sandy loam with the content of clay fraction from 10 to 15% (Table 1). The soil sampled from the subsurface horizons (28 to 55 cm deep) showed the texture of sandy loam and fine sandy loam. The soil pH in the samples analysed was neutral and alkaline pH_{KCl} 6.9–7.7 (Table 1).

Mean organic carbon content in surface horizon was 17.0 $g \cdot kg^{-1}$ in Phaeozems and 9.4 $g \cdot kg^{-1}$ in Luvisols (Table 2). Stuczyński et al. (2007) report the average SOC content in the soils of the Kujawy and Pomorze Province as 18.5 $g \cdot kg^{-1}$ and they point to the existence of a strong trend of decreasing humus content, mostly in soils naturally rich in organic matter, which is definitely the feature of Phaeozems. SOC content below 20 $g \cdot kg^{-1}$ indicated a need to change the use of the soils and apply adequate cultivation treatments. Lal (2013) identified 10 $g \cdot kg^{-1}$ of organic carbon as critical level for soil quality decline. Van Camp et al. (2004) pointed out that the critical low level of SOC can be established across soil types and climatic regions. The contents of total organic carbon and total nitrogen in the surface horizon of Phaeozems were higher than in Ap horizon of Luvisols. It is a consequence of soil origin because Phaeozems are soils with a deep surface horizon that is rich in organic matter (Łabaz and Kabała 2014).

The stock of organic carbon and total nitrogen in horizon Ap ranged from 5.89 to 8.49 $kgC \cdot m^{-2}$ and from 0.47 to 0.85 $kgN \cdot m^{-2}$ in Phaeozems, whereas in Luvisols ranged from 3.80 to 4.81 $kgC \cdot m^{-2}$ and from 0.17 to 0.49 $kgN \cdot m^{-2}$ (Fig. 1, 2). Although Phaeozems demonstrated a significantly higher content of TOC, as compared with Luvisols (Table 3), the amount of DOC was similar in both soil types, which points to a higher share of DOC in the total organic carbon content in Luvisols (up to 17.5%) (Table 2). The difference of mean stock of DOC and DN (Fig. 3 and 4) in soil samples between soil types was non-significant. A significantly ($p<0.05$) higher content of Nt and stock of nitrogen was noted in Phaeozems.

TABLE 1. Texture, pH, and CEC of soils

No.	Horizon	Depth	Texture [%]			PTG (2009)	pH	CEC
			2.0–0.05	0.05–0.002	<0.002			
		cm	mm				1M KCl	cmol·kg^{-1}
P-I	Ap	0–30	65	21	14	gpdr	7.3	19.6
	A2	30–56	63	24	13	gl	7.6	17.9
P-II	Ap	0–28	69	18	13	gpdr	7.0	16.3
	A2	28–40	68	20	12	gpdr	7.1	13.9
	AB	40–55	64	21	15	gl	7.6	16.3
P-III	Ap	0–28	68	19	13	gpdr	7.2	17.7
	A2	28–49	70	16	14	gpdr	7.2	18.5
P-IV	Ap	0–26	68	19	13	gpdr	7.3	15.0
	A2	26–42	63	23	14	gl	7.7	18.8
P-V	Ap	0–29	65	20	15	gpdr	7.2	17.6
	AB	29–51	61	24	15	gl	7.2	19.2
P-VI	Ap	0–28	65	22	13	gpdr	7.0	24.3
	A2	28–44	60	25	15	gl	7.2	21.0
L-I	Ap	0–28	67	18	15	gpdr	7.1	17.3
	Bt	28–51	54	27	19	gl	7.0	19.5
L-II	Ap	0–29	68	19	13	gpdr	7.1	16.3
	Bt	29–49	57	24	19	gl	7.0	18.8
L-III	Ap	0–27	70	19	11	gpdr	7.1	9.48
	Et	27–45	71	21	8	gpdr	6.9	7.57
L-IV	Ap	0–29	70	20	10	gpdr	7.0	8.84
	Et	29–50	74	18	8	gpdr	6.9	7.15

gpdr – fine sandy loam; gl – sandy loam; PTG – Polish Society of Soil Science, CEC – cation exchange capacity.

deeper horizons of the soil profiles was lower than in the topsoil of all the soils under study. Such a relationship was observed by Sosulski et al. (2013) only in the Luvisols sampled in autumn from the plots with only mineral fertilization. Finally, Sosulski et al. (2013) found that DOC content was higher in the subsurface horizons than in the Ap horizon of soils fertilized with manure, or with manure and mineral fertilizers than in the soils fertilized with mineral fertilisers only. Frequently, as a result of intensive use of soils, the process of mineralization of organic matter is accelerated and the process of leaching of DOC deep down the soil profile is intensified. The content of dissolved organic carbon in the soils in the present study was higher than in the Luvisols form Pomorze and Kujawy region (Kobierski et al. 2009).

