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Chapter 2. SOIL SCIENCE

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SOIL ORGANIC MATTER CHANGES IN LITHUANIAN SOILS: EXPERIENCES AND RESULTS

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Abstract

Data have been obtained for sandy loam *Eutric Albeluvisol-ABe* at the Kaltinėnai Research Station of the Lithuanian Institute of Agriculture on the undulating topography of Western Lithuania. Results from 18-years of field investigations show significant increases in soil organic matter (SOM) content under grass-grain crop rotations compared with field and grain-grass crop rotations, which thus provides evidence for carbon sequestration in soil. SOM content was analysed using the Tyurin titrimetric method, which is not widely used in Western Countries. Therefore, SOM data are also presented after split analysis using dry combustion, Walkley-Black (USDA) and loss-on-ignition (UK) methods, enabling the calculation of transfer functions between databases. International comparison of SOM databases assists many tasks, which include evaluating the importance of SOM/SOC in international collaborative terrestrial ecosystem studies, the development of effective soil conservation policies and the creation of a sustainable future for the modern Lithuanian rural society.

Key words: soil organic matter, soil erosion, SOM analytical protocols, *Eutric Albeluvisol*, soil conservation.

Introduction

Soil organic matter (SOM) plays a central role in maintaining key soil functions, such as increasing soil porosity and infiltration rates. In turn, this increases the water holding capacity of soil and makes tillage operations easier. The resultant increased water availability for plants decreases runoff and the pollution of watercourses with agrochemicals. The soil organic fraction accounts for 50–90% of the cation exchange capacity (CEC) of mineral surface soils, which allows macronutrient cations (K, Ca, Mg) to be held in forms available to plants. Through CEC, organic matter also provides much of the soil pH buffering capacity /Brady, Well, 1999; Lal et al., 1998/. Nitrogen, phosphorus, sulphur and micronutrients are stored as constituents of SOM, which are slowly released by mineralization, thus aiding plant growth. Humic acids are constituents of SOM and these accelerate soil mineral decomposition, releasing macro- and micro-nutrients as exchangeable cations. Furthermore, SOM decreases soil erodibility /Munshower, 1994; Jacinthe et al., 2002; Jankauskas et al., 2007/.

Carbon (C) is a major component of SOM, which in turn plays a key role in the global C cycle. While ~8 gigatonnes (Gt) of anthropogenic C is emitted into the atmosphere annually, ~2 Gt of C is captured (sequestered) in SOM annually /Lal, 2001, 2002/. This underlines the importance of SOM in relation to climate change. There are, however, limits to the amount of organic matter and hence C that can be stored in soils.

SOM decline is of particular concern in many European areas. According to the European Soil Bureau, based on the limited data available, nearly 75% of the total area analysed in the Mediterranean region of Southern Europe has low (3.4%) or very low (1.7%) SOM contents. Typically, agronomists consider soils with <1.7% organic matter to be in a pre-desertification stage /CEC, 2002; Gobin et al., 2002/. Unfortunately, the problem is more widespread. For instance, SOM values for England and Wales show the percentage of soils with <3.6% organic matter rose from 35% to 42% in the period 1980–1995, which is chiefly due to changing management practises /CEC, 2002; Gobin et al., 2002/. For the same period, in the Beauce region, south of Paris, SOM decreased by half, which is attributed to the same reasons /CEC, 2002/. Because SOM decline is a cross-cutting issue that also affects associated soil parameters, such as fertility, erosion and conservation, it is extremely difficult to estimate its true environmental and financial cost.

Soils serve a crucial role in the global C cycle, providing an estimated 2300 Pg (2.3×10^{18} g) of the total C pool /Batjes, 1996; Lal, 2002; 2003/. Consequently, C cycle models provide valuable tools for understanding and predicting SOM turnover and, thus, assist national and international C-sequestration estimates. Models require the input of characteristic soil and climate data, such as soil texture, SOM, precipitation, temperature and evapotranspiration /King et al., 1997; Smith et al., 1997/. Therefore, transferable soil data, beyond those of institutional and national boundaries, has international importance for soil C model inclusion and quantification of the global C budget. Unfortunately, differences between international protocols employed to determine SOM content produce different estimates and interpretations.

