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Relationships between soil organic matter content and soil erosion severity in Albeluvisols of the Žemaičiai Uplands

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This article analyses relationships between soil erosion severity and soil organic matter (humus) content. The paper describes approaches to assess cumulative soil loss due to the combined action of natural (geological) and accelerated (human induced) soil erosion on Eutric Albeluvisols in Lithuania. Evaluation of soil erosion severity helps us understand which segments of the landscape are susceptible to erosion and therefore require soil conservation. The study also evaluates changes in soil organic matter content in relation to erosion severity.

Factors considered in evaluating soil erosion severity included the existing genetic soil horizons remaining after soil erosion processes, the estimated thickness of lost soil and slope inclination. The estimated depth of soil loss due to the combined action of natural and accelerated soil erosion varied from 0.1–0.8 m on the undulating topography of the Žemaičiai Uplands.

Erosion rates increased with slope steepness. Therefore, natural soil fertility (as indicated by spring barley yields) decreased by 21.7, 39.7 and 62.4% on slopes of 2–5°, 5–10° and 10–15°, respectively, compared with flat land. Crop yield was strongly negatively correlated ($r^2 = 0.790$, $P < 0.001$, $n = 138$) with erosion severity and strongly positively correlated ($r = 0.922$; $P < 0.001$, $n = 80$) with soil organic matter content.

Key words: undulating landscape, soil erosion severity, soil organic matter, plant productivity

INTRODUCTION

Soil organic matter (SOM) is the most important indicator of soil quality and productivity and consists of a complex and varied mixture of organic substances. Commonly, soil organic matter is defined as the percent humus in soil. Humus is the unidentifiable residue of plant soil micro-organisms and fauna that becomes fairly resistant to further decay. Organic matter is very important in the functioning of soil systems for many reasons. Soil organic matter increases soil porosity, thereby increasing infiltration and water-holding capacity of the soil, providing more water availability for plants and less potentially erosive runoff and agro-chemical contamination (Lal et al., 1998). SOM is an important component of both managed and unmanaged terrestrial ecosystems, but is especially important in influencing soil erodibility. SOM contains three times more carbon than vegetation and twice that of the atmosphere. Organic matter in eroded soil decomposes at a greater rate than in intact soil. The organic carbon content within the erodible fine surface fraction is usually ~1–2% (Boyle, 2002).

Stable SOM (humus), which can have a mean residence time of centuries, becomes a potential source of 'greenhouse gases' through a series of biochemical transformations initiated by the physical process of erosion. Erosion enhances SOM decomposition at two locations: the eroded surface of the land and the eroded 'in transit' soil / sediment. Erosion creates a new pool of mineralizable organic matter that is different from the remaining stable organic matter. This transported soil organic fraction is no longer under the same physical and environmental conditions that allowed the organic matter to initially stabilize (Jenny, 1980).

Water erosion eliminates two of the usual rate-limiting factors leading to decomposition of SOM: substrate diffusion and moisture. Erosion turbulently mixes micro-organisms and organic matter and transports the soil under near-saturated conditions from a site of stabilization, even if just a few metres away. It is well established that when topsoil is disturbed and aerated there is a flush of SOM decomposition. This temporary enhancement of decomposition rates is primarily dependent on soil temperature and moisture. Once the physical protection conferred by the aggregate is removed, these fluctuating conditions allow the eroded organic fraction to decompose much more rapidly, in anaerobic conditions to CH_4, CO_2 and N_2O and in aerobic environments to CO_2 and H_2O (Boyle, 2002).