The Luvisols under study showed a lower content of clay fraction which would play a SOM-protective function, which, in turn, could make the

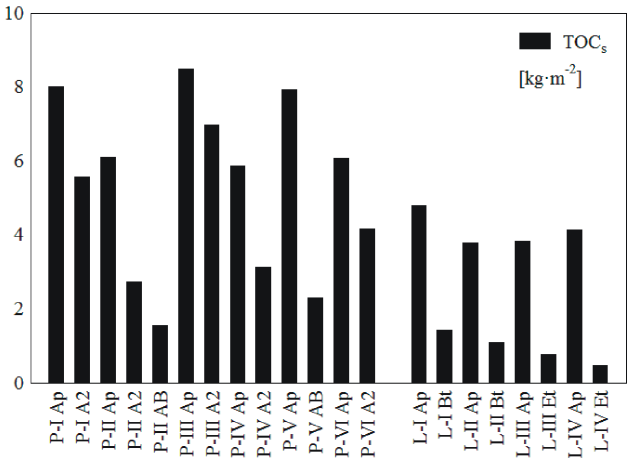

FIGURE 1. Organic carbon stock in the soil studied (symbols of profiles and horizons as in Table 1)

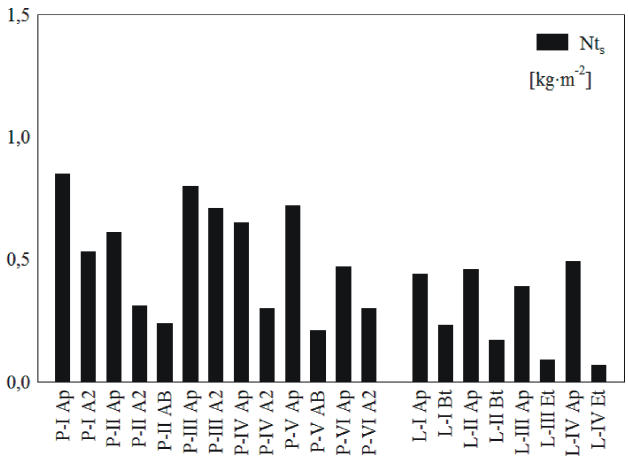

FIGURE 2. Total nitrogen stock in the soil studied (symbols of profiles and horizons as in Table 1)

Mean carbon content, to a depth of 0.3 m, range from 5.0 kg·m^{-2} for Luvisols to 8,4 kg·m^{-2} for Phaeozems in Central and Eastern Europe (Batjes 2002).

Conventional tillage systems of the soils combined with simplified crop rotation, as well as a lack of fertilisation with manure could result in decreasing the amount of organic matter coming in the cycle of transformations of organic carbon and, as a result, decreasing its content and stock. The DOC content in the share of DOC fraction in TOC slightly higher than in Phaeozems. This feature concerns mostly subsurface horizons.

In Ap horizon the bulk density ranged from 1.42 to 1.65 Mg·m^{-3}, while in subsurface horizons – from 1.48 to 1.72 Mg·m^{-3} (Table 4). The soil compaction is one of the form of soil degradation that changes the soil structure and influences the soil productivity (Hamza and Anderson 2005). Values ρ_a point to a

TABLE 2. Content of total organic carbon (TOC) and nitrogen (Nt), content of dissolved organic carbon (DOC) and nitrogen (DN), and concentration of available P, K and Mg