Determination of SOM content is a routine procedure in soil analytical laboratories throughout the USA and other Western countries. However, there is no satisfactory universal method for determining SOM content. It can be determined indirectly by measuring soil organic carbon (SOC) content and multiplying the result by the ratio of organic matter to organic C normally found in soil. Direct determination of SOM usually involves destruction of the organic fraction by oxidation or ignition of the soil at high temperature. Soil weight loss is taken as a measure of organic content. However, the oxidation method has serious limitations, mostly because the oxidation process is incomplete, and the extent of oxidation can vary between soils /Page et al., 1992/.

Universal or harmonized quantification of SOM concentrations is essential and data comparability can be achieved by harmonization of analytical protocols. At present, due to methodological differences between regional and national laboratories, problems of SOM data comparison and acceptance exist, particularly where results are presented for international publication or inclusion in soil C models. Consequently, there is a need to develop transfer functions between analytical protocols used to determine SOM content by: 1 – dry combustion, 2 – Walkley-Black, 3 – loss-on-ignition, 4 – Tyurin photometrical and 5 – Tyurin titrimetrical methods /Ball, 1964; Орлов, Гришина, 1981; Александрова, Найденова, 1986; USDA, 1995; Никитин, 1999/. Traditionally, the latter two techniques have been and continue to be used in Central and East European countries.

Transfer equations have been calculated using data from the pilot project 'Carbon sequestration in Lithuanian soils' (F/00630B), which was supported by the Leverhulme Trust, UK /Jankauskas et al., 2006/. Five SOM/SOC analytical protocols, used in laboratories of the LIA and the University of Wolverhampton (UK), were compared. Correlation coefficients between sets of results analysed by different methods varied between $r = 0.81–0.89$ (0–20 cm, n = 46, $P < 0.001$). This promotes the possibility of data transfer, based on the strength and significance of correlation and regression relationships.

The objectives of this article are to: 1) investigate SOM content changes under various land use systems on Lithuanian Eutric Albeluvisols, based on 18-years of field investigations; 2) explore the possibility to transfer SOM content results from the Tyurin titrimetric method to dry combustion (D_c), Walkley-Black (W-B) and loss-on-ignition (LoI_W) methods; and 3) contribute to a more sustainable future for the modern Lithuanian village by creating conditions for the implementation of erosion-resisting land use systems on hilly-rolling landscapes.

Research methods

Field data were collected at the Kaltinenai Research Station (KRS) of the Lithuanian Institute of Agriculture (LIA) during 1983–2000, which is located on the southern-central Žemaičiai Uplands of Western Lithuania. Study sites A, B and C were on slopes of 2–5, 5–10 and 10–14^o, respectively.

Field experiments were performed on sandy loam *Eutric Albeluvisol (Abe)* /Mažvila et al., 2006/. Soil was differentially eroded along the slopes, being slightly eroded on 2–5^o slopes (Site A), moderately eroded on 5–10^o slopes (Site B) and strongly eroded on 10–14^o slopes (Site C), with colluvial deposits on basal slopes. Soil erosion was caused mainly by tillage and water erosion, under continuous intensive cropping. The agro-chemical properties of Ap horizons (0–20 cm) before field experiments show that the topsoil was slightly acid, P-deficient, moderately K-rich and contained varying SOM contents. The highest SOM content was on the less eroded 2–5^o slope and the lowest on the 10–14^o slope /Jankauskas et al., 2008/. For historical reasons, soil analytical techniques mainly follow East European procedures.

In Lithuania, water erosion occurs mostly on arable slopes, as natural vegetation (woods, shrubs and grasslands) effectively protects soil from erosion /Jankauskas et al., 2008/. Mean annual precipitation in Lithuania is 626 mm, with ~858 mm on the central Zemaiciai Uplands and 750–800 mm on the upland fringe. Annual precipitation during the study period was 635–1 075 mm.