Water erosion occurs mostly on arable slopes in Lithuania, as the natural vegetation (woods, shrubs or grasslands) effectively protects soil from erosion (Jankauskas, 1996). Soil erosion intensity depends mainly on tillage (mechanical) erosion, which has been identified as the main cause of accelerated soil erosion on arable slopes (Kiburys, 1989; Jankauskas, 1996). Agricultural implements (such as ploughs, cultivators and harrows) were used for tillage, which encouraged soil translocation on the hilly relief in the mid-twentieth century. The rate of soil translocation under tillage erosion depends on slope steepness, tillage equipment and the direction of tillage operations. The farmers often create favourable conditions for both water and wind erosion, using tillage equipment on a hilly relief. Tillage erosion only moved soil over a short distance (75–85 cm), whereas water and wind erosion transport soil over much greater distances (Jankauskas, Kiburys, 2000).

The oldest water erosion monitoring sites in Lithuania have been operational since 1960 at the Dūkštas Research Station of the Lithuanian Institute of Agriculture (LIA) (Pajarskaitė, 1965). The research data of the Dukštas Research Station represent soil and meteorological conditions on the Baltic Uplands of Eastern Lithuania. Monitoring sites include bare fallow, grain crops, grasses and wasteland (untilled / uncultivated land) landuses. Losses of clay loam soil due to water erosion on hill slopes of Eastern Lithuania over 40 years varied markedly: from 4.5 t ha^{-1} yr^{-1} of soil under cereal grain crops to 46.6 t ha^{-1} yr^{-1} on bare fallow on 5–7^o slopes (Bundinienė, Paukštė, 2002).

Erosion-preventive grass-grain crop rotations (>50% grass) decreased soil losses on arable slopes of 2–5^o, 5–10^o and 10–14^o by 77–81%, while the grain–grass crop rotation (<50% grass) decreased these rates by 21–24% compared with the field crop rotation according to 12 years of field experiments at the Kaltinenai Research Station of the LIA. These results represent the soil and meteorological conditions of the Žemaičiai Uplands of Western Lithuania (Jankauskas, Jankauskiene, 2003).

The main aims of this paper are: (1) to assess cumulative soil loss due to the combined action of natural and accelerated soil erosion in Lithuania, (2) to evaluate changes in SOM content in relation to erosion intensity, and (3) to understand which segments of undulating landscapes are susceptible to erosion and therefore require soil conservation to decrease both erosion processes and the decomposition of soil organic matter.

MATERIALS AND METHODS

The Kaltinėnai Research Station (KRS) of the LIA conducted field studies on the undulating topography of the Žemaičiai Uplands, an area of moderately and severely podzolized-eluviated soils (Fig. 1). Albeluvisols (AB) form the major soil group and Eutric Albeluvisols (ABd), Eutric Regosols (RGe) and Gleyic Albeluvisols (ABg) form individual soil units on the investigated slopes (FAO / UNESCO, 1994). Loamy sands and clay loam textures prevail on the research plots. A methodology to classify soil erosion severity on Eutric Albeluvisols in Lithuania was described by Jankauskas and Fullen (2002), and partially by Янкаускас (1993). The goal of investigations was to assess cumulative soil loss due to the combined action of accelerated and natural soil erosion. Evaluation of soil erosion severity helps us understand which segments of the landscape are susceptible to erosion and therefore require soil conservation. Its helps us to better understand relationships between soil erosion severity and changes in SOM content.

Table 1 shows the location and altitudes of some study sites. Full field studies included description of 23 longitudinal landscape or slope transects, 87 soil profiles

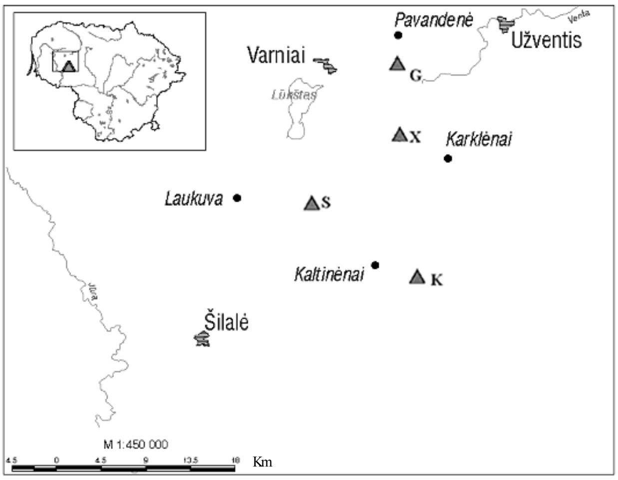

Fig. 1. Location of study sites in the Žemaičiai Uplands of Lithuania.