No.	Horizon	TOC	Nt	(DOC)		(DN)		P_2O_5	K_2O	Mg
		g·kg^{-1}	g·kg^{-1}	mg·kg^{-1}	% TOC	mg·kg^{-1}	% Nt	mg·100g^{-1}		
P-I	Ap	18.0	1.9	385	2.1	73.8	3.9	10.4	21.6	8.7
	A2	13.7	1.3	304	2.2	33.9	2.6	8.8	19.3	8.2
P-II	Ap	13.9	1.4	320	2.3	68.2	4.9	11.5	11.4	9.0
	A2	13.4	1.5	317	2.4	68.9	4.6	7.2	9.5	8.4
	AB	8.4	1.3	312	3.7	126	9.7	5.6	8.6	7.4
P-III	Ap	20.1	1.9	359	1.8	69.8	3.7	8.7	15.3	7.3
	A2	20.7	2.1	339	1.6	90.6	4.3	7.6	13.4	8.5
P-IV	Ap	15.5	1.7	318	2.0	38.5	2.3	9.2	7.8	6.1
	A2	14.4	1.4	242	1.7	30.5	2.2	8.7	7.9	5.7
P-V	Ap	18.7	1.7	453	2.4	55.0	3.2	11.2	11.4	6.5
	AB	6.7	0.6	136	2.0	21.8	3.6	10.3	10.8	7.0
P-VI	Ap	15.6	1.2	280	1.8	41.2	3.4	11.6	14.8	8.4
	A2	16.7	1.2	246	1.5	35.9	3.0	9.8	13.2	7.6
L-I	Ap	11.0	1.0	379	3.4	40.1	4.0	8.3	8.8	6.2
	Bt	3.7	0.6	349	9.4	29.4	4.9	8.6	8.7	6.8
L-II	Ap	8.3	1.0	392	4.7	61.2	6.1	8.9	9.2	7.0
	Bt	3.3	0.5	350	10.6	35.7	7.1	8.6	8.7	6.6
L-III	Ap	8.9	0.9	367	4.1	46.9	5.2	7.2	10.4	5.1
	Et	2.6	0.3	182	7.0	34.8	11.6	6.7	7.9	4.7
L-IV	Ap	9.4	1.1	335	3.6	54.1	4.9	8.2	6.3	3.5
	Et	1.4	0.2	245	17.5	38.4	19.2	7.5	5.2	3.3

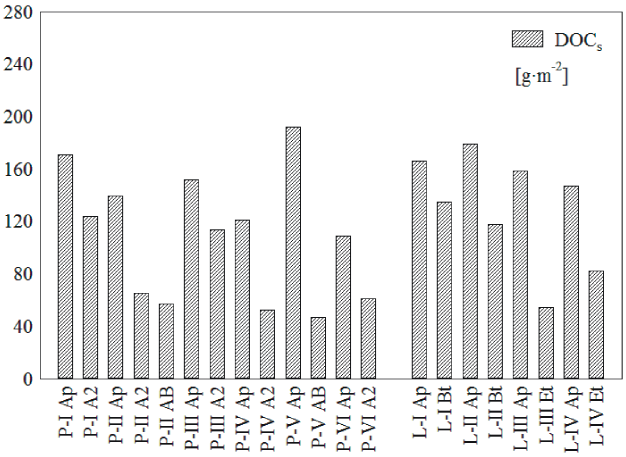

FIGURE 3. Dissolved organic carbon stock in the soil studied (symbols of profiles and horizons as in Table 1)

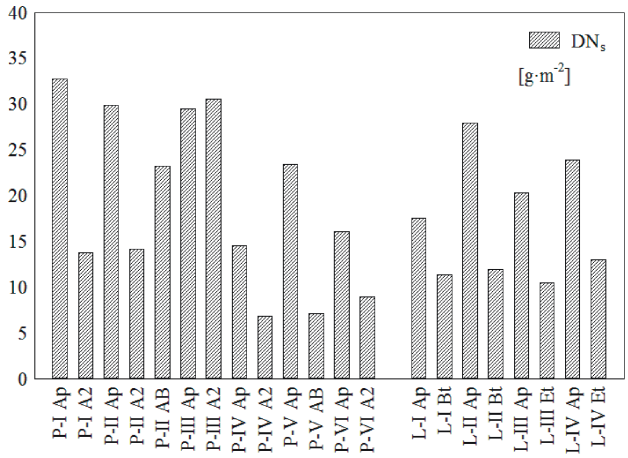

FIGURE. 4. Dissolved nitrogen stock in the soil studied (symbols of profiles and horizons as in Table 1)