Long-term field experiments have been conducted since 1982. Four six-course crop rotations were compared. These were:

(a) The field crop rotation: 1) winter rye (*Secale cereale* L.), 2) potatoes (*Solanum tuberosum* L.), 3–4) spring barley *(Hordeum vulgare L.)*, 5–6) mixture of clover-timothy (CT) (*Trifolium pratense* L. – *Phelum pratense* L.).

(b) The grain-grass crop rotation: 1) winter rye, 2–4) spring barley, 5–6) CT.

(c) The grass-grain I crop rotation: 1) winter rye, 2) spring barley, 3–6) CT.

(d) The grass-grain II crop rotation: 1) winter rye, 2) spring barley, 3–6) mixture of orchard grass-red fescue (OF) (*Dactylis glomerata* L. – *Festuca rubra* L.).

A multi-species mixture of perennial grasses for long-term use (sod-forming grasses: g) was sown on 10–14^{o} slopes, instead of the field crop rotation (as tillage crops are not recommended on slopes >10^{o} in Lithuania). The grass mixture consisted (20% each) of common timothy, red fescue, white clover (*Trifolium repens* L.), Kentucky bluegrass (*Poa pratensis* L.) and birdsfoot trefoil (*Lotus corniculatus* L). The field experiments contained four replications.

Winter rye and spring barley were the only crops included in all investigated rotations. A mixture of clover-timothy was grown in three crop rotations (field, grain-grass and grass-grain I). Potatoes were grown only in the field crop rotation, while a mixture of orchard grass-red fescue was grown only in the grass-grain II rotation.

A total of 88 *Eutric Albeluvisol* samples were collected from topsoil (0–20 cm) of three field experiments described above and analysed for SOM content by the Tyurin titrimetric method, described below.

For SOM determination, each sample was sub-sampled and analysed by five separate techniques: 1) the traditional West European approach of loss-on-ignition (LoI) /Ball, 1964/, conducted in both the laboratories of the University of Wolverhampton (UoW), UK and the KRS of the LIA, 2) the East European Tyurin titrimetric ($T_{t.}$) method /Александрова, Найденова, 1986/, performed in the laboratory of KRS of the LIA, 3) the Tyurin photometric ($T_{ph.}$) method /Орлов, Гришина, 1981; Никитин, 1999/, 4) the USDA Walkley-Black (W-B) method /USDA, 1995/ and 5) the dry combustion (D_c) method using an automatic analyser Vario EL III (2002) in the Chemical Research Laboratory of the LIA. A summary of analytical methods is presented in Table 1. Sample preparation for each method involved the removal of visible plant and animal residues from bulk soil samples and then sieving (< 0.2 mm). Ponomariova and Plotnikova /Пономарева, Плотникова, 1980/ provided detailed descriptions of soil preparation for SOM (humus) analyses by the Tyurin method.

Statistical analysis was used to evaluate the significance of differences among the data sets and were determined using Fisher's LSD_{05} using the computer programs *Anova* and *Stat* from the package *Selekcija* and *Irristat* /Tarakanovas, Raudonius, 2003/.

Table 1. Summary of SOC and SOM analytical methods
1 lentelė. *DOA ir DOM metodų santrauka*

Indicators *Rodikliai*	Loss-on-ignition (LoI) *Kaitinimo nuostoliai*		Tyurin titrimetric (T_t) *Tiurino titrimetrinis*	Tyurin photometric (T_{ph}) *Tiurino fotometrinis*	Walkley-Black (W-B) *Walkley-Black*	Vario EL III (D_c) *Sauso deginimo*
Laboratory *Laboratorija*	UoW *Volverhamptono universitetas*	KRS of LIA *LŽI Kaltinėnų bandymų stotis*		LIA / *LŽI*		
SOC/DOA			+	+	+	+
SOM/DOM	+	+	Recalc. SOM = SOC × 1.724	Recalc. SOM = SOC × 1.724	Recalc. SOM = SOC × 1.724	Recalc. SOM = SOC × 1.724

Note. + indicates the type of measurement performed by the analytical technique.
Pastaba. + pažymėtas analitinio nustatymo būdas.