G, S and X are codes of the longitudinal profiles, K is Kaltinėnai Research Station

Table 1. **Location of the main study sites**

Locality	District	Code	Latitude (N)	Longitude (E)	Altitude (m)
Kaltinėnai	Šilalė	K	55° 34'	22° 29'	140–150
Maž. Vankiai	Šilalė	S	55° 39'	22° 21'	180–190
Pavandenė	Telšiai	G	55° 47'	22° 29'	200–210
Pagirgždutis	Kelmė	X	55° 40'	22° 32'	190–200

K stands for Kaltinėnai Research Station; S, G, X are study sites.

and 68 boreholes, supported by chemical analysis of 647 soil samples from these profiles. The slope transects were representative of the undulating relief of the Žemaičiai Uplands: 22 transects were on loamy sands and clay loams, and one was on sandy soil. The characteristic feature for soils on 18 transects was the presence of a deep calcareous soil horizon at a depth of 1.20–1.85 m. Only five transects had a relatively shallow calcareous horizon (0.72–1.00 m deep). The altitudes of the slopes ranged from 140 to 210 m above sea level.

Stable soil organic carbon (humus) was determined by the Tiurin method (Бельчикова, 1975; Орлов, Гришина, 1981), which is a wet combustion technique similar to the Walkley–Black method (USDA, 1995). Humified soil organic matter was oxidized by solution of potassium dichromate with sulphuric acid, ratio 1 : 50(25), and excess dichromate determined by titration with ferrous sulphate (Mohr solution). However, the protocol determines 'humus' rather than soil organic matter or organic carbon, because only humified organic matter remains after a thorough exclusion of undecomposed plant and animal residues.

Exchangeable P_2O_5 and K_2O (mg kg^{-1}) were extracted with ammonium acetate-lactate (A–L solution, pH 3.7; ratio 1 : 20). Exchangeable P_2O_5 was determined by spectrophotometry and K_2O by flame photometry (Egner et al., 1960).

The significance of differences between treatment means was determined using Fisher's LSD_{05} (Tarakanovas, Raudonius, 2003; Clower, Scarisbrick, 2001). Statistical correlation–regression analyses were performed using the computer programs ANOVA, STAT, SPLIT-PLOT from the package SELEKCIJA and IRRISTAT (Tarakanovas, Raudonius, 2003).

RESULTS AND DISCUSSION

Lost soil layer or soil profile truncation

One representative transect from the group of the 23 longitudinal transects studied (see Materials and Methods) is shown in Fig. 2. Soil profile S0 was an uneroded profile in a wood on Transect S. The calcareous soil horizon was at a depth of 1.81 m on soil profile S0 in woodland and at 1.85 m on soil profile S2 on a sloping