TABLE 3. Results of statistical analysis (for Anova, the Tukey test)

Parameter	Significant level	Phaeozems n=13	Luvisols n=8
		mean content	
TOC [g·kg^{-1}]	p=0.004	15.1	6.1
TOC$_s$ [kg·m^{-2}]	p=0.018	5.31	2.55
Nt [g·kg^{-1}]	p=0.007	1.47	0.7
Nt$_s$ [kg·m^{-2}]	p=0.044	0.51	0.29
DOC [mg·kg^{-1}]	p=0.667	308	325
DOC$_s$ [g·m^{-2}]	p=0.354	108	130
DN [mg·kg^{-1}]	p=0.213	58.0	42.6
DN$_s$ [g·m^{-2}]	p=0.600	19.3	17.1

direct effect of ploughing on soil density, which will further affect SOC stock measurements. In the topsoil (5–10 cm), total porosity ranged from 0.365 to 0.439 m^3·m^{-3} and it was similar to the one reported in subsurface horizons (Table 4). Based on the soil quality criteria developed by Paluszek (2011), the soil material in horizon Ap of the soils demonstrated a low and medium total porosity. The subsoil densities are used to estimate the current packing density, which is considered as an indicator for susceptibility for soil compaction (Jones et al. 2003). The subsoil of the Phaeozems and Luvisols in Kujawy region represented soil material with a medium and high packing density and moderate and high inherent susceptibility to compaction (Table 4).

TABLE 4. Selected properties of soils

No.	Horizon	Gravel content (%)	Fraction <0.02 mm	Particle density (ρ_s)	Bulk density (ρ_a)	Porosity	Packing Density (PD)
		>2 mm	%	$Mg \cdot m^{-3}$		$m^3 \cdot m^{-3}$	$Mg \cdot m^{-3}$
P-I	Ap	1	27	2.57	1.55	0.397	
	A2	2	28	2.61	1.66	0.364	1.78
P-II	Ap	2	23	2.59	1.60	0.382	
	A2	3	24	2.60	1.63	0.373	1.75
	AB	1	28	2.64	1.55	0.413	1.63
P-III	Ap	2	24	2.59	1.54	0.405	
	A2	1	22	2.62	1.55	0.418	1.74
P-IV	Ap	3	23	2.60	1.45	0.442	
	A2	2	27	2.61	1.48	0.433	1.61
P-V	Ap	1	28	2.54	1.48	0.417	
	AB	1	28	2.59	1.59	0.386	1.65
P-VI	Ap	2	29	2.53	1.42	0.439	
	A2	3	27	2.57	1.61	0.374	1.76
L-I	Ap	3	25	2.60	1.61	0.381	
	Bt	2	33	2.63	1.72	0.346	1.75
L-II	Ap	2	24	2.59	1.61	0.378	
	Bt	2	33	2.64	1.72	0.348	1.75
L-III	Ap	3	19	2.60	1.65	0.365	
	Et	1	21	2.64	1.69	0.360	1.71
L-IV	Ap	3	18	2.60	1.57	0.396	
	Et	2	15	2.65	1.64	0.381	1.65

Soil organic matter and clay content contribute to the cation exchange capacity. Adsorbed cations are released to the soil solution as needed for uptake by plants. A significantly positive correlation (r=0.47, p<0.05) between the amount of clay fraction and the content of magnesium available to plants was identified (Table 5). The soil samples with a higher content of organic carbon contained a significantly higher content of phosphorus and magnesium available to plants. The maintenance of soil organiccarbon levels is the key to sustaining soil and the optimization of nutrient cycling is necessary to the stable productivity of the soil analysed. Soil samples with a higher content of clay fraction had significantly higher total organic carbon content and cation exchange capacity (Table 5). CEC values of Phaeozems ranged from 13.9 to 24.3 $cmol \cdot kg^{-1}$, and from 7.15 to 19.5 $cmol \cdot kg^{-1}$ in Luvisols. The soil samples with higher cation exchange capacity had higher concentrations of potassium, phosphorus and magnesium available to plants. Class of soil abundance in plant-available phosphorus and potassium was low for most of the samples (Table 2). Luvisols were medium rich in magnesium, whereas Phaeozems P-I, P-II, P-III and L-VI showed a high abundance of this nutrient. The small amount of dissolved organic carbon as a share of TOC showed that the content of DOC does not depend on the amount of soil organic matter. This relationship confirms the lack of significant correlation between these parameters.