Results and discussion

Changes in SOM content. SOM accumulation is a slow process and considerably slower than the rate of decline /Lal et al., 1998/. Fortunately, accumulation can be enhanced by positive farm management techniques, such as permanent grassland, cover crops, conservation tillage, mulching, green manures and applications of farmyard manure or compost. Most of these techniques have also proved effective in preventing erosion, increasing fertility and enhancing soil biodiversity /Lal, 2001; 2002/. The natural fertility of *Eutric Albeluvisol* on the Žemaičiai Uplands has decreased by 21.7, 39.7 and 62.4% on slightly, moderately and severely eroded slopes, respectively, in turn causing the deterioration of soil physico-chemical properties /Jankauskas, Fullen, 2002/.

SOM content changes in long-term field experiments at the KRS illustrate multiple influences of land use systems on SOM dynamics (Table 2). Firstly, the variety of crops as constituents of the rotation can differentially affect C-sequestration processes /Lal et al., 1998/. Secondly, different land use systems require different intensities of soil tillage. Consequently, more intense soil tillage stimulates more SOM mineralization, which releases more C from the soil store to the atmosphere /Lal, 1999/. Thirdly, water erosion rates varied with land use systems: highest losses were under the field crop rotation and the lowest were under grass-grain rotations /Jankauskas, Jankauskiene, 2003; Jankauskas et al., 2004/. The higher soil losses led to higher losses of SOM. Furthermore, different land uses influence C-sequestration by changing soil physical properties, such as dry bulk density, total soil porosity and field capacity. At KRS, the erosion-preventive grass-grain crop rotations and long-term perennial grasses significantly increased total porosity and field capacity /Jankauskas et al., 2008/. There were small changes in SOM after both the first and even the second crop rotation (Table 2). However, differences in SOM became more evident after the third crop rotation in 2000. Significantly higher SOM values were found under the grass-grain crop rotations on the

2–5° and 5–10° slopes compared with the field crop rotation, and under the sod-forming perennial grasses on the 10–14° slope compared with the grain-grass crop rotation.

Table 2. Mean SOM contents under different land use systems
2 lentelė. *DOM vidutinės reikšmės taikant įvairias žemirbystės sistemas*
1983–2000

Crop rotations / *Sėjomainos*	SOM (%) by Tyurin titrimetric method / *DOM %, analizuojant Tiuruno titrimetriniu metodu*		
	after 1st crop rotation, 1988 / *po I sėjomanos rotacijos, 1988 m.*	after 2nd crop rotation, 1994 / *po II sėjomanos rotacijos, 1994 m.*	after 3rd crop rotation, 2000 / *po III sėjomanos rotacijos, 2000 m.*
2–5° slope / *2–5° šlaitas*			
a) Field / *Lauko*	3.47a*	2.73a,b	2.64a
b) Grain-grass *Javų ir žolių*	3.46a	2.54a	2.99b
c) Grass-grain I *Žolių ir javų I*	3.08a	3.65b	3.39c
d) Grass-grain II *Žolių ir javų II*	3.23a	3.47b	3.46c
LSD_{05} / $R_{95\,\%}$	0.412	0.301	0.284
5–10° slope / *5–10° šlaitas*			
a) Field / *Lauko*	2.52a	2.37a	2.17a
b) Grain-grass *Javų-žolių*	2.47a	2.35a	2.01a
c) Grass-grain I *Žolių-javų I*	2.48a	2.27a	2.75 b
d) Grass-grain II *Žolių-javų II*	2.41a	2.31a	2.67b
LSD_{05} / $R_{95\,\%}$	0.287	0.169	0.164
10–14° slope / *10–14° šlaitas*			
g) Grasses** / *Žolės*	2.49a**	2.59b**	2.51b** (2.72**)
b) Grain-grass *Javų ir žolių*	2.42a	2.24a	1.99a (1.69)
c) Grass-grain I *Žolių ir javų I*	2.71b	2.47b	2.45b (2.18)
d) Grass-grain II *Žolių ir javų II*	2.50a	2.39a	2.43b (2.22)
LSD_{05} / $R_{95\,\%}$	0.232	0.221	0.328