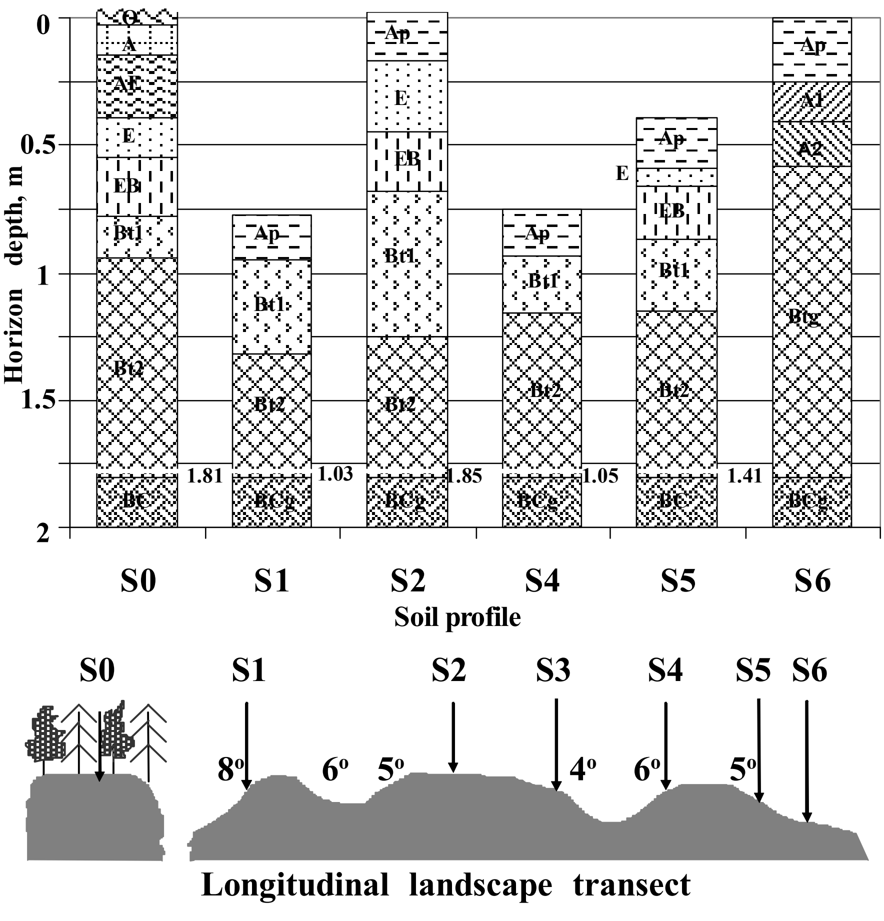

Fig. 2. Severity of soil erosion on transect S in the Žemaičiai Uplands (Maž. Vankiai village, Šilalė District).

S0–S6 are soil profiles. S0: non-eroded soil in a woodland; S1 and S4: very severely eroded soil; S2: slightly eroded soil; S5: severely eroded soil, S6: colluvial soil on a foot-slope. Location of soil profiles is indicated by arrows. White line indicates the depth of the calcareous horizon, while the adjacent numbers indicate depth (m) plateau (Fig. 2). This 1.81 depth to the calcareous soil horizon was used as the basis for the calculation of eroded soil on Transect S. The thickness of soil above the calcareous horizon was 1.03 m (soil profile S1), 1.05 m (soil profile S4) and 1.41 m (soil profile S5). Therefore, the estimated approximate thickness of lost soil (soil profile truncation) was 0.78 m on the top of the 8^0 slope (soil profile S1), 0.76 m on the 6^0 slope (soil profile S4) and 0.40 m on the 5^0 slope (soil profile S5), and varied within 0.1–0.8 m on the other longitudinal landscape transects studied on the undulating topography of the Žemaičiai Uplands.

According to more generalized research data, both soil profile truncation and erosion severity increased with increasing slope steepness $\leq 10^0$ and is best expressed by the correlation–regression quadratic equation:

$$Y = 0.055 + 0.112\,X - 0.004\,X^2,$$

where Y is soil truncation (m), X is slope steepness (%).

The other equation parameters were: $r^2 = 0.92^{**}$; t = 7.065; n = 72; correlation $XY = 0.774 \pm 0.211$; determination $XY = 0.60$; multiple $r = 0.959$; regression coefficient $Y / X = 0.92$ or 92.1%.