Soil degradation depletes SOC pool, and its restoration to threshold levels of at least 11.0 to 15.0 $g \cdot kg^{-1}$ is critical to reducing soil and environmental degradation risks (Lal 2015). The most desirable tillage systems are those which restore soil quality, improve use efficiency of fertilizers and minimize risks of SOC and nutrient depletion.

TABLE 5. Significant correlation coefficient at $p < 0.05$ (n=21)

=Soil properties	Clay	TOC	Nt	TOC_s	Nt_s	DOC	DN	DOC_s	DN_s	K_2O	P_2O_5	Mg
Clay												0.47
CEC	0.75	0.50								0.59	0.55	0.75
TOC			0.94	0.90	0.84				0.47		0.62	0.58
Nt				0.84	0.87	0.46	0.54		0.60			
TOC_s					0.97	0.52		0.60	0.65			
Nt_s						0.61		0.67	0.75			
DOC								0.87	0.66			
DN									0.72			
DOC_s									0.66			

CONCLUSIONS

1. Although Phaeozems demonstrated a significantly higher content of total organic carbon (TOC) in comparison with Luvisols, the amount of dissolved organic carbon (DOC) was similar in both soil types.
2. The differences between the stock of organic carbon (TOC_s) in Phaeozems and Luvisols from the Kujawy region are a natural consequence of their pedogenesis.
3. If the soil management practices are similar the amounts of DOC and dissolved nitrogen (DN) and their stock do not depend on the type of soils.
4. Bulk density can change over time in response to management practice changes and so this parameter affected the values of TOC_s, Nt_s, DOC_s, DN_s.
5. The soil samples with a high content of organic carbon contained a significantly higher content of plant-available phosphorus and magnesium. A significantly positive correlation between the amount of clay fraction and the content of magnesium available to plants was identified.

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Received: November 16, 2015
Accepted: February 9, 2016

Ocena cech użytkowych czarnych ziem i gleb płowych rejonu Kujaw

Streszczenie: Do oceny cech użytkowych czarnych ziem i gleb płowych z regionu Kujaw (województwo kujawsko-pomorskie, Polska) wykorzystano wskaźniki jakości gleb takie jak: zawartość węgla organicznego oraz składników pokarmowych, a także gęstość objętościową. Badane gleby charakteryzowały się podobnymi właściwościami skały macierzystej (skład granulometryczny, głębokość jej zalegania, rodzaj minerałów ilastych) oraz podobnym sposobem użytkowania (zabiegi uprawowe, zmianowanie, nawożenie). Oznaczono gęstość objętościową, uziarnienie, pH w roztworze 1M KCl, zawartość przyswajalnych form potasu, fosforu i magnezu oraz zawartość węgla organicznego (TOC) i azotu ogólnego (Nt). Zawartość rozpuszczalnego węgla (DOC) i azotu (DN) oznaczono po ekstrakcji z 0.004 M $CaCl_2$. Obliczono zapas TOC_s, Nt_s oraz DOC_s i DN_s w poziomach powierzchniowych i podpowierzchniowych gleb. Całkowita zawartość węgla organicznego w poziomie orno-próchnicznym czarnych ziem była istotnie wyższa (13,9–20,1 $g \cdot kg^{-1}$) niż w poziomie Ap gleb płowych (8,3–11,0 $g \cdot kg^{-1}$), co jest następstwem ich genezy. Zapas węgla organicznego w poziomie Ap czarnych ziem wynosił od 5,89 do 8,49 $kg \cdot m^2$ oraz od 3,80 do 4,81 $kg \cdot m^2$ w glebach płowych. Pomimo, że czarne ziemie zawierały wyższą zawartość TOC w porównaniu z glebami płowymi to ilość rozpuszczalnego węgla była zbliżona w obu typach gleb. Wskazuje to na wyższy udział DOC w całkowitej zawartości węgla organicznego w glebach płowych (do 17,5% w poziomie Et). Jeśli gleby są podobnie użytkowane to zawartość rozpuszczalnych form węgla i azotu oraz ich zapas w glebie nie zależy od typu gleb.

Słowa kluczowe: jakość gleb, zapas węgla organicznego, czarne ziemie, gleby płowe