* – values with the same letter subscript are not significantly ($P < 0.05$) different / *vienodomis raidėmis pažymėtų duomenų skirtumai yra neesminiai esant* $R_{95\,\%}$.
g)** – the sod-forming perennial grasses were grown instead of the field crop rotation on the 10–14° slope / *lauko sėjomainos vietoje 10–14° šlaite augintos daugiametės žolės.*

The data presented (shown in the brackets of the last column of Table 2) for the 10–14^o slope represent results from plots sampled in 2002 for the project 'Carbon sequestration in Lithuanian soils'. The data in brackets represent two replications and are, therefore, unsuitable for analyses for significant differences. There is evidence of consistent SOM patterns from both data sets i.e. the lowest SOM values were under the grain-grass crop rotation and the highest were under the sod-forming perennial grasses (Table 2).

Comparable results were found at the Hilton Experimental Site, Shropshire, UK. Conversion of 10 erosion plots from bare arable to grass ley set-aside reversed the trend of declining SOM contents, which then significantly increased, especially in the first four years. Mean soil organic content (0–5 cm depth) significantly ($P < 0.001$) increased from 2.04% by weight (SD 0.45, $n = 50$ samples) in April 1991 to 3.11% (SD 0.68, $n = 50$ samples) in April 2001, compared with permanent grassland values of ~4.5%. Soil erodibility after six years of set-aside (sampling date 24/04/97) was determined using a drip-screen rainfall simulator. Soil aggregate stability was higher on the grassed soils, compared with set-aside and bare arable soils. Despite no significant ($P > 0.05$) differences between grassland and set-aside soils, both these treatments were significantly ($P < 0.001$) greater than bare soils /Foster et al., 2000; Fullen et al., 2002/.

Comparison of analytical protocols. Traditionally, the main method for determination of soil humus (as equivalent of SOC content in mineral soils) in East European countries was the wet combustion method of Tyurin, or some modifications of this indirect method /Пономарева, Плотникова, 1980/. The Tyurin dichromate oxidation method does not require expensive instrumentation and is not affected by the presence of lime. However, the disadvantage of this method is incomplete oxidation of organic matter /Orlov et al., 1993/, which is especially obvious, for instance, when analysing peaty soils, soils containing considerable decayed plant residues or upper horizons of forest soils /Орлов, Гришина, 1981; Rojkov et al., 2002/. Organic C values determined by the Tyurin method are ~90% of those determined by the dry combustion method of Gustavson /Бельчикова, 1975/. Moreover, similar data presented in the literature are diverse and even contradictory.

Large archive databases of SOM/SOC exist in Lithuania and in other Central and East European countries. Most of these data were generated using the Tyurin titrimetric protocol. Due to methodological differences between laboratory protocols, difficulties exist using these data for international eco-environmental assessments, for joint research projects and for data acceptance in international publications. Short descriptions of investigations at the KRS were presented in the 'Introduction'. The exhaustive results had been presented by Jankauskas et al. (2006) and are summarized in Table 3. The results indicate the possibility of transferring data from methods widely used in Eastern Europe to other protocols, using simple linear regression equations, more complex paired regression equations or conversion coefficients.