Erosion changes soil physical properties, mainly because of the removal (soil profile truncation) of surface soil rich in organic matter and exposure of lower soil layers. Arriaga (2003) indicated that the bulk density and hydraulic conductivity of saturated soil increased slightly with erosion severity. Numerous field and laboratory studies have shown that soils with low organic matter contents are more erodible than more organic soils, and generally soils with <2% organic matter content by weight are highly erodible (Fullen, Catt, 2004). A plausible explanation for the stabilization of soil profile truncation is the tendency to avoid use of slopes $>10^o$ for crop rotations in Lithuania. Thus, steep slopes

Table 2. **Quantity of SOM and available phosphorus and potassium in differently eroded and deposited soils on landscape transect S (south-west of the Žemaičiai Uplands)**

Soil horizon and depth (cm)		Sampling depth (cm)	SOM	P_2O_5	K_2O
			(mg kg^{-1} of soil)		
Soil profile S0: non-eroded soil in a woodland (flat)					
A	4–16	5–15	95.2	35	53
AEl	16–40	25–35	12.1	18	36
El	40–56	43–53	3.2	15	39
ElB	56–79	62–72	2.3	5	78
Bt1	79–95	82–92	1.4	10	96
Bt2	95–181	110–120	0.8	17	127
Soil profile S2: slightly eroded soil on the gently sloping plateau					
Ap	0–22	5–15	19.0	34	48
El	22–50	30–40	2.2	7	60
ElB	50–73	55–65	2.2	31	72
Bt1	73–130	75–85	2.9	45	122
Btg2	130–185	140–150	2.1	68	101
Soil profile S5: severely eroded soil on a 5° slope					
Ap	0–20	5–15	18.0	32	44
ElB	27–48	30–40	3.6	23	60
Bt1	48–76	55–65	0.9	23	106
Bt2g	76–141	100–110	1.9	64	107
BCg	>141	145–156	2.2	93	97
Soil profile S4: very severely eroded soil on a 6° slope					
Ap	0–18	5–15	14.7	33	88
Bt1	18–41	25–35	3.6	58	109
Bt2	41–105	50–60	–	98	92
BC	>105	110–120	–	17	78
Soil profile S6: colluvial soil on a foot-slope					
Ap	0–25	10–20	57.1	41	71
A	25–41	30–40	75.6	60	149
Al	41–64	43–53	74.6	44	335
Bg	64–96	75–85	2.6	187	107

Table 3. **Quantity of SOM and available phosphorus and potassium in differently eroded and deposited soil (landscape transects G, K, X on the Žemaičiai Uplands)**

Number of soil profile	Severity of soil erosion	SOM	P_2O_5	K_2O
		mg kg^{-1} of soil		
	Landscape transect G, Pavandenė, Telšiai District			
G0	Non-eroded	2.72	74.0	349.0
G7	Slightly eroded	1.82	52.8	107.1
G6	Moderately eroded	1.48	92.0	98.2
G5	Very severely eroded	1.12	65.0	90.5
G3	Eroded-colluvial	2.01	153.3	52.3
	Landscape transect K, Gineikiai, Šilalė District			
K0	Non-eroded	2.46	59.0	107.0
K4	Severely eroded	1.50	67.0	209.0
K3	Moderately eroded	1.70	95.0	203.0
K2	Slightly eroded	1.90	54.0	218.0
K1	Eroded-colluvial	3.40	56.2	105.0
	Landscape transect X, Karklynaliai, Kelmė District			
X0	Non-eroded	3.12	77.0	124.0
X1	Slightly eroded	2.88	160.0	183.0
X2	Moderately eroded	2.33	104.0	324.0
X3	Severely eroded	2.04	66.0	190.0
X5	Colluvial	9.80	67.0	203.0

Table 4. **Dependence of barley yield on slope gradient and erosion severity in landscape transect S**

Relief component	Degree of soil erosion	Yield* from 9 investigated plots		
		t ha^{-1}	Decrease (t ha^{-1})	In relative numbers
Flat land	Non-eroded	20.9	–	100
2–5° slopes	Slightly eroded	11.3	9.6	54.1
5–10° slopes	Moderately eroded	6.9	14.0	33.0
Foot-slopes	Deposited soil	19.0	1.9	90.9
LSD_{05}		3.9		

* The mean of 3-year grain and straw gross yield.

are usually used for pastures and their soil is under perennial grass cover (Jankauskas, 1996; Шведас, 1974).

SOM on differently eroded soil

The amount of SOM in the arable soil layer (Ap horizon) is not only affected by erosion processes, but also influenced by human activity, i.e. fertilization by organic and mineral fertilizers, liming of acid soils, the composition and sequence of crops and crop residues, tillage systems and crop treatments. All these factors were practically equal on the described area (soil profiles S1–S6 in Fig. 2), because this field was under the same field crop rotation. The natural factors, such as temperature, precipitation, wind and age of soil formation, were also practically analogous and it is believed that the slight soil textural variability did not markedly influence SOM contents. The main visible differences were only in the situation of different plots on the landscape transect and slope inclination, thus presenting different conditions for tillage, water and partially for wind erosion. More severely eroded areas lost more soil and SOM, therefore less SOM and nutrients were left available for plant nutrition on the newly exposed eroded arable topsoil (Table 2). Colluvial soil on the foot-slope (soil profile S6) contained much more SOM and available nutrients not only in the arable (Ap) horizon, but also in deeper (EB, Bt) horizons.

Runoff and snowmelt eroded soil on the slopes, and soil profiles became truncated. Excavation of eluvial subsoil (Bt) horizons is characteristic and, when ploughed, these soils have thinner humic topsoils. The ploughed out subsoil of eroded Albeluvisols is especially nutritionally poor and leads to decreasing SOM content in the arable soil layer. Over time the SOM content progressively decreased to 1.47% on the very severely eroded plot (S4). The SOM content was 1.8 and 1.9% on

Table 5. **Dependence of barley yield on slope gradient and erosion severity in the Žemaičiai Uplands (Gineikiai and Burniai (Šilalė District) and Pavandenė (Telšiai District) villages)**

Relief component	Soil erosion degree	Yield* from 80 investigated plots × 3 years		
		t ha^{-1}	Decrease (t ha^{-1})	In relative numbers
Flat land	Non-eroded	18.9	–	100
2–5° slopes	Slightly eroded	14.8	4.1	78.3
5–10° slopes	Moderately eroded	11.4	7.5	60.3
10–14° slopes	Severely eroded	7.1	11.8	37.6
Foot-slopes	Deposited soil	19.5	–	103.2
LSD_{05}		1.1		

* The mean of 3-year grain and straw gross yield.

Table 6. **Dependence of SOM content on slope gradient and erosion severity in the Žemaičiai Uplands (Gineikiai and Burniai (Šilalė District) and Pavandenė (Telšiai District) villages)**

Relief component	Degree of soil erosion	SOM content from 80 investigated plots		
		mg kg^{-1}	Decrease (mg kg^{-1})	In relative numbers
Flat land	Non-eroded	25.7	–	100
2–5° slopes	Slightly eroded	22.7	3.0	88.3
5–10° slopes	Moderately eroded	19.2	6.5	74.7
10–14° slopes	Severely eroded	13.1	12.6	51.0
Foot-slopes	Deposited soil	30.9	–	120.2
LSD_{05}		0.19		

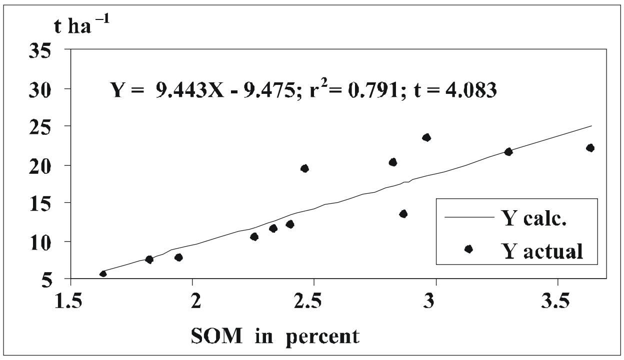

Fig. 3. Relationship between SOM content and spring barley yield (Mаž. Vankiai village, Šilalė District)