The presented equations and transfer coefficients were used to recalculate SOM content data received by the Tyurin titrimetric method for previous data (10–14^o slope, 2000) presented in Table 2. This choice was made because the data available two years later, i. e. in 2002, from the soil erosion monitoring sites were used for the above-mentioned project 'Carbon sequestration in Lithuanian soils.' Recalculated data sets

(Table 4) show that highest values of SOM were obtained using the loss-on-ignition method (2.63–3.60%), while much lower values were generated by the Walkley-Black (2.13–2.86%) and dry combustion (1.93–2.60%) methods. Noticeable variations in mean SOM data were achieved using different recalculation methods. The highest mean value (2.85%) was using linear regression, a lower mean value (2.76%) was achieved using paired modified power regression and the lowest value (2.63%) using transfer coefficients (Table 4).

Table 3. Regression equations and transfer coefficients for recalculation of SOM data received by Tyurin titrimetric method to other analytical protocols, 0–20 cm (n = 46)
3 lentelė. *Regresijos lygtys ir DOM perskaičiavimo koeficientai iš duomenų, gautų Tiurino titrimetriniu metodu, į gautuosius kitais analitiniais metodais*

Recalculation: *Perskaičiavimas:* from – X *iš X*	to – Y* *į Y*	Linear regression (LR) *Tiesinė regresija*	Modified power regression (MPR) *Rodiklinė regresija*	Transfer coefficient *Pervedimo koeficientas*
Tyurin titrimetric *Tiurino titrimetrinis*	D_c	$Y = 0.504 + 0.833X$ $r = 0.837$	$Y = 0.966 \times 1.469^X$ $r = 0.843$	0.97
Tyurin titrimetric *Tiurino titrimetrinis*	W-B	$Y = 0.628 + 0.889X$ $r = 0.865$	$Y = 1.130 \times 1.436^X$ $r = 0.856$	1.07
Tyurin titrimetric *Tiurino titrimetrinis*	LoI_W	$Y = 0.173 + 1.364X$ $r = 0.825$	$Y = 1.141 \times 1.556^X$ $r = 0.742$	1.32

* – SOM methods: D_c = dry combustion, W-B = Walkley-Black, LoI_W = loss-on-ignition method.
* – *DOM metodai: D_c = sausojo deginimo, W-B = Walkley-Black, LoI_W = kaitinimo.*

Table 4. Comparison of SOM data sets recalculated by selected protocols to the Tyurin titrimetric method
4 lentelė. *DOM duomenų, gautų kitais analitiniais metodais, palyginimas su gautaisiais Tiurino titrimetriniu metodu*

Treatments on the 10–14^o slope *Variantai 10–14^o šlaite*	SOM (%) data sets / *DOM % duomenų grupės*			
	original, analysed by T_t *originalūs, analizuoti T_t metodu*	Recalculated by equations or coefficients *Perskaičiuota naudojant lygtis arba koeficientus*		
		linear regression (LR) *tiesinė regresija*	modified power regression (MPR) *rodiklinė regresija*	transfer coefficient *pervedimo koeficientas*
1	2	3	4	5
Recalculated to dry combustion method / *Perskaičiuota į sausojo deginimo metodą*				
g) Grasses** *Žolės*	2.51b	2.60b	2.54b	2.43b
b) Grain-grass *Javų ir žolių*	1.99a	2.16a	2.08a	1.93a
c) Grass-grain I *Žolių ir javų I*	2.45b	2.55b	2.48b	2.38b
d) Grass-grain II *Žolių ir javų II*	2.43b	2.53b	2.46b	2.36b