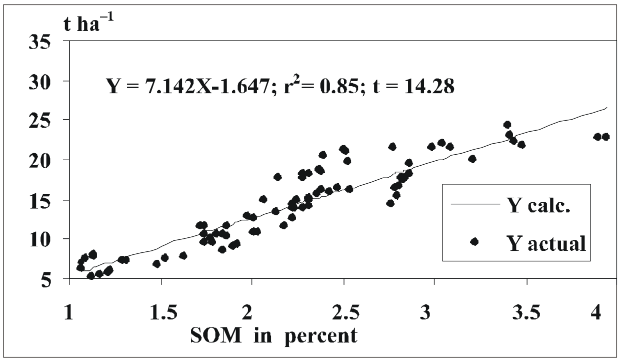

Fig. 4. Relationship between SOM content and spring barley yield (Žemaičiai Uplands, Šilalė and Telšiai Districts)

the severely (S5) and slightly (S2) eroded slopes, respectively. The humic layer of soil in the wood and deposited soil horizon on the foot-slope was rich in SOM (9.52 and 5.71–7.56%, respectively). The deeper soil horizons had little SOM (only 0.08–0.36%) on eroded slopes, but higher contents (even 7.46–7.56%) on colluvial foot-slope deposits. SOM content was 1.72–3.12% on the other non-eroded plots of Eutric Albeluvisols on the top of hills. On moderately and severely eroded soil on the slopes, SOM values were only 1.12–2.04% and 1.48–2.33% SOM, respectively (Table 3).

SOM and fertility of eroded soil

The changed properties of eroded arable topsoil on the area of landscape transect S decreased soil fertility, as indicated by spring barley yields (Table 4). Barley yield decreased by 45.9 and 67.0% on the slightly and moderately eroded slopes, respectively, compared with yields on flat land. The percentage of SOM on different landscape positions strongly correlated with average barley yield ($r = 0.889 \pm 0.145$; $P < 0.001$; $n = 12$). The paired regression between the same characteristics of %SOM and spring barley yield show strong relationships ($r^2 = 0.791$; $P < 0.001$; $n = 12$) according to the linear equation in Fig. 3.

The area of transect S was only moderately steep, with no slopes >10°. The more representative results are presented in Table 5. Barley yield decreased there by 21.7, 39.7 and 62.4%, on the slightly, moderately and severely eroded slopes, respectively, compared with yield on flat land. Crop yield was negatively correlated ($r^2 = 0.790$, $P < 0.001$, $n = 138$) with erosion severity (Jankauskas, Fullen, 2002) and strongly positively correlated ($r = 0.922 \pm 0.044$; $P < 0.001$, $n = 80$) with SOM%. These findings accord with the literature (*e.g.*, Morgan, 1995; Fullen, Catt, 2004; Evans, 2005; Piccarreta et al., 2006).

Analogous results were found in relative SOM contents on the same plots (Table 6). SOM content decreased by 11.7, 25.3 and 49.0%, on the slightly, moderately and severely eroded slopes, respectively, compared with SOM content on adjacent flat land. The decreasing amounts of SOM can be considered a potential source of CO_2, thus contributing to atmospheric greenhouse gases. Of course, some lost SOM will contribute to colluvial sediments.

Percentage SOM in the differently eroded soils of the Žemaičiai Uplands was strongly correlated ($r = 0.922 \pm 0.044$; $P < 0.01$, $n = 80$) with spring barley yield. Paired regression between SOM content and spring barley yield showed strong linear relationships (Fig. 4).