Table 4 continued
4 lentelės tęsinys

1	2	3	4	5
LSD_{05} / $R_{95\,\%}$	0.328	0.344	0.334	0.318
Mean / *Vidurkis*	2.35	2.46	2.39	2.28
Recalculated to Walkley-Black method / *Perskaičiuota į Walkley-Black metodą*				
g) Grasses** *Žolės*	2.51b	2.86b	2.80b	2.69b
b) Grain-grass *Javų ir žolių*	1.99a	2.40a	2.32a	2.13a
c) Grass-grain I *Žolių ir javų I*	2.45b	2.81b	2.74b	2.62b
d) Grass-grain II *Žolių ir javų II*	2.43b	2.79b	2.72b	2.60b
LSD_{05} / $R_{95\,\%}$	0.328	0.370	0.370	0.351
Mean / *Vidurkis*	2.35	2.72	2.65	2.51
Recalculated to loss-on-ignition method / *Perskaičiuota į Walkley-Black metodą*				
g) Grasses** *Žolės*	2.51b	3.60b	3.46b	3.31b
b) Grain-grass *Javų ir žolių*	1.99a	2.89a	2.75a	2.63a
c) Grass-grain I *Žolių ir javų I*	2.45b	3.51b	3.37b	3.23b
d) Grass-grain II *Žolių ir javų II*	2.43b	3.49b	3.34b	3.21b
LSD_{05} / $R_{95\,\%}$	0.328	0.472	0.452	0.433
Mean / *Vidurkis*	2.35	3.37	3.23	3.10

g)** – the sod-forming perennial grasses / *velėną formuojančios daugiametės žolės.*

Comparison with data sets from the 'Carbon-sequestration in Lithuanian soils' Project (initial data set) enables the evaluation of the optimal recalculation procedures (Table 5). The closest association for this data set after recalculation using the various transfer approaches is using paired modified power regression. However, the association lessens after recalculation using transfer coefficients.

Table 5. Comparison of recalculated SOM data (%) with the initial data set
5 lentelė. *Perskaičiuotų duomenų palyginimas (%) su pradiniais*

Methods *Metodai*	Initial data set *Pradiniai duomenys* (n = 46)	Mean values from Table 4 recalculated by: *Vidutiniai 4 lentelės duomenys, perskaičiuoti naudojant*		
		equation of LR *LR lygtį*	equation of MPR *MPR lygtį*	transfer coefficient *pervedimo koeficientus*
T_t	2.21 ± 0.091	2.35	2.35	2.35
D_c	2.35 ± 0.091	2.46	2.39	2.28
W-B	2.59 ± 0.094	2.72	2.65	2.51
LoI_W	3.19 ± 0.151	3.37	3.23	3.10

Several attempts have been made to establish transfer coefficients for different organic analytical methods. The following coefficients were suggested to recalculate the data of the dichromate method of Walkley-Black into dry combustion results: 1.24–1.32 (depending on soil parent material: 1.24 for soils developed on basalt, alluvium or sand, 1.32 for soils developed on granite or metamorphic rock) /Gillman et al., 1986/, 1.33 /Bornemisza et al., 1979/ and 1.41 /USDA, 1995/. In this work, we used the correction factor of 1.3 recommended by Nilson and Sommers (1982) to compensate for incomplete oxidation in the primary stage of calculations. Therefore, mean values of W-B data are slightly higher than D_c equivalents. A generalized coefficient of 1.28 ± 0.19 was suggested for the recalculation of OC content determined by the Tyurin method into that determined by dry combustion by automatic analysers. The following transfer coefficients have been suggested for different soils: typical chernozem (1.13); soddy-podzolic soil (1.30); light chestnut soil (1.26); leached chernozem (1.23); calcareous chernozem (1.29) and solonetzes (1.32) /Когут, Фрид, 1993/. A general coefficient of 1.34 was proposed for mineral soils /Orlov et al., 1993/. However, calculation of transfer coefficients is simple, but not precise; while linear and paired power regression equations appear to be notably more precise (Table 3).

Development, refinement and employment of this calibration approach will assist the harmonization of international SOM/SOC data and appraisal of long-term global soil C-storage trends. These include international collaborative studies on the role of SOM/SOC in terrestrial ecosystems and the development of effective soil conservation policies. Effective policies will create better conditions for the implementation erosion-resisting land use system on hilly-rolling landscapes and will, thus, contribute to a more prosperous and sustainable future for the modern Lithuanian rural society.

Conclusions

1. Generally, higher soil erosion rates promote greater SOM loss. Furthermore, various land use systems influence erosion rates and changes in soil physico-chemical properties. Erosion-preventive grass-grain crop rotations and perennial grasses for long-term use significantly increased SOM on 2–5^{o} and 5–10^{o} slopes, compared to field crop rotations. Sod-forming perennial grasses significantly increased SOM on 10–14^{o} slopes compared with the grain-grass crop rotation.

2. The feasibility of transferring data from the Tyurin titrimetric method to other protocols was investigated. The presented data sets appear comparable and appropriate for recalculation. Successful recalculation was achieved using simple linear regression equations, more complex paired regression equations, or transfer coefficients. Transfer coefficients are only applicable to *Eutric Albeluvisol*, although the question remains if they are applicable to a wider spectrum of Albeluvisols and related soil groups. Therefore, there is an urgent need to continue cross-calibration using more soil samples across a broader range of soil textures.

3. Employment of this approach will assist the harmonization of international SOM/SOC data and appraisal of long-term global trends in soil carbon storage.

4. Erosion-preventive cropping systems (grass-grain crop rotations and long-term perennial grasses) significantly increased SOM/SOC when maintained for ≥12 years, and thus provides evidence of effective carbon sequestration in soil.

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ORGANINĖS MEDŽIAGOS KAITA LIETUVOS DIRVOŽEMIUOSE: PATIRTIS IR REZULTATAI

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Santrauka

Straipsnyje pateikti tyrimų duomenys, gauti vykdant Didžiosios Britanijos Leverhulmo Fondo (the Leverhulme Trust) finansuotą pradinį projektą „Anglies fiksavimas Lietuvos dirvožemiuose“. Tyrimai atlikti Lietuvos žemdirbystės instituto Kaltinėnų bandymų stotyje, Žemaičių aukštumos (Vakarų Lietuva) kalvotame banguotame reljefe, kur vyrauja priesmėlio ir priemolio pasotintieji balkšvažemiai *Eutric Albeluvisol (ABe)*.

Tyrimų rezultatai parodė esminį dirvožemio organinės medžiagos (DOM) kiekio padidėjimą dirvožemyje 18 metų auginant žolių ir javų sėjomainos augalus, palyginti su dirvožemiu, kuriame tiek pat laiko auginti lauko sėjomainos augalai. Tai akivaizdi anglies fiksavimo dirvožemyje galimybė. DOM kiekis bandymų dirvožemyje analizuotas Tiurino titrimetriniu metodu, kuris nėra plačiai taikomas Vakarų šalyse, todėl projekto vykdymo metu dirvožemio ėminiai buvo papildomai analizuoti sausojo deginimo, Walkley-Black (USDA) ir kaitinimo (plačiai taikomo Didžiojoje Britanijoje) metodais.

Nustatyta, kad egzistuoja esminiai metodiniai skirtumai tarp įvairių dirvožemio organinės medžiagos analizavimo metodų, bet tarp lygintų gana skirtingų metodų nustatyti labai glaudūs aukšto patikimumo lygio koreliaciniai ryšiai. Koreliaciniai linijinės priklausomybės ryšiai tarp tirtais metodais gautų duomenų svyravo intervale r = 0,742–0,865 (n = 46, P < 0,01). Porinės regresijos kreivės parodė labai glaudžius porinės regresijos ryšius (determinacijos koeficientai r^2 artimi vienetui), o porinės regresijos lygtys leidžia atlikti labai tikslius perskaičiavimus. Vadinasi, egzistuoja trejopa matematiškai pagrįsta galimybė perskaičiuoti Centrinės ir Rytų Europos šalyse taikomais metodais gautus DOM tyrimų duomenis į gautus Vakarų šalyse taikomais metodais, ir atvirkščiai. Ateityje panašius tyrimus vertėtų atlikti panaudojant bandinius iš kitų dirvožemio grupių.

Reikšminiai žodžiai: dirvožemio organinė medžiaga, dirvožemio erozija, DOM analizavimo metodai, pasotintieji balkšvažemiai, dirvožemio apsauga.