CONCLUSIONS

1. The estimated thickness of lost soil was ≤0.78 m on very severely eroded Eutric Albeluvisols on the undulating topography of the Žemaičiai Uplands. This loss was a combined result of natural and accelerated (tillage, water and wind) erosion. The strongest correlation–regression ($r^2 = 0.92$, $P < 0.001$, $n = 72$) between erosion severity and slope steepness was best expressed as a quadratic equation.

2. Changes in soil erosion severity changed ecological conditions for plant growth, and this was reflected in changed soil fertility. Barley yield on strongly, moderately and severely eroded soils decreased by 21.7, 39.7 and 62.4%, respectively, while soil organic matter content decreased by 11.7, 25.3 and 49.0%, respectively, using adjacent non-eroded flat land as a control.

3. The content of soil organic matter in differently eroded soils of the Žemaičiai Uplands strongly correlated ($r = 0.922 \pm 0.044$; $P < 0.001$, $n = 80$) with spring barley yield. There was a very strong evidence of inverse relationships between soil erosion severity and the quantity of organic matter in eroded soils (i.e. the more soil is eroded the less SOM it contains). Therefore, all measures leading to increased SOM content can be considered to assist soil conservation.

4. These results demonstrate the need for soil conservation measures on arable undulating environments in Lithuania. Therefore, research data and experience of soil conservation practices on the undulating relief of the Republic are very important for sustainable agricultural development.

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ŽEMAIČIŲ AUKŠTUMOS BALKŠVAŽEMIŲ ORGANINĖS MEDŽIAGOS PRIKLAUSOMYBĖ NUO DIRVOŽEMIO NUARDYMO LAIPSNIO

S a n t r a u k a

Išanalizuotas siauras ekologijos klausimas: gamtinių ir antropogeninių faktorių veikiamo kalvoto reljefo dirvožemio santykis su gyvybiškai svarbia jo dalimi – stabilia organine medžiaga humusu, o per ją ir su augalais, kaip labiausiai dirvožemio formavimąsi lemiančiais gyvaisiais organizmais. Aprašoma, kaip vertinti bendrą dirvožemio netektį dėl natūraliosios (geologinės) ir pagreitintosios Lietuvos pasotintųjų balkšvažemių erozijos ir nustatyti dirvožemio erozijos įtaką jo organinių medžiagų kaitai. Dirvožemio nuardymo laipsnio įvertinimas padeda suprasti, kuriuos kraštovaizdžio segmentus, jautriausius ardymui, reikia apsaugoti. Dirvožemio nuardymo laipsnio vertinimo veiksniai apima egzistuojančias dirvožemio horizontų liekanas, faktinį šlaito statumą ir apskaičiuotą dėl erozijos netekto dirvožemio sluoksnio storį. Nustatytasis netekto dirvožemio sluoksnio storis banguotame Žemaičių aukštumos kraštovaizdyje kito nuo 0,1 iki 0,8 m. Netekto dirvožemio sluoksnis didėjo didėjant šlaito nuolydžiui, todėl natūralusis dirvožemio derlingumas mažėjo 21,7, 39,7 ir 62,4% atitinkamai 2–5^{o}, 5–10^{o} ir 10–15^{o} šlaitų nuolydžiams, lyginant su nenuardyto dirvožemio derlingumu lygumoje. Augintų augalų produktyvumas glaudžiai koreliavo ($r = 0,922 \pm 0,044$; $P < 0,001$, $n = 80$) su dirvožemio organinės medžiagos kiekiu ir buvo atvirkščiai proporcingas ($r^2 = 0,79$, $P < 0,001$, $n = 138$) šlaito statumui ir dirvožemio nuardymo laipsniui. Todėl visos priemonės, padedančios kaupti dirvožemio organines medžiagas, kartu yra ir antierozinės priemonės.

Raktažodžiai: kalvotas kraštovaizdis, dirvožemio erozijos intensyvumas, dirvožemio organinės medžiagos, augalų produktyvumas